Upscaling Ecosystem Based Climate Resilience of Vulnerable Rural Communities in the Valles Macro-region of the Plurinational State of Bolivia (RECEM-Valles)

Annex 2: Feasibility Study

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Food and Agriculture Organization of the United Nations

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ACRONYMS

AAPS	Authority of Contol and Supervision of Drinking Water and Sanitation
AFS	Agroforestry System
AMDEBENI	Municipal Association of Beni
AMDECO	Municipal Association of Cochabamba
AMDECH	Municipal Association of Chuquisaca
AMDECRUZ	Municipal Association of Santa Cruz
AMDEOR	Municipal Association of Oruro
AMDEPANDO	Municipal Association of Pando
AMDEPO	Municipal Association of Potosí
AMT	Municipal Association of Tarija
APMT	Plurinational Authority of Mother Earth
APU	Agricultural Production Unit
BDP	Productive Development Bank
CAF	Development Bank of Latin America
CONAF	National Forestry Corporation
CSF	Conservation Strategy Fund
CSUTCB	Single Trade Union Confederation of Small Farmer Workers of Bolivia
EMAGUA	Environment and Water Executing Agency
ETA	Autonomous Territorial Agency
EWS	Early Warning System
FAM	Federation of Municipal Associations
FAO	Food and Agriculture Organization of the United Nations
FFS	Farmer Field School
FILAC	Fund for the Development of Indigenous Peoples of Latin America and the Caribbean
FONABOSQUE	National Forest Development Fund
FSTMB	Union Federation of Mining Workers of Bolivia
GCF	Green Climate Fund
GAD	Autonomous Departmental Government
GAM	Municipal Autonomous Government
GCF	Green Climate Fund
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Corporation for International Cooperation)
IDB	Interamerican Development Bank
IPCC	Intergovernmental Panel on Climate Change
MMAyA	Ministry of Environment and Water
MDRyT	Ministry of Land and Rural Development
MPD	Ministry of Development Planning
MT	Metric Ton
NPV	Net Present Value
OPEC	Organization of the Petroleum Exporting Countries
OFID	OPEC Fund for International Development
PA	Protected Areas

PDES	Economic and Social Development Plan
PDO	Pacific Decadal Oscillation
PROMETA	Environmental Protection Foundation
PRONAREC	National Irrigation Program with a Basin Approach
PTDI	Comprehensive Development Territorial Plan
PTGC	Community Territorial Management Plan
SENAHMI	National Meteorological and Hydrological Service
SENARI	National Irrigation Service
SENASBA	National Service for the Sustainability of Basic Sanitation Services
SPIE	Comprehensive State Planning System
TCO	Communal lands (Tierras Comunitarias de Origen)
TIOCs	Peasant/Indigenous territories (Territorios Indígenas Originarios Campesinos)
TOU	Territorial Operating Units
TPFP	Permanent Forest Production Lands
UCEP – MI RIEGO	Coordination and Execution Unit of the MI RIEGO Program
UNDP	United Nations Development Programme
POTM	Land Use Plan at the Commonwealth Level
UNFCCC	United Nations Framework Convention on Climate Change
VRHR	Vice Ministry of Water Resources and Irrigation
WUA	Water Users Association

Glossary

Adaptation: Defined as any adjustment in natural or human systems in response to climatic stimuli or their effects, which moderates, harm or exploits its potential benefits (According to the Intergovernmental Panel on Climate Change - IPCC, 2014) (FAO -PNUD, 2019).

Intervention Area: Geographical area where the different actions proposed in the Project are implemented.

Sustainable Agriculture: A form of agricultural production that must find a balance between the protection and sustainable use of natural resources and at the same time satisfy the growing needs of society, offering decent and resilient livelihoods (FAO, 2015 - http://www.fao.org/3/a-i4413e.pdf).

Conservation Agriculture: Seeks the sustainable production of the cropping system based on the strengthening of the natural processes of the soil and through the use of agronomic practices that alter its composition, structure and biodiversity as little as possible and that prevent its erosion (FAO, 2006). Its components are: a) Use of permanent plant cover, b) Reduced tillage of the soil c) Rotation of crops. (Mamani et al, 2015).

Threat: Hazards of natural origin: drought, floods, hail and frost, and those of anthropic origin: fires (Methodological Guide PTDI, 2016).

Andean Wetlands: The Andean Wetlands / bofedales or *jok'os* (Aymara name) are a particular type of peat bog wetlands, characteristic of the high Andean and Puno areas within the subtropical and tropical Andes, located at elevations between 3,200-5,000 m. They are characterized by being made up of plants in the form of flat cushions. In the Cordillera Real (Bolivia), the cushions are represented mainly by *Distichia* muscoides and Oxychloe andina, while *Distichia filamentosa, Plantago tubulosa* and *Phylloscirpus deserticola* may be dominant only locally. Towards the south of the Central Andes, D. muscoides can be found but O. andina and *Patosia clandestina* dominate. In the middle of this matrix of vegetation bodies of water emerge and / or cross (pools and streams) (Loza Herrera et.al., 2015).

Climate Change: It is understood as a change in climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that adds to the natural variability of the climate observed during comparable periods of time. (https://www.ipcc.ch/pdf/glossary/tar-ipcc-terms-sp.pdf).

Collection Center: Public-private marketing space for the sale and distribution of food on a large scale. It brings together producers, merchants and consumers, offering an optimal, predictable and organized supply mechanism (Municipal Committee for Food Safety of La Paz, 2016).

Land Degradation: Reduction or loss of biological or economic productivity and complexity of rainfed agricultural lands, irrigated croplands or meadows, pastures, forests and wooded lands, caused, in arid, semi-arid and dry sub-humid areas, by land use systems or by a process or a combination of processes, including those resulting from human activities and settlement patterns, such as: (i) soil erosion caused by wind or water, (ii) the deterioration of the physical, chemical and biological properties or of the economic properties of the soil, and (iii) the lasting loss of natural vegetation (United Nations Framework Convention to Combat Desertification UNCCD).

Life-Zone Ecosystem: It includes the biogeographic-climatic units with conditions of altitude, ombrotype, bioclimate and soil (Methodological Guide PTDI, 2016).

Adverse Effects of Climate Change: Changes in the physical environment or biota resulting from climate change that have significant adverse effects on the composition, resilience or productivity of natural or managed ecosystems, or on the functioning of socio-economic systems , or in human health and well-being (UN, UNFCCC, 1992)[1].

Soil Erosion: Absolute loss of soil in the surface layer and its nutrients, generally due to a high percentage of runoff that wear and transport granular material, producing erosion. This process is the result of the inadequate management of grazing areas, productive practices and deforestation (PTDI Municipality of Uriondo, 2016).

Environmental Functions: Defined as carbon capture and storage; presence of organic matter in the soil; water availability; and presence of biodiversity in areas of high conservation value (http://www.cancilleria.gob.bo/webmre/node/1109).

Water Footprint: The water footprint is an indicator of water use that takes into account both direct and indirect use by a consumer or producer. The water footprint of an individual or community is defined as the total volume of fresh water that is used to produce the goods and services consumed by the individual or by the community.
(http://www.fao.org/in-action/agronoticias/detail/es/c/511925/; https://waterfootprint.org/en/).

Mother Earth: Dynamic living system made up of the indivisible community of all life systems and living beings, interrelated, interdependent and complementary, that share a common destiny. It is the home that contains, sustains and reproduces all living beings, ecosystems, biodiversity, organic societies and the individuals that compose it (Law 300 of Mother Earth, 2012).

Organic: Applied to products that have been produced based on organic standards throughout the production, handling, processing and marketing phase and that have been certified by a duly constituted certification body or authority. Therefore, the term organic refers more to a process than to a product; This does not necessarily mean that the food produced is healthier, safer or totally natural; it simply means that the product complies with established production and handling standards (Quintero y Gioanetto, 2006) en Hernandez *et. al*., 2009).

Territorial Planning for Integral Development: New vision of territorial planning that integrates two processes in the formulation of a single Plan, such as the integral development planning and the processes of land use planning. In this way, the comprehensive planning of the Autonomous Territorial Entities concludes in the formulation of a single Plan called the Territorial Plan for Comprehensive Development (PTDI) (PTDI Methological Guide, 2016).

Risk: Possible damage that could be generated by the implementation of an activity and its action measure (CONAF, 2016)[2].

Agricultural Productive System: Ecosystem that changes, is managed and administered by man in order to produce goods that are useful to him. To modify these ecosystems, man uses the factors of production, which in a simplified way can be grouped into three: the labor force, the land and the capital.

[1] UN, United Nations Framework Convention on Climate Change (UNFCCC). (1992). Available in: http://unfccc.int/resource/docs/convkp/convsp.pdf
[2] Rey, D., Roberts, J., Korwin, S., Rivera, L., and Ribet, U., Guide to Understanding and Implementing the REDD + Safeguards of the UNFCCC. ClientEarth, London, UK. (2013). Available in:http://www.clientearth.org/reports/guia-para-comprender-e-implementar-las-salvaguardas-de-redd+-de-la-cmnucc.pdf

Agroforestry System (AFS): Methods of use and management of natural resources in which woody species (trees, shrubs, palms) are used in deliberate association with agricultural crops or with animals on the same land, simultaneously or in a time sequence (CIPCA, 2015).

Executive Summary

The RECEM-Valles project activities will target peasant and indigenous communities and small-scale agricultural and livestock producers from the Bolivian Valles Macro-region. This region covers several ecoregions in the center and south of the country, i.e. from the Yungas in the departments of La Paz and Cochabamba, the Inter-Andean Dry Valleys in Santa Cruz, the highlands in Potosí and Tarija, to the Tucuman-Bolivian Forests in Chuquisaca and Tarija. The biogeographical and climate conditions in this Macro-region are highly varied. It comprises 111 municipalities and covers an area of approximately 13,107,900 hectares.

In view of the high prevalence of poverty (approximately 63% of the population is poor), the Valles Macro-region is considered the most vulnerable area within the national territory. The people currently living in poverty are mainly concentrated in rural areas, where 56% of the inhabitants work in agriculture – relying on the availability of natural resources, ecosystem functions, and favorable weather conditions for their livelihoods and even survival. Vulnerability may increase with the effects of climate change. Studies conducted for the Valles Macro-region point to significant changes in temperature and rainfall that will undoubtedly give rise to losses of production systems and therefore greater poverty and food insecurity. In order to address this problem, a climate change adaptation project is proposed, with resilience to climate change as the strategic line of action.

The project will be executed over a five-year period and its central objective is to "enhance the resilience to climate change of communities and small farmers in the Valles Macro-region, through capacity building and the development of best agricultural practices to increase the productivity and sustainability of their agroecosystems, aimed at adapting to the increasing variability of temperatures and rainfall." Communities and small-scale farmers will apply climate-resilient agricultural practices, based on the revitalization and expanded coverage of efficient irrigation systems, which will be complemented by comprehensive and sustainable water, soil and biomass management activities with the objective of optimizing water recharge and supply cycles, reducing erosion and risks, and minimizing agricultural disasters. The project will include activities to strengthen the decision-making capacities of local institutions, especially targeting women, and to enhance the capacity of women and youth to produce and market value-added agricultural products.

Local natural resources are under great pressure in the rural area of the Valles Macro-region. Forests are not sustainable managed. There is also pressure from farming families who hunt wildlife and expand agricultural lands into natural ecosystems. Human settlements spring up haphazardly in sectors where there are government lands. Deforestation and unsustainable agricultural practices have a great impact on the biodiversity, soils and water in the region. Mining activities in the area are rarely monitored and contribute significant levels of pollution and environmental damage. Compounding this situation is the environmental pressure of growing urban cities that demand natural resources and pollute water bodies with waste and sewage disposal.

Bolivia is already experiencing climate change impacts: historic trends show an increase in temperature of 0.10°C per decade from 1939 to 2009 with the rate of increase of 0.32°C in the last 25 years. The country is also experiencing rainfall variability. Future climate projections show further changes to both temperature and rainfall. Climate change scenarios (RCP 8.5) for the year 2050 in the Valles Macro-region show a likely increase in temperature from +2.7ºC to +3.4ºC. These changes will drastically affect the availability of water in quantity and quality, due to greater moisture loss through evaporation from soils and transpiration of vegetation. This increase in temperature is accompanied by an increase in rainfall variability, including late arrival of the monsoonal rains vital for agriculture, lengthy dry spells during the rainy season, increased drought, and sudden torrential rains causing flash floods.

The vulnerability of water systems and the agricultural sectors to climate change impacts is high. Recent studies predict that the crop and livestock sectors will be among the most affected, facing significant productivity and economic losses. Smallholder farmers are particularly vulnerable as their current crop yields are already very low. Poor land management and unsustainable land use change exacerbate these impacts.

A comprehensive multi-criteria vulnerability assessment was conducted for this feasibility study, which includes an analysis of erosion threats, desertification threats, biomass, adaptive capacity indicators, area of cropland under irrigation, percentage of population living in poverty, economic activity in the primary sector, availability of electricity, access to piped drinking water, and agricultural mechanization indicators. Using these criteria, many of the municipalities in the Valles Macro-region are shown to have high vulnerability to climate change.

The policy and institutional context of the project includes the Constitution of Bolivia, which was enacted in 2009 and lays the legal foundation for environmental regulations in the country. Some of the laws analyzed for this feasibility study include the Law of Mother Earth and Integral Development for Living Well of 2012, which establishes the political, technical, and legal guidelines to guarantee sustainable development and the restoration and regeneration of the life zones of Mother Earth. In terms of international agreements, the Nationally Determined Contribution of the Plurinational State of Bolivia was officially submitted to UNFCCC in 2016, which establishes results through an integrated focus on three main areas: water, energy and forests.

One of the Bolivian government's priorities has been to provide solutions to the problems regarding water sources. Considerable financial resources investments have been made to provide solutions to the problems of water scarcity and sanitation, and comprehensive policies have been developed to address several challenges. Investment in irrigation projects have increased in the country; however, there are substantial challenges that must be faced, which are set out in the Patriotic Agenda 2025, the Economic and Social Development Plan (PDES) and the sectoral plans at the national and subnational level.

The project is specifically tailored to address and overcome institutional and local barriers that inhibit resilience-building by vulnerable populations with respect to climate change. At the local level, these barriers are largely socio-economic in nature rather than technical, reflecting issues related to farmers' agricultural practices, available financial resources, and coordination. An adaptation barrier analysis was conducted, which outlines the identified barriers and the project's approach to address them.

For the selection process of the intervention areas of RECEM-Valles and the beneficiaries of the project, a multi-criteria analysis was conducted in which environmental, geographical distribution and socioeconomic criteria of the population were applied. The project will focus on the areas of highest socioeconomic and environmental vulnerability, identified through the application of variables of direct relevance to vulnerability and the potential for achieving adaptation and mitigation benefits.

Within the framework of the climate change adaptation approach, the project was designed with 4 interrelated Components that seek to achieve climate change resilient productive systems which are compatible with the conservation of ecosystems and environmental functions and which the local population and authorities can manage themselves:

- Component 1. Strengthened food and income security in changing climate through climate resilient agricultural systems
- Component 2: Smallholder water resources secured to reduce the risks from droughts and low rainfall
- Component 3: Restored and conserved micro-watersheds and ecosystem functions and services
- Component 4: Enabling conditions created to implement and upscale climate-resilient agroecological management, climate-informed integral micro-watershed management, and access to financial mechanisms

For each of the Components of the project, results and goals are proposed. Based on the expected results and the proposed goals, a series of activities were proposed and agreed with stakeholders, that respond to the different needs that small farmers have, to face the adverse effects of climate change on productivity, crop yields, and on environmental functions that provide environmental services to local populations, etc. The proposed activities also consider the region's socio-economic and ecological characteristics and particularly the vulnerability of agricultural production to climate change.

The governance mechanisms for project execution, coordination and oversight have been agreed in close consultation with the Ministry of Environment and Water (MMAyA), the Ministry of Rural Development and Lands (MDRyT), the Ministry of Development Planning (MDP, GCF NDA), the Federation of Associations of Municipalities (FAM), and the National Fund for Forest Development (FONABOSQUE). FAO will be the sole Executing Entity for the GCF funds. The Government of Bolivia, acting through MMAyA, and the FAM will be responsible for the implementation of activities funded from their co-financing resources.

Introduction

The project activities will target peasant and indigenous communities and small-scale agricultural and livestock producers from the Bolivian Valles Macro-region (PDES 2020-2025)[3]. This region covers several ecoregions in the center and south of the country, i.e. from the Yungas in the departments of La Paz and Cochabamba, the Inter-Andean Dry Valleys in Santa Cruz, the highlands in Potosí and Tarija, to the Tucuman-Bolivian Forests in Chuquisaca and Tarija. The biogeographical and climate conditions in this Macro-region are highly varied. It comprises 111 municipalities and covers an area of approximately 13,107,900 hectares. The project has identified 65 municipalities with high and very high vulnerability, which will be the focus on its interventions.

In view of the high prevalence of poverty (approximately 63% of the population is poor), the Valles Macro-region is considered the most vulnerable area within the national territory. The people currently living in poverty are mainly concentrated in rural areas, where 56% of the inhabitants work in agriculture, livestock and fishery, relying on the availability of natural resources (water, soil, biodiversity), the environmental functions of the life zones and favorable weather conditions for their survival. Among the main agricultural crops are wheat, potatoes, corn, peas and broad beans, which cover a total area of 379,134.54 hectares. Furthermore, other agricultural products that are becoming increasingly relevant for small growers in this region of Bolivia should be highlighted because of the economic benefits they bring and in view of the increasing local, regional and national demand. This is the case of fruits such as peach, apple, grapes; vegetables such as garlic and onions, and others for which the demand is going up, such as honey and its derivatives. Nonetheless, increasing the production of these products requires specialized technical assistance. With regard to livestock, the peasant and indigenous communities living in the Valles Macro-region have an important cattle herd with a livestock-driven economy based on sheep, goats, cattle and llamas, in that order. This family animal husbandry is important for food security, but also for trading in urban centers. The predominant livestock model in the region is extensive (extensive grazing).

Considering the socio-economic and environmental characteristics of the Valles Macro-region, the possibility of losing natural and food resources may further worsen the socio-economic situation and the people currently at the poverty line (24.5%) may fall below that threshold and into poverty. Clearly, the moderate poor could also fall into destitution if climate change seriously affects their fundamental sources for producing and reproducing their living conditions.

Vulnerability may increase with the effects of climate change. Studies conducted for the Valles Macro-region point to significant changes in temperature and rainfall that will undoubtedly give rise to losses of production systems and therefore greater poverty and food insecurity. In order to address this problem, a climate change adaptation project is proposed, with resilience to climate change as the strategic line of action.

The project will be executed over a five-year period and its central objective is to *"enhance the resilience to climate change of communities and small farmers in the* Valles Macro-region*, through capacity building and the development of best agricultural practices to increase the productivity and sustainability of their agroecosystems, aimed at adapting to the increasing variability of temperatures and rainfall."*

[3] PDES: Economic and Social Development Plan of the Plurinational State of Bolivia

To this effect, the communities and small-scale farmers will apply climate-resilient agricultural practices, based on the revitalization and expanded coverage of efficient irrigation systems, which will be complemented by comprehensive and sustainable water, soil and biomass management activities with the objective of optimizing water recharge and supply cycles, reducing erosion and risks, and minimizing agricultural disasters. The project will include activities to strengthen the decision-making capacities of local institutions, especially targeting women, and to enhance the capacity of women and youth to produce and market value-added agricultural products.

This feasibility study begins with the social, environmental, and economic context, including a description of the ecosystems in the project area and the agricultural sector. The next section is the climate change profile, which includes historical climate trends and future climate change projections, and climate vulnerability and impacts in the Valles Macro-region and project intervention area. The following section describes the policy and institutional context, including the institutional framework, other projects and programmes, and investments from the Bolivian government. The feasibility study continues with the project description, including the objective and duration of the project, the adaptation barrier analysis, the project location and beneficiaries, the project structure, and the investment rationale. The feasibility study concludes with the implementation arrangements and risks of the project.

1. Social, environmental and economic context

The assessment of the state of the environment in the Valles Macro-region, as presented in the Valles Macro-region Integrated Development Study (ADEMAF, 2016), shows that local natural resources are under great pressure in rural areas. For example, while forests still cover 38% of the area of the Valles Macro-region, they are not sustainable managed. In the east of the Valles Macro-region there are large tracts of forests, mainly in the Yungas and Tucumano-Boliviano forests, that are in protected areas but constantly under threat from human activities. In the rest of the Macro-region, Andean forests are isolated patches in a mosaic of grassland and shrublands characteristic of the Andean puna. There is also pressure from farming families who hunt wildlife and expand agricultural lands into natural ecosystems. Human settlements spring up haphazardly in sectors where there are government lands. Unsustainable agriculture practices (such as felling, slashing and burning; overusing pesticides; using restricted or banned pesticides; clearing headwaters of watersheds and ecological easements; taking livestock to graze on water recharge areas, etc.) have great impact on the biodiversity, soils and water in the region. In the west of the Macro-region, there is mining activity, mainly by mining cooperatives, which are rarely monitored and contribute significant levels of pollution and environmental damage. The level of pollution by mining activities of water sources used for human consumption and irrigation in this region is of great concern, and even more so because water is scarce. Compounding this situation is the environmental pressure brought to bear by the main urban cities (capital and intermediate) of the departments of Santa Cruz, Cochabamba, Chuquisaca, Tarija and Potosí that demand natural resources, mainly water for human consumption, and food, and pollute water bodies with waste and sewage disposal. The incursion of urban areas into surrounding rural areas, as is the case of the cities of Tarija and Cochabamba, puts a great strain on forest areas, and the aquifer recharge areas used not only for water for human consumption but also for irrigation.

The RECEM-Valles project seeks to reduce the pressure to land use changes that negatively impact on the ecosystems and find alternative farming activities that are compatible with forest and vegetation cover conservation by, for example, implementing Agroforestry Systems (AFSs). Using water efficiently will be encouraged through irrigation modernization. Conserving soils and water will be done by changing traditional farming over to organic farming and conservation farming, using organic and inorganic resources that have a low impact on the environment. One key Component of this project is to protect water sources (headwaters of basins and water recharge zones) through the conservation and restoration of degraded soils, and therefore will restore ecosystems. Therefore, the inventory of water sources and water recharge zones, and the environmental monitoring of them will provide valuable information for decision making by governments and farmers.

With regards to evaluating the farming systems, the production sustainability conditions are currently rather low in the Valles Macro-region (ADEMAF, 2016). This means that the farming systems are not using resources such as water, soil, and agricultural inputs (fertilizers, pesticides, manure, etc.) or new technologies that complement traditional farming methods efficiently. Large areas of the Macro-region still use ancestral farming methods that often, because of the effects of climate change (prolonged drought, frequent frost and hail, changes in rainfall patterns, rising local temperatures, etc.), and a shortage of natural resources like water, are not the most efficient and therefore do not yield as much as expected and/or crops or lost. Overall, the region is highly dependent on low-yield agriculture and therefore a high degree of food insecurity. The vulnerability of water resources and agricultural production to the effects of climate change is high; recent studies predict that the farming and livestock sectors will be the most affected as they face losses of 6 – 14% of the sectors' GDP. This scenario will also bring limited productivity and weak yields affecting a series of basic crops will result in only 17% of the demand for food being satisfied. Therefore, the smallholder farmers are a highly vulnerable group as their crop yields are already very low – the average potato yield is 5.7 t/ha, the lowest in the Andean region, whereas the average corn yield is only 2.2 t/ha. Currently, 161,982 hectares in the Valles Macro-region have irrigation systems, while another 86,740 hectares are dry-farmed. On the other hand, 40% of the irrigation systems around the country are subject to great variations in rainfall and there is no training on how to use water efficiently, which would guarantee continual access to this vital resource, and reduce the vulnerability of the smallholder farmers.

Currently, irrigation systems are implemented using the participatory "top-down" planning approach, complemented with technical assistance to maintain the systems and practical support for the smallholder farmers to level up their capacities to adapt effectively to changes in rainfall patterns. Nevertheless, the centralized administration of community irrigation systems in an area as vast as the Valles Macro-region is inefficient, slows down the producers' decisions and takes responsibility away from them, which then has a knock-on effect on local actors' capacity to administer and adapt their irrigation systems to climate change in a timely and strategic fashion.

Another point that should be mentioned is that the flow of communication between the primary and the transformation sector is fractured (even though the Macro-region is home to many food manufacturing companies) (ADEMAF, 2016). Many producers, mainly fruit and vegetable farmers, have problems selling their produce. The lack of specific markets for their produce and low prices when there is excess supply are reasons why they waste produce.

The project proposes a series of activities that will support local producers and government authorities to face the current problems affecting the farming systems, and how farming produce is produced and commercialized. To tackle the adverse effects of climate change which, year in year out, lead to losses and the ensuing economic effects on the families, technologies, such as greenhouses, anti-hail netting, hydrogels, thermal mesh, etc. will be used to counteract frost, drought and hail. The irrigation systems will be upgraded to ensure that water is used efficiently given that around 90% of irrigation in the Macro-region is currently flood or gravity-fed, which is not very efficient as this region is prone to water shortages and droughts. Plans also include supporting developing infrastructure and equipment to store water; reservoirs and water tanks that enable water to be captured during the rainy season to be used during dry periods. Training sessions and training local technicians will accompany installing these technologies so that local producers and technicians can take over the new technology.

Regarding transforming and commercializing production, the project aims to support producers participating in markets tailored for their produce, open new markets to ensure that produce is sold, collected, refrigerated, and transformed. These activities will help reduce wastage (rotting) and increase family income by adding value to their produce through transformation. The need for the families to diversify their production should be mentioned as the effects of climate change, the shortage of resources like water, and the changes in consumer trends are drivers behind this need. Therefore, the project will identify high-value products and support initiatives, such as honey, that are currently in demand at the local and national level.

The social assessment of the Valles Macro-region shows that as well as the population being very culturally diverse, it is particularly vulnerable to climate change because of the underlying poverty. The annual income per capita is Bs. 648 ($US 93.96) with 63% of the population living in moderate poverty and 21% in extreme poverty. Regarding access to basic services, there is a real lack with many rural communities still without decent housing. Likewise, there are few opportunities for young people in rural areas to access technical training, and the high rates of migration to the cities dampen the impact of training programmes. A detailed baseline assessment of farmers' socio-ecological situation has been developed (Appendix 5). That assessment examines the specific challenges, opportunities, resources and constraints facing each discrete community and zone in the proposed intervention area: Los Valles Cruceños, Los Chichas, Gran Centro Potosí, Norte de Potosí, Chuquisaca Centro, Chuquisaca Norte, Los Cintis, Héroes de la Independencia, Cono Sur, Valle Alto, Zona Andina. While the specific mix of crops, agroecological challenges, organizational capacity, and existing infrastructure varies from one community / zone to another, the analysis finds consistent challenges related to the availability and quality of water resources.

The financial system in Bolivia is made up of EIFs (Financial Intermediation Entities), complementary financial services companies, stock market participants and insurance entities. Within all the EIFs, there are the DFIs (Development Financial Institutions), which are characterized by incorporating aspects related to climate change in their credit technology (individual and group) for small and medium-sized agricultural producers.

Bolivia, for the preservation of the stability and efficiency of the financial system, has the Financial Stability Council chaired by the MEF (Ministry of Economy and Public Finance), the MPD (Ministry of Development Planning, of the BCB (Central Bank of Bolivia) , the ASFI (Supervision Authority of the Financial System) and the Supervision and Control Authority of Pensions and Insurance, who through DS (Supreme Decrees) can implement different actions related to the financial market.

The Law 393 (Financial Services) is the framework standard and regulates financial intermediation activities and the provision of financial services, as well as the organization and operation of EIFs, the protection of financial consumers and the definition of ASFI as a regulatory entity of the Bolivian financial market. There are three SDs that are specifically related to the agro-financial market:

• Supreme Decree No. 1842 (year 2013), which establishes the system of active interest rates and the minimum levels of credit portfolio for loans destined to the productive sector.

• Supreme Decree No. 2055 (year 2014), establishes the annual interest rates for productive loans according to the size of the productive unit: micro (11.5%), small (7%) and medium and large (6%).

• Supreme Decree No. 4409 (year 2020), establishes that all EIFs carry out the refinancing and/or rescheduling of credit operations, whose installments were deferred (as an exceptional emergency measure due to the COVID-19 pandemic).

From the side of the EIFs, the panorama is not so favorable since the profits of the EIFs were reduced, especially of the DFIs that work with the small agricultural producers of the Macro Region of the Valleys.

FINRURAL data on the ROE (Return on equity) and the ROA (return on each of the assets) of DFIs show a positive historical trend but with a downward trend, especially since the application of the aforementioned Supreme Decrees. The 2013 ROA went from 2.77% to 0.32% in 2021; while the ROE went from 11.86% in 2013 to 2.12% in 2021. IMPRO and FONDECO are two of the 9 IFDs, which have fewer clients and portfolio in 2022 compared to 2012; and they decided to promote productive technology but for the peri-urban area.

In this sense, IFD has a challenge to maintain its equity situation and profits in positive amounts and continue providing care to small producers in productive agricultural sectors. To maintain their profits, several DFIs adopted productive group credit (Communal Banking) as an option that allows them to grow in number of clients.

Additionally, it can be seen that there are no explicit regulations that promote, in the EIF, the development of products for small agricultural producers under the approach of adaptation or mitigation of the effects of climate change, taking into account international treaties and standards as well as regulatory frameworks. in the context of climate change.

It is important to take into account that the DFIs are promoting greater Productive Communal Banking technology that, although it has interest rates of 33%, its advantages are, on the one hand, that its requirements for access to group credit require that the group that forms the Bank Communal guarantee each other, and on the other hand, it is a loan that is approved in less than 15 days and allows the members of the group to generate a culture of credit since it is complemented with strong training so that their level of arrears is minimum.

On the other hand, although individual productive credits are regulated, their access requirements are not so easy for clients to meet, there is also the fact that the credit is approved on average a month after a small agricultural producer requested it. Sembrar Sartawi, is an IFD that has extensive experience in agricultural microcredit for small producers and to mitigate the effects of climate change, it implements agricultural insurance that interrelates financial risks with the vulnerability to which its clients are exposed.

The financial intermediation entities that work with small producers, in the Valles macro region, are the Development Finance Institutions (DFIs), which by 2022 show that 33% of their agencies and points of attention directly serving small agricultural producer. On the demand side, the agrifnance market study indicates that, in rural areas, the main destinations of microcredit are for: agriculture and livestock (42%), followed by financial intermediation (since 2018) and others in third place with an average of 15% per year.

As noted in the market analysis, Bolivia's financial sector contains multiple categories of financial intermediary. These include:

- Multiple Banks such as Banco Nacional de Bolivia S.A, Banco Mercantil Santa Cruz S.A., Banco Bisa S.A., Banco de Crédito de Bolivia S.A., Banco Económico S.A., Banco Ganadero S.A., Banco Solidario S.A., Banco de la Nación Argentina, Banco para el Fomento a Iniciativas Económicas S.A., Banco Fortaleza S.A., Banco Prodem S.A., Banco Fassil S.A.
- SME Banks such as Banco PYME de la Comunidad S.A., Banco PYME Ecofuturo S.A.
- Majority state-owned financial entities such as Banco de Desarrollo Productivo S.A.M., Banco Unión S.A.

- Entidades Financieros de Vivienda (EFV), which specialize in housing loans
- Open Savings and Credit Cooperatives (CAC), which provide financial services to their members and the general public
- Non-profit Development Finance Instutions (DFIs), which have an explicitly social and sustainable development focus, and
- Complementary financial service providers such as leasing companies, clearing and settlement houses, mobile payment service companies, money transfer and remittance companies, and exchange houses.

The project proposes involving women and youth in the majority of the training activities and focuses on implementing modern technologies and changes in the farming systems to deal with climate change and increase the families' incomes.

2. Environmental features

Ecoregions and ecosystems. According to the classification of Bolivian ecoregions, the project intervention area includes 9 ecological regions. The largest ecoregions are the northern puna and the inter-Andean dry forests, which cover 35% and 32% of the territory respectively, while the Gran Chaco and the south-west Amazon only cover 1.5% of the project area. The Yungas forest and Tucumano-Boliviano forest cover 18% of the project areas.

Table 1 Ecoregions and sub-ecoregions in the project intervention areas

Ecoregion	Sub-ecoregions	Area in km^2	%
Northern puna	Semi-humid Puna	28,785	35
Inter-Andean dry forests	Inter-Andean Dry Forests	25,800	32
Tucumano-Boliviano forest	Tucumano-Boliviano Forest	10,522	13
Prepuna	Prepuna	6,819	8
Yungas	Yungas	4,332	5
Chaco Serrano	Chaco Serrano	2,983	4
Southern puna	Desert Puna below the snowline of the Western Cordillera	1,331	2
South-west Amazon	Sub-Andean Amazonian Forests	907	1
Gran Chaco	Gran Chaco	354	0.4

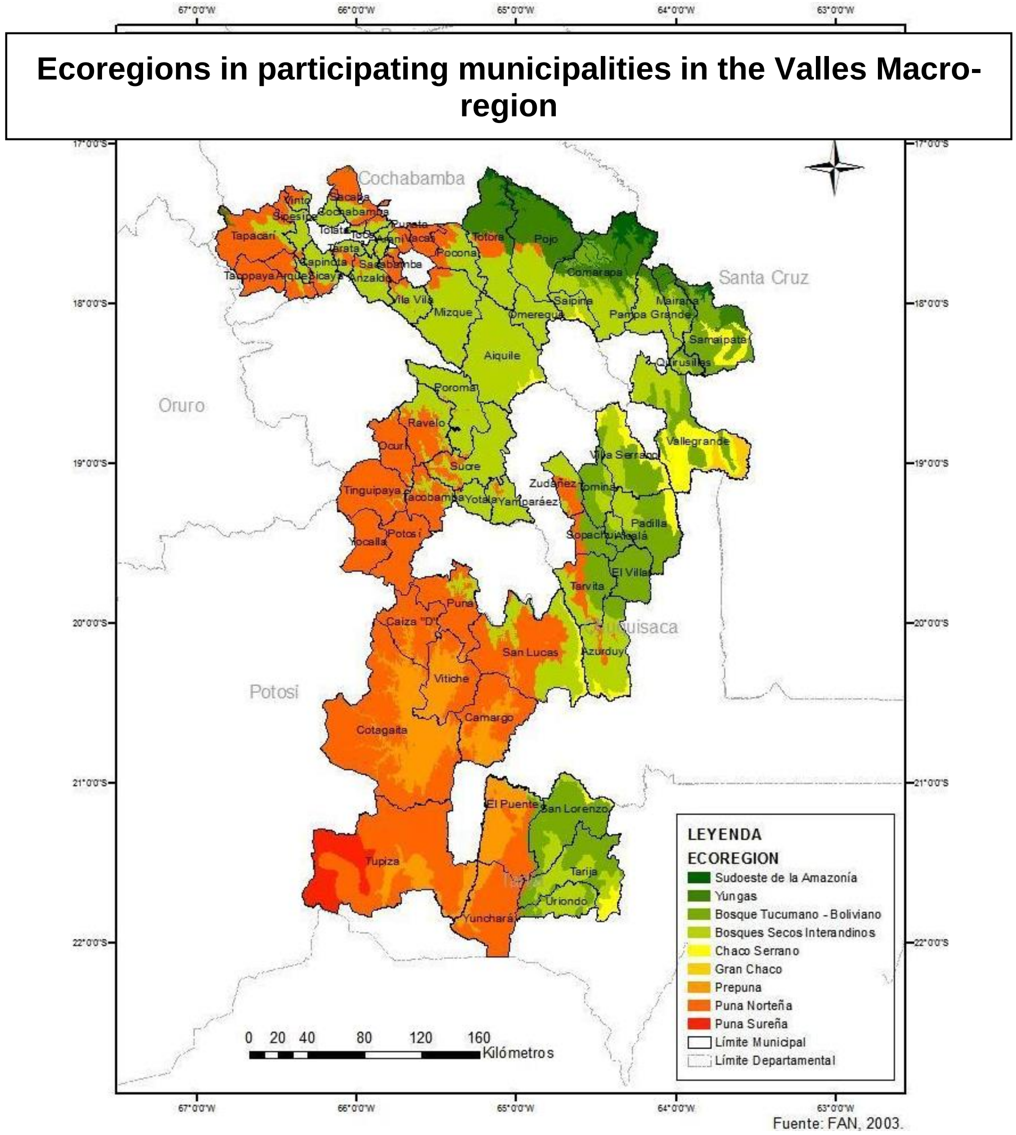

Figure 1 Ecoregions in the Valles Macro-region

Puna (Northern puna, Southern puna, Prepuna)[4]*:*

This ecoregion is a high-elevation montane grassland with an altitudinal range between 3200 and 6600 m above sea level, where open meadows are dotted with herbs, bunchgrass, moss, lichens, and rock. It contains typical mountain features: snow-capped peaks, mountain pastures, and high lakes, valleys, and plateaus. The puna rests on volcanic formations created after the Andes were formed around 6 to 8 million years ago, with sedimentary and metamorphic rocks and volcanic soils. The vegetation is mainly grasslands composed of different grasses, but mainly from *Calamagrostis*, *Agrostis* and *Festuca* genera. Shrubs from the *Margyricarpus* and *Parasthrephia* genera are present, as are *Puya Raimondi*, which is the largest bromeliad species in the world. There are also montane forest relics like tree species in the *Buddleia*, *Escallonia*, and *Polylepis* genera. There are some wet grassland formations including peat bogs, reed beds, and bofedales. The endemic plant species in this ecosystem include supu-tola (*Diplostephium tovari*) and mullu-mullu (*Ribes brachybotrys*). Many of the plants have interesting

[4] https://www.worldwildlife.org/ecoregions/nt1002

adaptations to the high-altitude climate, including stunted and very slow growth, high resin content. The fauna also have adaptations like fur and plumage that help tolerate low temperatures and strong winds, and strong incisors to feed on the tough flora strengthened with silicon content. The most abundant fauna include vicuña (*Vicugna vicugna*), guanaco (*Lama guanicoe*), chinchilla (*Chinchilla brevicaudata*) and vizcacha (*Lagidium* sp.), and endemic species include the suri (*Pterocnemia pennata*) and the rodent *Punomys lemminus*. Threatened bird species include *Cinclodes aricomae*, *Conirostrum tamarugense*, flamenco de James (*Phoenicopterus jamesi*), and gallareta gigante (*Fulica gigantea*). The puna faces threats from increasing mining activity leading to the removal of scarce plant cover and the contamination of soil and water, as well as from expanding population centres and highways, which place growing pressures on the local fauna.

Inter-Andean Dry Forests[5]*:*

This ecoregion has been given critical/endangered status by the World Wildlife Fund. These dry broadleaf forests occur at an altitude range of 350 – 700 m above sea level and act as a dry transition between the highland Puna and the lowland Yunga zones. Much of this habitat has already been seriously altered by human activities, but the original forest contained spiny tree species such as *Acacia caven*, *Prosopis aplataco*, and *Dodonea viscosa*, with some regions including species such as *Schinopsis haenckeana* and *Aspidosperma quebracho colorado*. Dense chapparal thickets also contained species from genera such as *Acacia*, *Proustia* and *Kentrothamnus*. The fauna includes a high diversity of felids, including Puma (*Felis concolor*), Ocelot (*F. pardalis*), Pampas Cat (*F. colocolo*), Geoffroy's Cat (*F. geoffroyi*) and Jaguarundi (*Herpailurus yagouaroundi*). There are a number of rare and endemic bird species, including the Bolivian Recurvebill (*Simoxenops striatus*), Bolivian Blackbird (*Oreopsar bolivianus*), Torrent Duck (*Merganetta armatta*), Wedge-tailed Hillstar (*Oreotrochilus adela*), Black-hooded Sunbeam (*Aglaeactis pamela*), Carbonated Flower-piercer (*Diglossa carboniaria*) and a number of finches including Citron-headed Yellow Finch (*Sicalis luteocephala*) and Warbling Finches (*Poospiza garleppi* and *P. boliviana*).

Yunga and Tucumano-boliviano forests[6]*:*

These tropical and subtropical moist broadleaf forests form a transition between the highland Puna habitat and lowland Amazon forest. Habitats in these forests range from lowland forest to cloud forest and montane forest, and this transitional position along with complex topography has resulted in high levels of biodiversity and endemism. The region has roughly 35 range-restricted species and endemics including the green-capped tanager (*Tangara meyerdeschauenseei*) and diademed tapaculo (*Scytalopus schulenbergi*). Although birds and plants represent the most endemic species, there are also endemic mammals such as brocket deer (*Mazama chunyi*). And while the region has many montane endemics, it has lowland species such as jaguar (*Panthera onca*) and tapir (*Tapirus terrestris*). This ecoregion is threatened because it is easier for local farmers to burn this type of forest than true montane forest for growing cash crops. Forest clearance in the area to cultivate crops has already endangered over 70 species of birds, and certain game species are threatened by the wild bird trade and by hunting.

Chaco (Chaco Serrano, Gran Chaco) [7]*:*

The Guarani Indians initially named the region "Gran Chaco" for its productive hunting grounds. Today there are still many large game mammals in the northern Chaco, but not in the southern part of the region

[5] https://www.worldwildlife.org/ecoregions/nt0206
[6] https://www.worldwildlife.org/ecoregions/nt0105
[7] https://www.worldwildlife.org/ecoregions/nt0210

where rapid population growth and overgrazing have demonstrated unsustainable use of the ecoregion's resources. The ecoregion is made up of several habitats, though it is predominantly comprised of savanna, thorn forest, or a transition between these two. The savanna and grassland are characterised by an abundance of grasses, whereas the thorn forest is characterised by cacti, shrubs, thorny bushes (like *Prosopis* species) and scattered trees like *Aspidosperma quebracho*, *Bulnesia sarmientii* and *Schinopsis* species. This ecoregion has only recently been explored more adequately, so there have been discoveries of new species in recent studies, even including large vertebrates like the Chacoan Peccary (*Catagonus wagneri*) which was discovered as recently as the 1970s. There are also a number of endemic birds like the giant tuco-tuco (*Ctenomys conoveri*), amphibians like the horned frog (*Ceratophrys sp*.), and reptiles like the southern boa (*Boa constrictor occidentalis*).

Southwest Amazon[8]*:*

This ecoregion located in the Upper Amazon Basin, is characterized by a relatively flat landscape with alluvial plains dissected by undulating hills or high terraces. The elevation ranges from 100 to 200 m above sea level. The biota of the southwest Amazon moist forest is very rich because of the edaphic and topographical variations at both local and regional levels. This greater ecoregion has the highest number of both mammals and birds recorded for the Amazonian biogeographic realm: 257 with 11 endemics for mammals and 782 and 17 endemics for birds. Large areas appear to be structurally homogeneous with dense canopies 35 m high with some emergent trees up to 40 m; however, in terms of species, the canopy is very heterogeneous, with up to 300 tree species found in a single hectare of forest. The largest trees in the Bolivian Amazon are *Calycophyllum spruceanum*, *Ceiba pentandra*, *Dipteryx odorata*, *Poulsenia armata*, and *Swietenia macrophylla*. Lianas are common, with over forty species present. Much of the natural habitat of this region remains intact, protected by sheer inaccessibility, but some of this habitat is threatened by the expansion of the agricultural and pastoral frontier, as well as mining and selective logging activities.

Forests. Roughly, half of Bolivia is covered by forests, and about half of the remaining forests are primary forests. There are significant pressures on these forests, which are increasing with time. In the late 1980s, the country had a low deforestation rate—about 0.2 percent annually—due to several factors including the poverty and weak export market of the country. However, during the 1990s, Bolivia's deforestation rate more than doubled to over 270,000 hectares per year. The government granted some 20 million hectares to timber companies, while large swaths of forest were cleared for soybean and coca cultivation. Though the government passed laws requiring the logging industry to replant forests to ensure sustainability, loopholes made it possible for many logging companies to bypass the requirement. Further, illegal logging operations smuggled timber into Brazil where it was exported as Brazilian wood[9]. Nearly 10% of the country's forests have been felled over the past 30 years (Figure 2). Deforestation has now stabilized but at a high rate, with approximately 200,000 ha of forest still being lost each year[10].

[8] https://www.worldwildlife.org/ecoregions/nt0166
[9] https://rainforests.mongabay.com/20bolivia.htm
[10] https://www.cifor.org/publications/pdf_files/OccPapers/OP-108.pdf

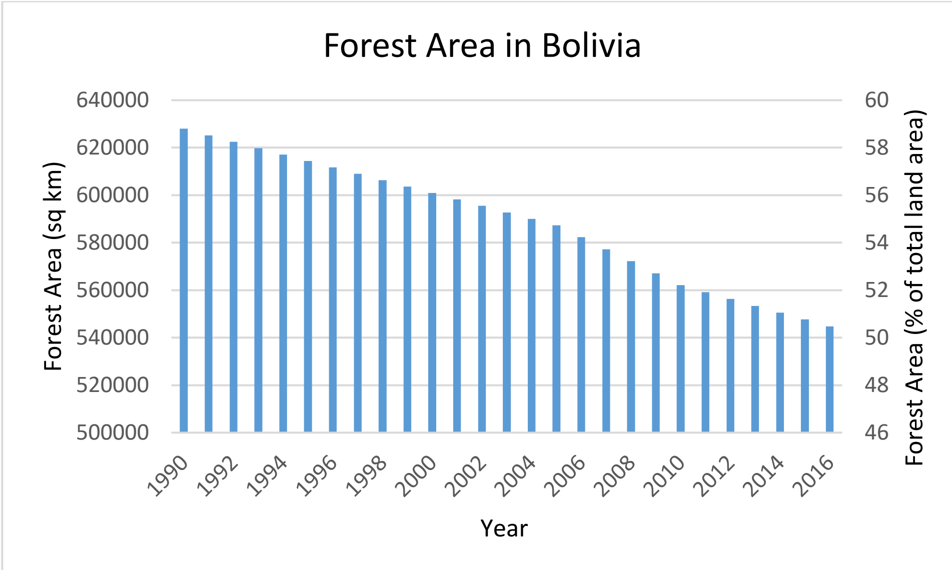

Figure 2 Forest area in Bolivia: 1990 – 2016 (Source: FAO)

The three main drivers of deforestation are mechanized agriculture, cattle ranching, and small-scale agriculture. Converting forest to pasture for grazing land caused more than half of Bolivia's deforestation in 2000–2010. Mechanized agriculture, mostly for soybean production for exportation, has been responsible for about 30% of deforestation, while small-scale agriculture has accounted for roughly 20%. Underlying drivers of deforestation include greater integration of the agricultural economy in international markets, increased international investment in forest products, increased demand in the domestic market due to the increased urban population growth, road expansion, and institutional weaknesses[11].

There is a clear link between the forests of Bolivia and climate change. Besides helping to mitigate climate change, the forests are an important asset for climate adaptation. The vulnerability of communities living in and around Bolivia's forests, particularly the indigenous communities, are affected by the availability and quality of foods, forest products (both edible and non-edible), as well as ecosystem services like water filtration and regulation[12]. An estimated 40% of the population of Bolivia includes forest resources in their livelihoods[13], so the clearing and degradation of forests will impact the economic vulnerability of Bolivian communities.

Within the project area, there are six types of forests represented (Ta), covering an area of 3,186,189 ha (Geo-Bolivia, 2016), which is equivalent to 38% of the project area. The Yungas forests and Tucumano-Boliviano forest are the most common types of forest in the project area. Deforestation within the Valles Macro-region has been estimated at 3,000 hectares a year (Fundación Amigos de la Naturaleza, 2018).

Table 2 Forests in the project areas

Type of forest	Area [ha]	Location
Andean Forest	47	Chuquisaca
	2,048	Cochabamba

[11] https://www.cifor.org/publications/pdf_files/OccPapers/OP-108.pdf
[12] http://euroclimaplus.org/intranet/_documentos/repositorio/Estrategia%20Nacional%20Bosque%20y%20Cambio%20Clim%C3%A1tico_2009.pdf
[13] https://www.researchgate.net/publication/277198222_Environment_and_Climate_Change_in_Bolivia_-_Challenges_and_Opportunities_for_Development

	234	Potosí
	35	Tarija
Amazonian Forest	16	Santa Cruz
Chaco Forests	31,179	Santa Cruz
Yungas Forest	525,168	Cochabamba
	731,305	Santa Cruz
Inter-Andean Dry Forests	38,110	Chuquisaca
	4,773	Cochabamba
	325	Potosí
	600,140	Santa Cruz
	20,250	Tarija
Tucumano-Boliviano Forest	447,011	Chuquisaca
	755,624	Santa Cruz
	29,926	Tarija
Total Area	**3,186,189**	

Source: (Ministry of the Environment and Water, 2017)

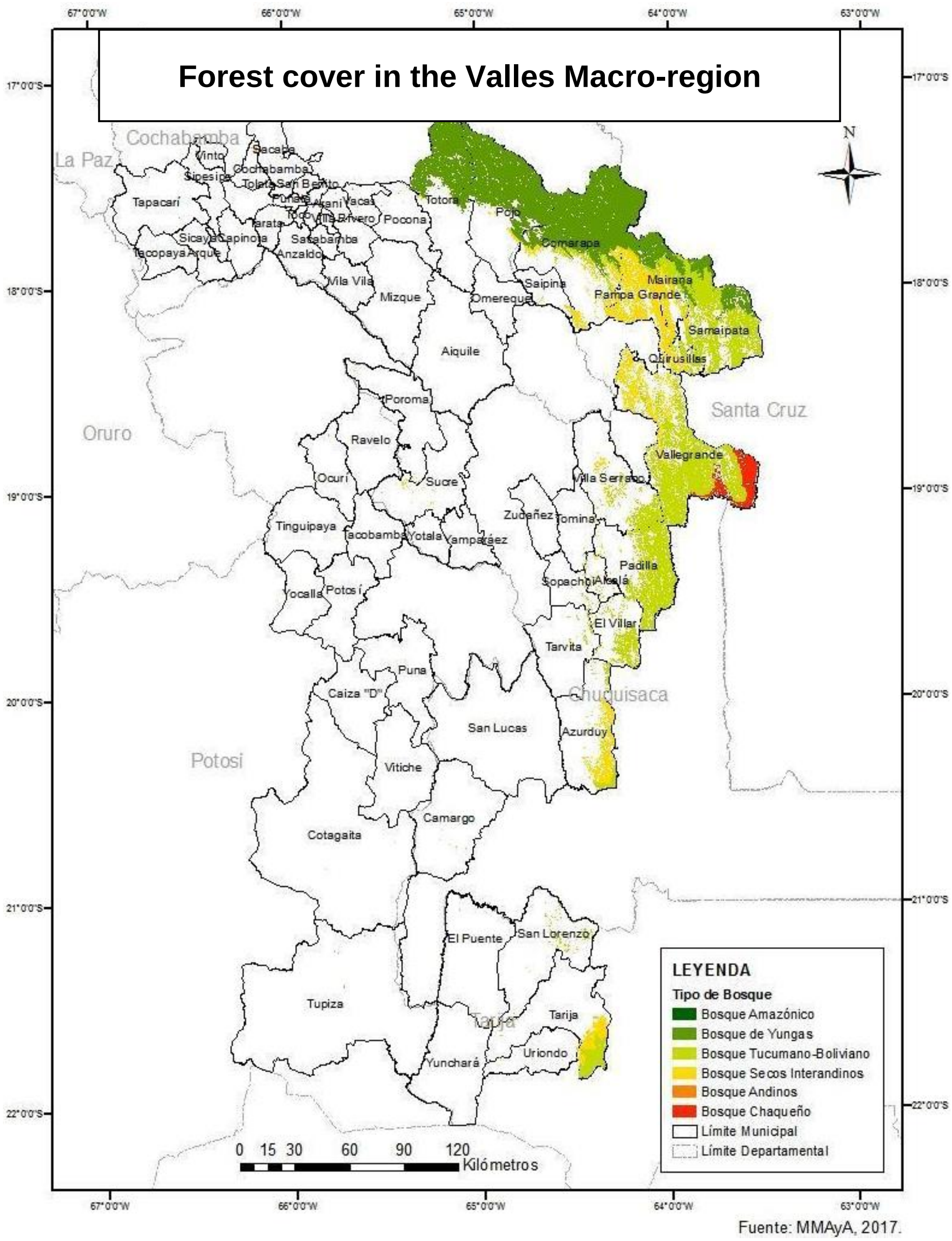

Figure 3 Types of forest in the Valles Macro-region

Wetlands. Wetlands are an important habitat, perhaps especially in the highland Puna grasslands of the project area. There is an estimated 7,725 ha of wetlands in the project intervention area, located in the municipalities of Arani, Sacaba, Vinto and Vacas in the Department of Cochabamba, and in the municipalities of Tupiza and Tinquipaya in the Department of Potosí. The municipalities with the most wetland area in the project area are Vacas and Tupiza.

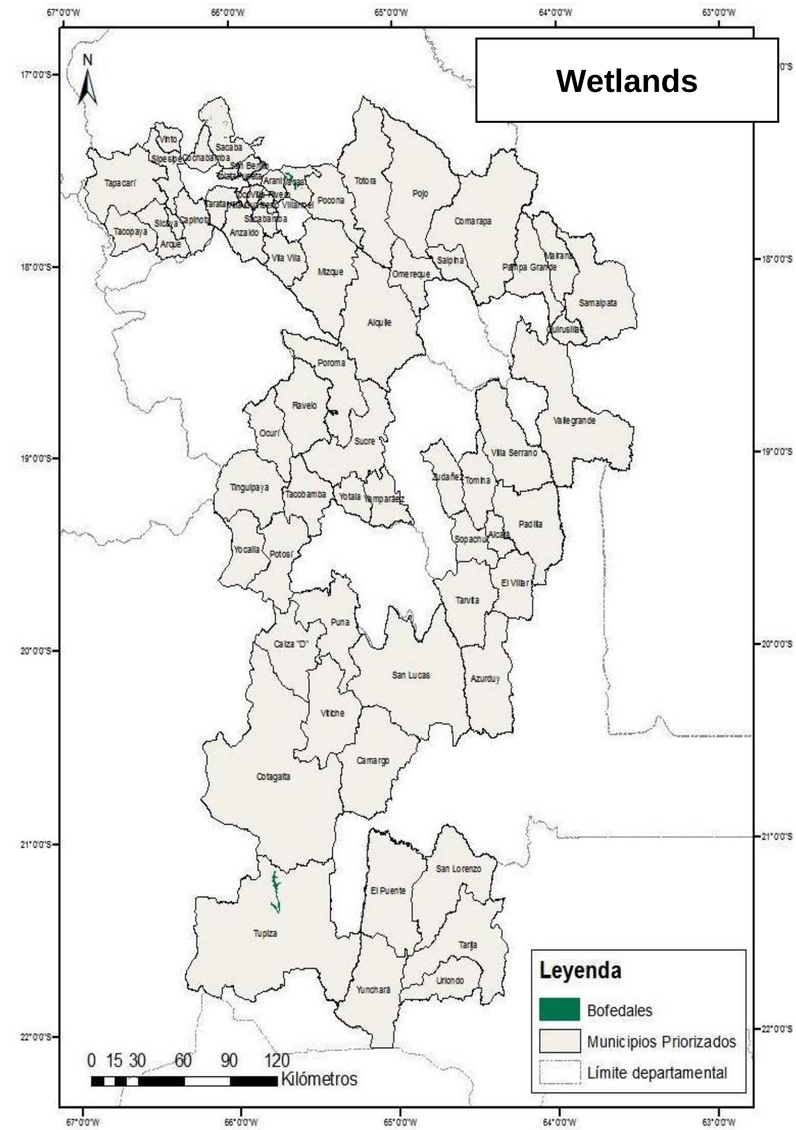

Figure 4 Wetlands

Land degradation. Bolivian soils, both in the highlands and the lowlands, have little depth and are fragile and easily eroded, meaning there are large amounts of land susceptible to degradation[14]. According to the FAO, between 1954 and 1996, the area of eroded soils increased by 86%, from about 24 to 43 million hectares[15]. While the rate of soil erosion has slowed since then, soil erosion rates from 2001 to 2012 were still among the highest in the world, at 37.8%[16]. This widespread erosion affects 45% of the country and up to 70-90% of the land in the valleys of the country[17]. The inequities with regard to land tenure and ownership in Bolivia not only generate social conflict but also play a key role in land degradation. In the highlands, where small and very small farms dominate, the land keeps being divided into extremely small plots. The increasing land pressure forces the peasants to overexploit soil and vegetation, which in turn increases vulnerability to wind and water erosion. In the lowlands, agriculture is dominated by extensive cattle grazing and cultivation of export crops on large land estates. The rapidly increasing monocultures

[14]https://www.researchgate.net/publication/277198222_Environment_and_Climate_Change_in_Bolivia_-_Challenges_and_Opportunities_for_Development
[15] https://europa.eu/capacity4dev/file/51852/download?token=_X3syhxZ
[16] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5722879/
[17] http://www.fao.org/3/I9016ES/i9016es.pdf

of soybean are highlighted as the main factor of land degradation[18]. The World Bank's estimated costs of environmental degradation are shown in Figure 5.

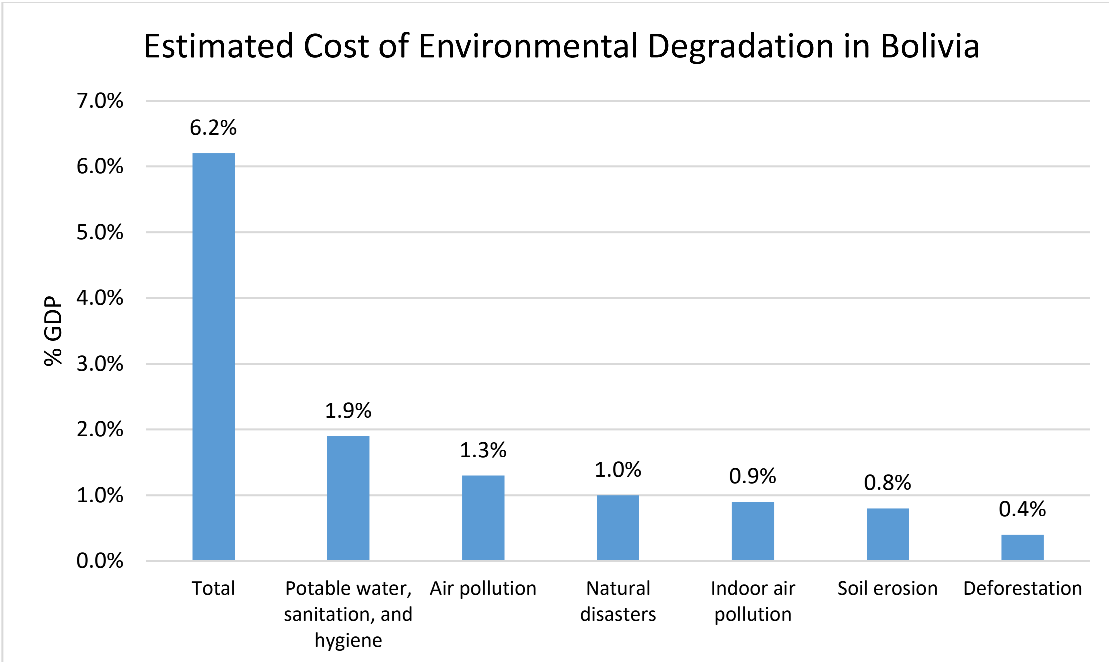

Figure 5 Costs of Environmental Degradation in Bolivia (Source: World Bank)

Erosion degrades land, which means it can support fewer plants that can take in climate-warming carbon dioxide. Not only would erosion lower the potential for soil to mitigate climate change (since soils potentially sequester enough greenhouse gases in a year to equal about 5% of all annual human-made GHG emissions[19]), but it could also increase climate change vulnerability. Likewise, climate change has the potential to worsen erosion. A report from the Intergovernmental Panel on Climate Change (IPCC) found that when cultivated without conservation practices, soil is currently eroding up to 100 times quicker than it being generated. The risk of erosion will become even higher in the future due to emissions-driven temperature changes, with resulting decreases in agricultural production, land value and human health[20]. Research shows that soil degradation in Bolivia has increased over the years and that soils are being destroyed faster than they are being generated, and that these degradation processes are to a large extent triggered by climatic conditions, so climate change could exacerbate the rate of soil degradation[21].

Ecosystem services. The diversity of ecoregions, forests and other vegetation in the Valles Macro-region of Bolivia provides important benefits to the local population. According to the Millennium Ecosystem Assessment,[22] these benefits or ecosystem services may be divided into two types: direct and indirect. Direct benefits relate to the provision of water and food, and the regulation of natural cycles, such as floods, soil degradation, desiccation and salinization, pests and diseases. Indirect services relate

[18] http://www.fao.org/3/I9016ES/i9016es.pdf
[19] https://www.wri.org/blog/2020/01/causes-effects-how-to-prevent-soil-erosion
[20] https://www.wri.org/blog/2020/01/causes-effects-how-to-prevent-soil-erosion
[21] https://edepot.wur.nl/278541
[22] The Millennium Ecosystem Assessment was called for by the United Nations Secretary-General Kofi Annan in 2000. Launched in 2001, its aim was to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems.

to how the ecosystem processes generate the direct services function (supporting), such as photosynthesis and the formation and storage of organic matter, soil formation, cycling nutrients and neutralizing toxic waste. Ecosystems also provide intangible benefits, such as recreational, aesthetic, spiritual and cultural (cultural services). The key environmental functions in the Valles Macro-region that are associated with the forests and wetlands are summarized in Table 3.

Table 3 Ecosystem services

Ecosystem services	Description
PROVISIONING	
Water provision (quantity and quality)	Smaller permanent watercourses, such as streams, springs or brooks. Water sources used to provide drinking water for humans and livestock (cattle, goats, horses, and poultry) and for irrigation.
Availability of natural pasturelands	Natural pastures, scrub and woodlands are areas dedicated to extensive livestock production.
REGULATING	
Water regime regulation	The forests help maintain the quality of the water, influence the amount of water available and regulate the flow of underground and groundwater. They also contribute to reducing risks, such as landslides, floods and drought, desertification, and salinization.
Local climate regulation (temperature regulation)	Vegetation plays an important role in regulating the weather. It acts as a cooling system through evaporation, capturing rainwater, storing, and filtering it, etc. Foliage can regulate the climate with increasing effectiveness as the density increases.
Carbon capture and storage	The forests sequester CO_2 through photosynthesis and store it in their biomass; therefore, reducing forest cover means reducing CO_2 in already existing carbon sinks, and also reduces the capacity to store more carbon.
CULTURAL	
Cultural identity and diversity	Cultural diversity: presence of indigenous peoples and farming communities, maintaining traditions and cultural identity despite outside influences.
SUPPORTING	
Crops and orchards pollination	Pollination increases crop and orchard yields. There are different pollinators in the area – insects, birds, and bats. A drop in the pollinator population would affect crop and orchard yields.

Source: Millennium Ecosystem Assessment

While there are many types of ecosystem services, most Payment for Ecosystem Services (PES) schemes in Bolivia have focused on two: hydrological services and carbon sequestration[23]. Most hydrological ecosystem service schemes have focused on forests in Bolivia, which protect the soils on steep slopes and improve downstream water quality by reducing siltation. They also stabilize the flows in the dry season and reduce peak flows and flooding in the rainy season. One PES scheme in Bolivian forests has found the unintended consequence of the reduced colonization of the forests by landless people; the formal contracts with maps and demarcation required for the scheme have helped institutionalise de facto land-tenure security and raised local ability to resist invasions[24].

Protected areas. In the project area there are 25 Protected Areas (PAs): 6 national, 3 departmental and 16 municipal. These PAs cover a total area of 1,393,417 ha, which is 45% of the total area of the country's

[23] http://www.brucebyersconsulting.com/wp-content/uploads/2011/07/Bolivia-Tropical-Forestry-and-Biodiversity-Assessment-Report-2008.pdf
[24] https://www.cbd.int/financial/pes/bolivia-pes.pdf

PAs, and 17% of the project intervention area. 36 of the 65 municipalities covered by the project have territories classified as PAs. Many of the PAs were set up not only because they are home to biodiversity but also because they are the source of water used for human and animal consumption and irrigation.

All project activities will adhere to current legislation regarding PAs (S.D. 24781 of 1997) and the environment (e.g. Law 300 of 2012; Law 1333 of 1996). In Bolivia, production activities and projects may be carried out inside PAs, including sustainable extraction of natural resources and different forms of non-consumptive use, depending on the details of the management plan for each PA.

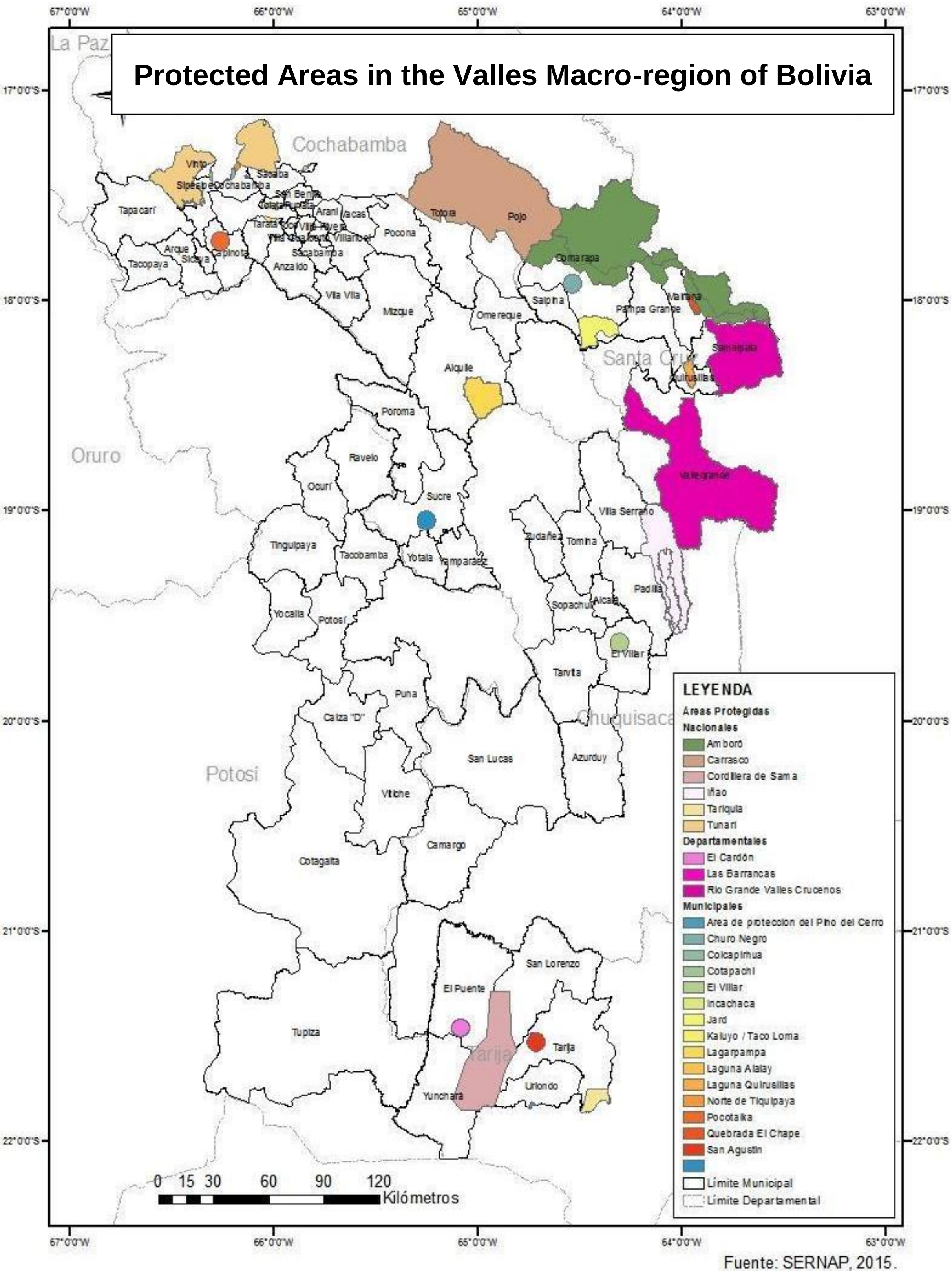

Figure 6 National, departmental and municipal protected areas in the Valles Macro-region

Table 4 Protected Areas in the project intervention area

Name	Category	Area (ha)	Area within project boundaries (ha)
National			
Amboró	Integrated Management Natural Area	160,864	81,512
	National Park	441,311	210,343
Carrasco	National Park	693,992	295,351
Cordillera de Sama	Biological Reserve	107,163	105,431
Iñao	Integrated Management Natural Area	171,192	70,679
	National Park	90,903	20,746
Tariquía	Flora and Fauna National Reserve	247,257	10,640
Tunari	National Park	328,520	100,812
Departmental			
Rio Grande Valles Cruceños	Integrated Management Natural Area	741,748	385,190
El Cardón	Natural Park and Integrated Management Natural Area	6,505	6,505
Las Barrancas	National Park	224	224
Municipal			
-	Landscape Protection Zone	7,322	7,322
Pino de Cerro PA	Wildlife Refuge	4,703	623
Churo Negro	Municipal Protected Area	7,359	7,359
Colcapirhua	Metropolitan Park	7,448	1,306
Cotapachi	Natural Archaeological Monument	7,448	682
El Villar	Forest and Water Reserve	7,304	7,304
Incachaca	Archaeological Park	7,445	519
Jard	Municipal Protected Area	22,260	22,260
Taco Loma /Kaluyo	Integrated Management Natural Area	7,437	2,438
Lagarpampa	Integrated Management Natural Area	29,962	29,962
Laguna Alalay	Environmental Protection Area	214	214
Laguna Quirusillas	Municipal Protected Area	6,098	6,098
Norte de Tiquipaya	Wildlife Reserve	7,449	1,708
Pocotaika	Municipal Protected Area	7,366	7,366
Quebrada El Chape	Municipal Protected Area	3,560	3,560
San Agustín	Flora and Fauna Forest Reserve	7,250	7,250

Biodiversity. Bolivia is very rich in both plant and animal species, and is considered one of the so-called "mega-diverse" countries of the world. Twenty-four new vertebrate species have been recorded since 2014[25], so a significant quantity of biodiversity in the country is as yet unknown to us. Bolivia also possesses a high level of genetic diversity and is a center of origin for domesticated plants and their wild relatives, such as potatoes, which together with Peru holds more than 4,300 native potato varieties. A recent study has shown that trade in products derived from biodiversity increased by 22% in Bolivia between 2010 and 2013, generating over 1.1 million dollars[26]. While there are benefits that come from the level of biodiversity found in Bolivia, including as a means of climate change adaptation, various drivers are causing the level of biodiversity to diminish in the country. Table 5 shows the number of species in Bolivia that have been assessed for the IUCN Red List, so it only begins to describe the levels of biodiversity in the country, as well as the number of threatened species.

[25] https://www.cbd.int/countries/profile/?country=bo
[26] https://www.cbd.int/countries/profile/?country=bo

Table 5 Number of plant and animal species in Bolivia (Source: IUCN)

Amphibians	Birds	Threatened bird species (2018)	Fish	Threatened fish species	Mammals	Threatened mammal species (2018)	Reptiles	Vascular plants	Threatened higher plant species (2018)
256	1438	55	404	8	363	21	315	17367	106

Water basins[27]. The project intervention area is part of three basins in the country, the Amazon Basin, the La Plata Basin and a very small fraction of the Altiplano Basin (Figure 7). In the Plurinational State of Bolivia, the Amazon Basin is located in the central and northern sector of the national territory. It is the most important of the three aforementioned basins because of its water volumes and because it is the most geographically extensive. The Amazon Basin is divided into six (6) main sub-basins, of which the Beni Sub-basin; Grande Sub-basin; and Ichilo - Mamoré Sub-basin are part of the Project's intervention area. It includes the departments of Pando, Beni and Cochabamba as a whole; the northeastern part of the department of La Paz; the northeastern part of the department of Chuquisaca; and the northwestern sector of the department of Santa Cruz. The Project's intervention area covers an area of 41,077 km2 of the Amazon Basin, which represents 6% of its total area in the country and around 49.7% of the project area. Some important rivers in this sector are the Rio Grande, Rio Mizque, Rio Tomina, Rio Caine, San Juan River.

A small sector of the Cotagaita Municipality, Nor Chichas Province of the Department of Potosí is part of the Altiplano watershed. The Altiplano watershed covers an approximate area of 36 km2 of the project area, which represents only 0.02% of the total area of this basin and 0.04% of the project area.

The La Plata Basin is located in the southeast, with an approximate area of 214,242 km2, which represents 20.6% of the national territory's surface, making it geographically the second largest basin. It includes the departments of Tarija and Chuquisaca. The project intervention area, which is part of this basin, has an approximate surface area of 40,626 km2, representing 19% of the total surface area of the basin in the national territory and 50% of the project area. Among the most important rivers in this sector of the La Plata basin are the Atocha River, Cotagaita River, Pilcomayo River, Tupiza River, and Tarija River.

According to the Level 3 hydrographic units map, the project intervention area includes a total of 23 sub-basins, including the Pilcomayo River sub-basin (12,268 km2), the Bermejo River (3,571 km2), the Tumusla River (13,547 km2), and the Mamoré River sub-basin (40,610 km2), among others (Figure 8).

Five strategic basins in the country currently have Basin Master Plans (Katari Basin, Rio Grande Basin, Rocha River Basin, Poopó Lake Basin and Guadalquivir Basin). These planning instruments will be useful for the project because the Rocha, Guadalquivir and Rio Grande river basins are an integral part of the project intervention area. Likewise, until 2020 it is planned to reach 14 River Basin Master Plans (PDC), in 14 selected strategic basins (PNC-PP, 2017-2020), so these planning instruments will be useful for the implementation of Project actions related to integrated watershed management.

[27] Castro, V.D.Q. 2019. Producto 1. Propuesta de intervenciones.

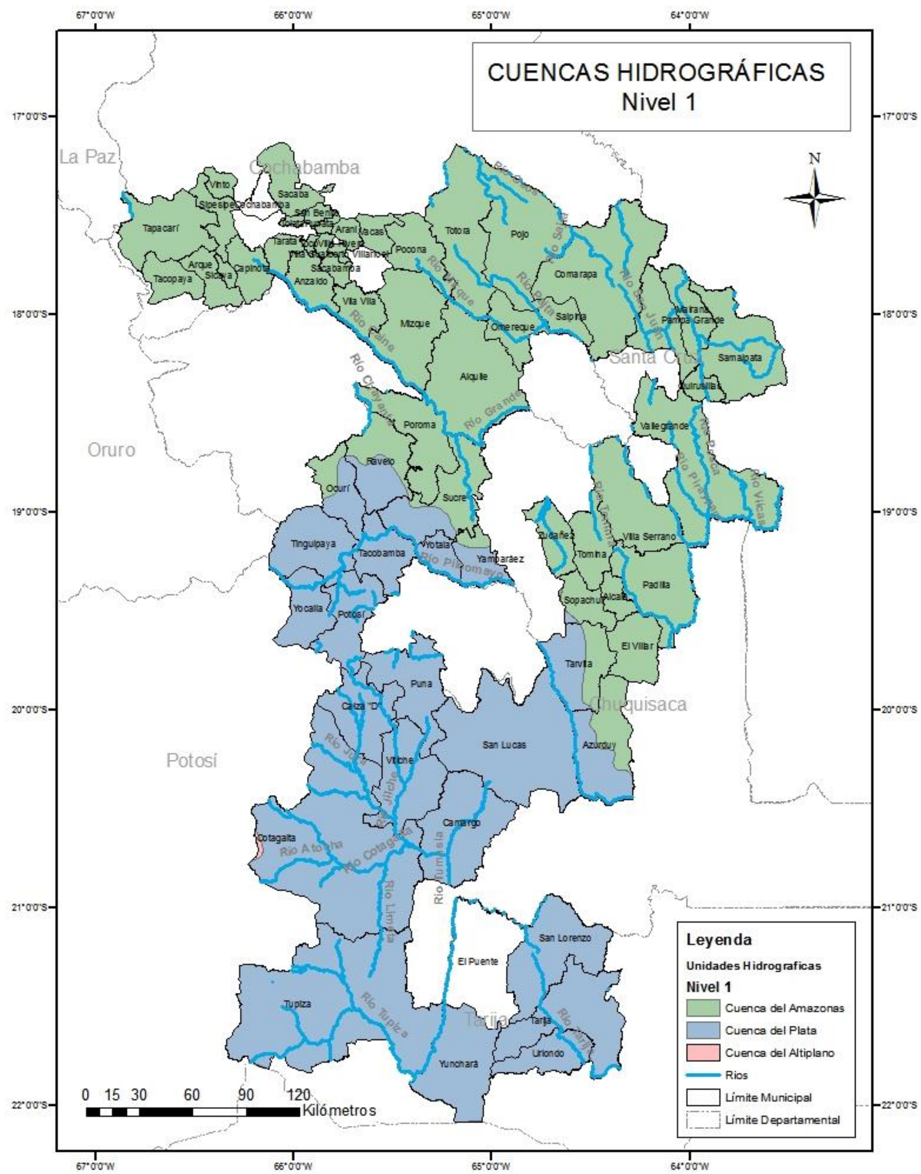

Figure 7 Water basins in the Valles Macroregion of Bolivia

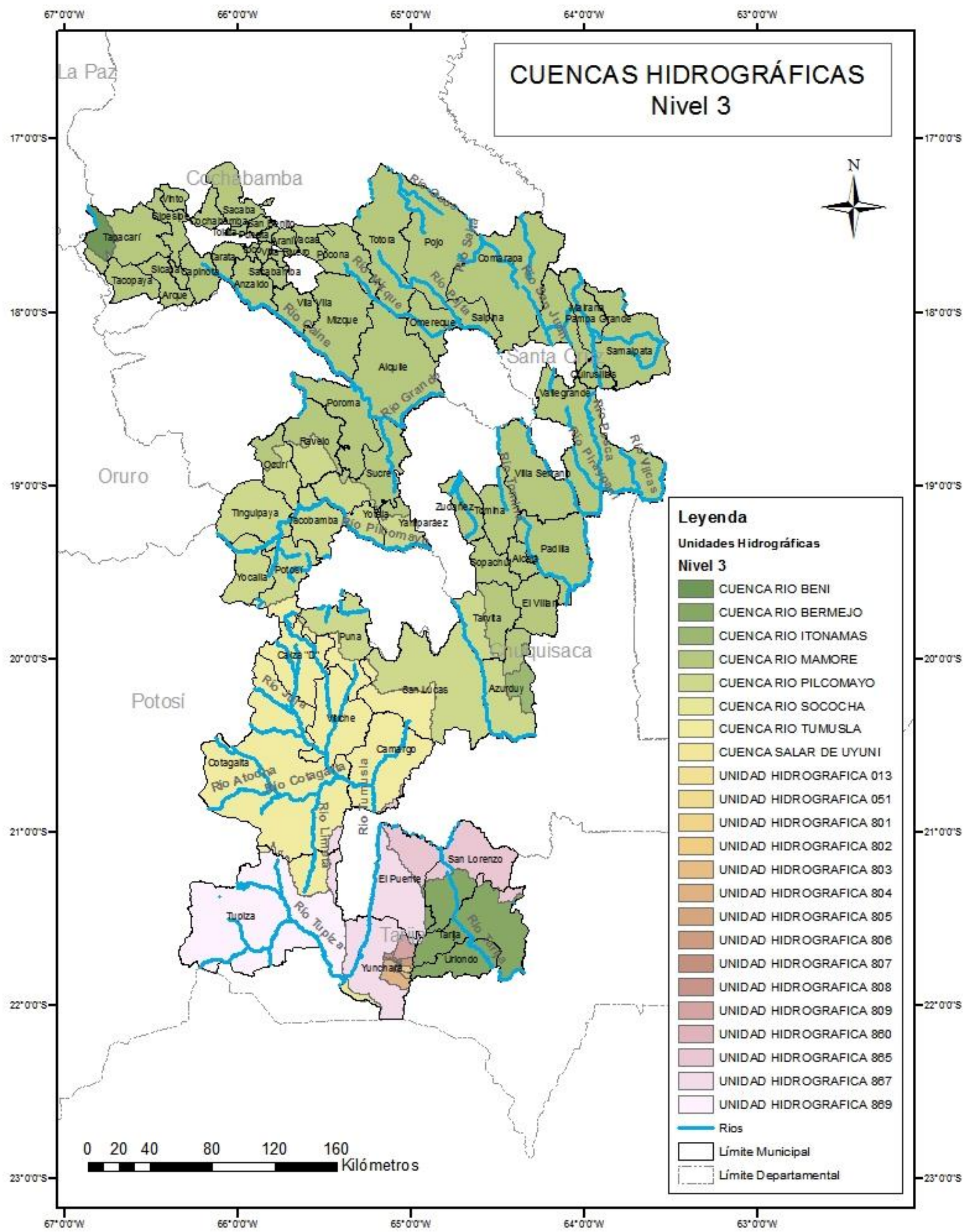

Figure 8 Sub-basins in the Valles Macroregion

3. Agriculture

Importance for economy

The agricultural sector is important for the economy of the Plurinational State of Bolivia and for the livelihoods of its population. In 1999, agriculture added the value of 4.998 billion USD to the economy, which represents 12.22% of the GDP. While agriculture has been adding more and more value to the Bolivian economy over the past few decades, the proportion of GDP coming from agriculture is decreasing as other sectors add value at a faster rate (see Figure 9). Bolivia's agricultural growth rates since the early 1990s are high compared to other countries: the fifth highest in Latin America and amongst the top two-dozen in the world[28].

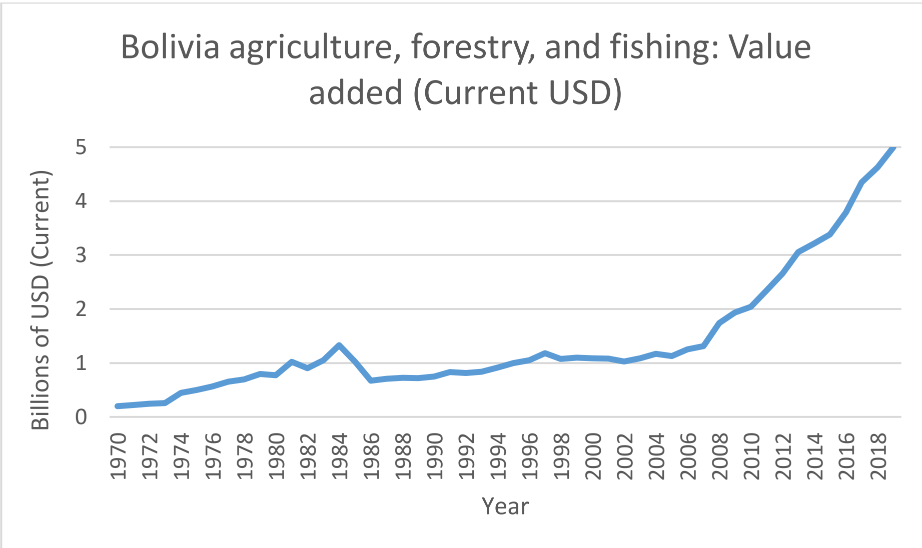

Figure 9 Value added by agriculture, forestry, and fishing to the Bolivian economy, in current USD (Source: World Bank)

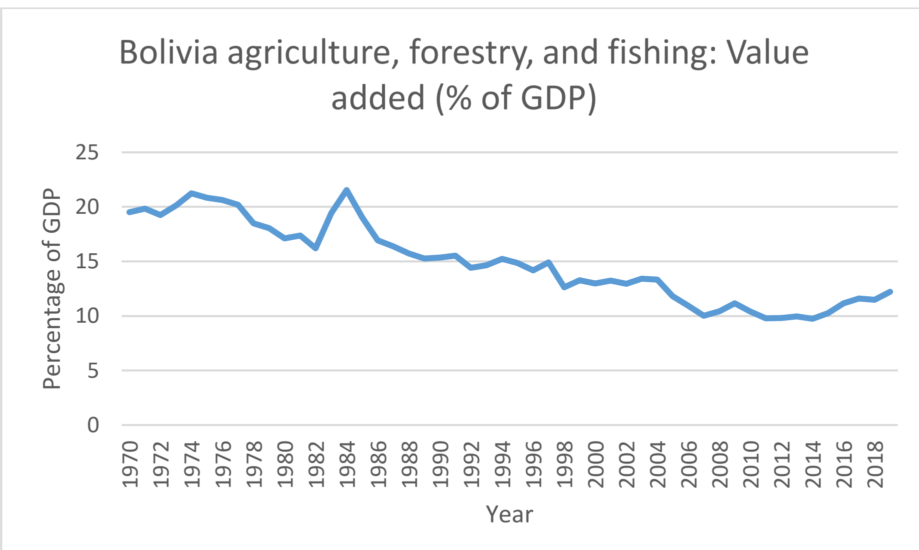

Figure 10 Value added by agriculture, forestry, and fishing to the Bolivian economy, as a percentage of the GDP (Source: World Bank)

Since 2001, the largest agricultural export is soybeans and soybean products, but other leading commercial crops include cotton, sugar, and coffee. In recent years, quinoa has become an increasingly important agricultural export as well due to its increasing demand as a health food in the United States, Canada, and Europe. The largest crops for domestic consumption are corn, wheat, and potatoes. The highest quantities of crops by mass are shown in Figure 11 but the most land used for cultivation are soybeans, maize, wheat, and rice (Figure 12). The highest yielding crops per area of land are sugar cane,

[28] https://assets.publishing.service.gov.uk/media/57a08bbc40f0b652dd000e5c/IPPGDP21.pdf

pineapples, bananas, and tomatoes (Figure 13). Yields and productivity remain among the lowest in Latin American agriculture, particularly for staple crops[29].

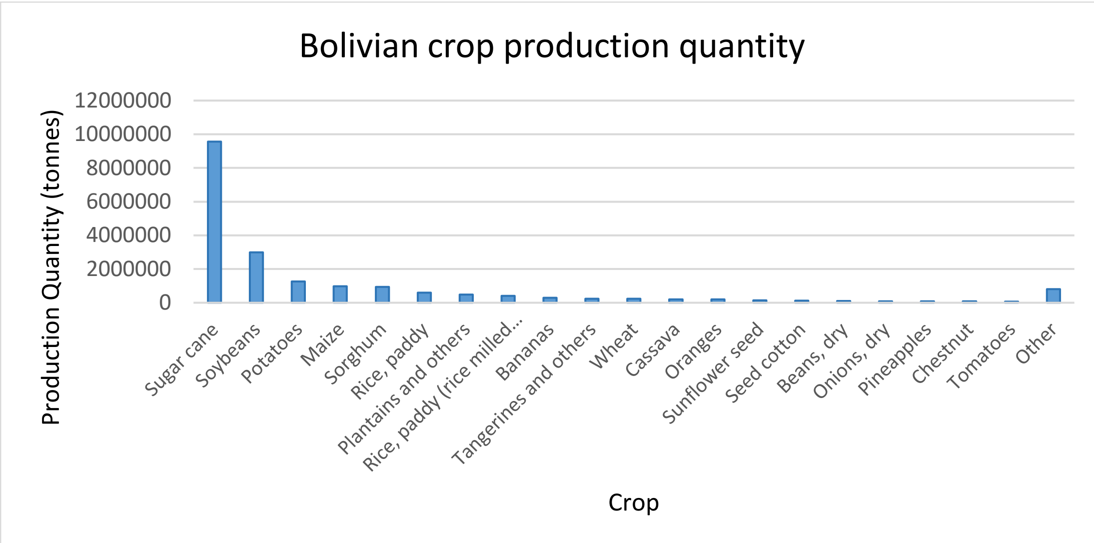

Figure 11 Production quantity in Bolivia in 2019 (Source: FAOSTAT)

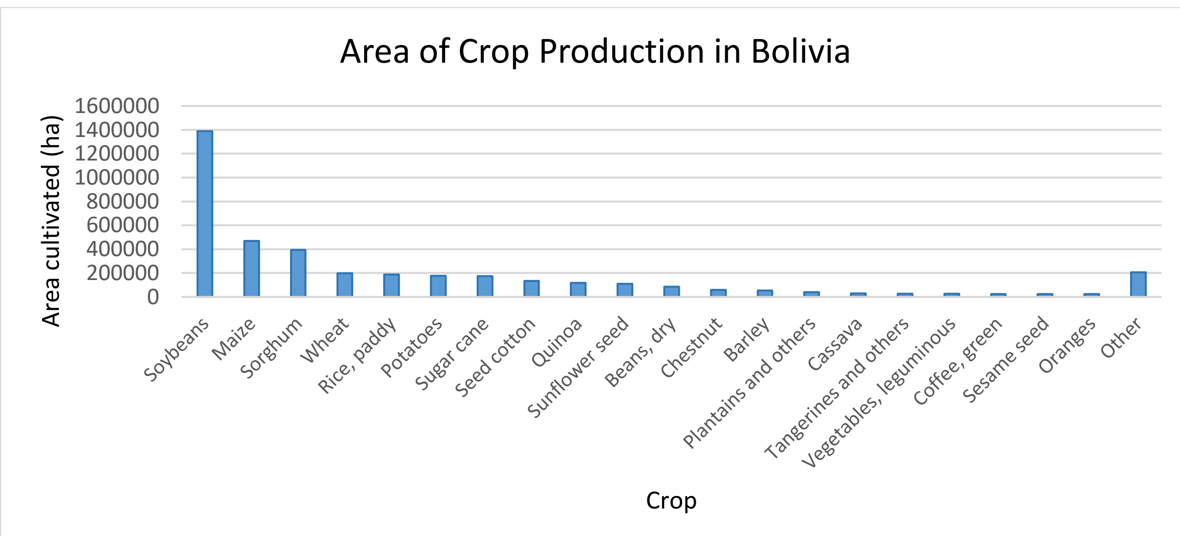

Figure 12 Area of crop production in Bolivia in 2019 (Source: FAOSTAT)

[29] https://ageconsearch.umn.edu/record/42367/files/IFPRIDP00732.pdf

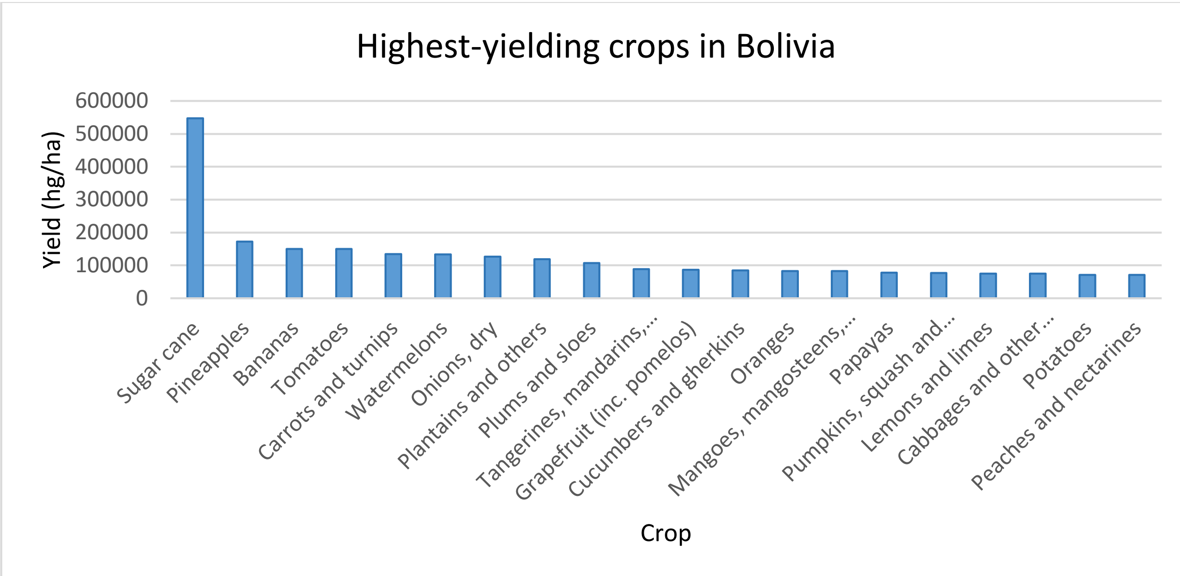

Figure 13 Highest-yielding crops in Bolivia in 2019 (Source: FAOSTAT)

Characteristics of agriculture in the Macroregion

Agricultural activity varies greatly across the country due to the variability of climatic, geographic, cultural, and other factors, such as road infrastructure and access to markets. In the west of the project's intervention area, where rainfall is scarce and temperatures are low, agriculture is subject to resource limitations and croplands are mainly confined to the mountains and hills. The main crops produced in this area are potatoes, corn, broad beans and peas.

In the east of the project area, crops are varied and the mild climate favours agricultural expansion, which has been moving into areas considered fragile and/or for conservation. The slash-and-burn technique used in the forest region has led to the deforestation of 48,000 hectares from 2000 to 2015. In this area the most important activity is agriculture, which is concentrated in the enclosed valleys at the foothills of the Andes, where there is usually water for supplementary irrigation (using water pumps) coming from primary and secondary runoffs. The most important crops in this area are beans, carrots, potato, broad beans, peas, tomato, cucumber, paprika, chard, celery, cabbage, broccoli, spinach, etc. Crops from fruit trees are also vital to this area: mainly bananas and citrus fruits.

The total area devoted to crops in the project area is summarized in Figure 14. It is clear that a significant area is devoted to cereals, tubers, and that mainly small-scale peasant and indigenous producers are engaged in this production given the dominance of smallholding in agriculture. The peasant and indigenous communities in the project area rely on livestock herds: mainly goats, sheep and cattle, in that order. This family animal husbandry is important for food security but also stands out in terms of trade in urban centers.

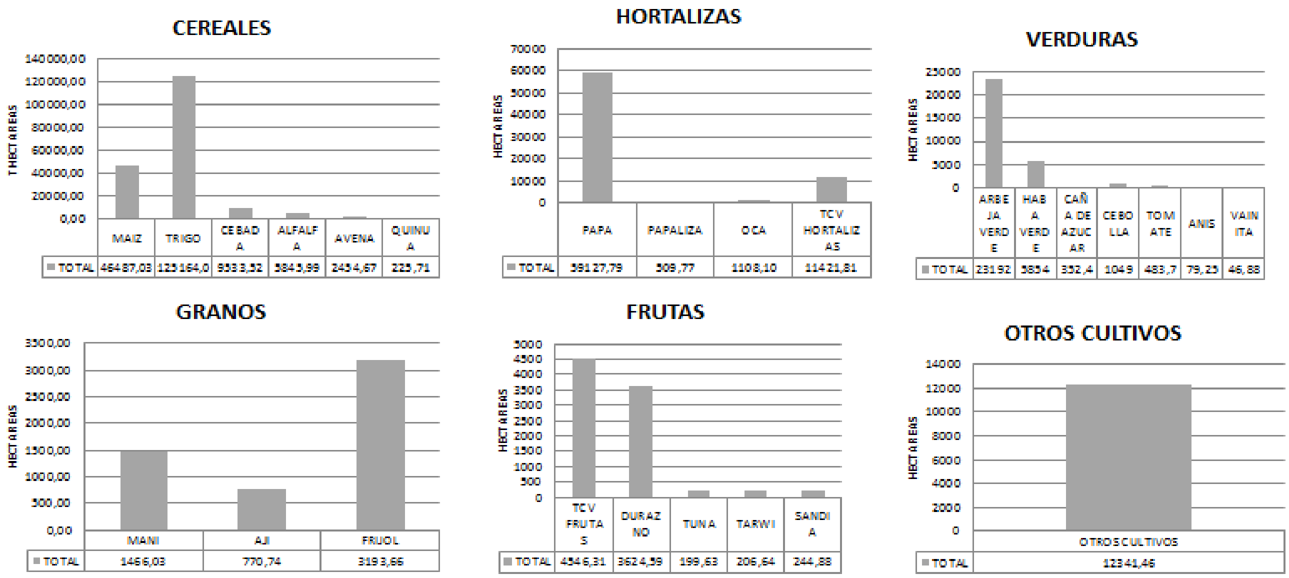

Figure 14 Agricultural production by area of land within the Valles Macro-region

Agriculture is an important source of employment for both men and women in Bolivia, especially in rural areas. It is estimated that 75% of the total population in rural areas is employed in agricultural activities[30]. Even including urban areas, 30% of the total employed population of both men and women are employed in the agricultural sector (Figure 15).

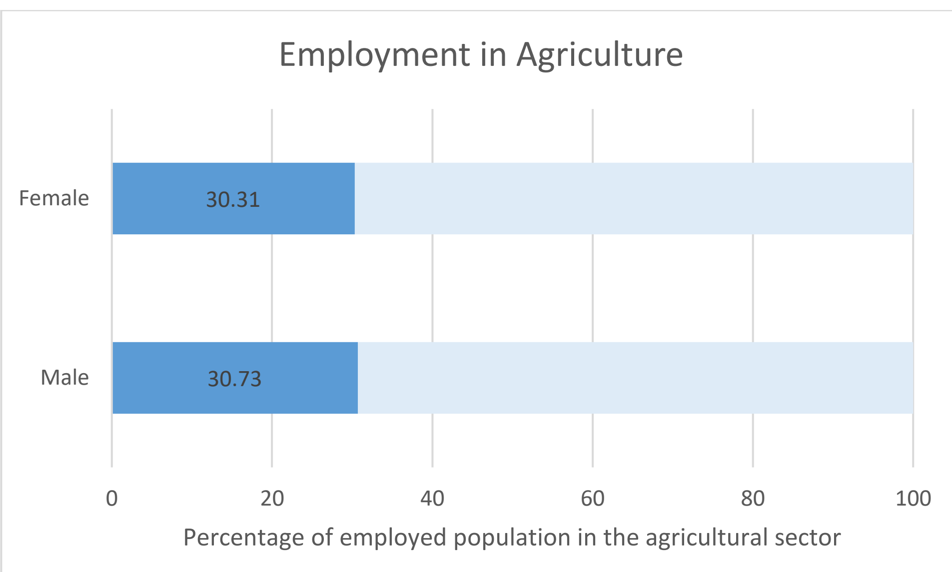

Figure 15 Employment in Agriculture (Source: World Bank)

[30] https://www.ifad.org/documents/38714170/39150184/Investing+in+rural+people+in+Bolivia_e.pdf/017f88cc-dd9a-4572-9b19-4646840b58d8

Family agroforestry gardens

The ecosystems of high Andean valleys, located above 3000 m a.s.l., represent one of the greatest challenges for agroforestry because these family systems require, in the first place, strength in family organization, confidence and decision; strong and solid principles in the families for their implementation because they have to "overcome" the high climatic instability of high altitude production systems due to continuous frosts, hailstorms and, mainly, droughts.

In this sense, in the municipality of Colomi, which is located in the Chapare province of the department of Cochabamba, in the central region of Bolivia, a series of agroforestry practices have been developed, so it is important to mention that family agroforestry is diverse and in its territory different ecological niches were identified with a diversity of local native species such as paja brava (Stipa ichu), muña (Minthostachys sp.), wild turnip (Brassica campestris) and wajcha barbero (Polygoniun arvensis). Special attention has been given to the queñua or kewiña, of which, according to Simpson 1979 and Baunman 1998, there are 12 to 15 varieties that are found in abundance on the slopes of the cultivated lands.

Since 1950, a process of strengthening local forest diversity began in the highland communities of the Colomi municipality with plantations of eucalyptus (Eucalyptus sp.), queñua (Polylepis sp), pine (Pinus radiata) and weeping willow (Salix babilonica). The latter is considered a "water caller", a definition gradually assumed by the local population. The introduced forest species complemented the productive systems and the new plantations were located on boundaries or as a natural division between properties, along riverbanks, roads, in t'oqos (small spaces within the micro-watersheds), etc.

The new forest plantations were articulated to the local culture and complemented it in an effective way under the premise "I build my new house next to my new forest plantations". The houses are located mostly on the municipal flatlands and some on the hillsides, according to the existing management between collectively-owned and individually-owned lands. This process has modified the local landscape and strengthened the production systems, which has benefited the families of the farming communities.

The agroforestry plots include Andean tuber crops such as potato (Solanum sp.), papalisa (Ullucus tuberosus), oca (Oxalis tuberosa), isaño (Tropaeolum tuberosum), associated with oats (Avena sativa), a grass, and legumes such as tarwi (Lupinus mutabilis) and fava beans (Vicia faba). Families also raise cows, sheep, horses, pigs and other animals on these plots, which complement the agroforestry strength of these production systems.

Diversity of agroforestry systems, multiplicity of impacts

Several criteria can be used to classify agroforestry systems (Nair, 1985, cited in Farrell and Altieri, 1999). Generally, system structure (composition and arrangement of components), function, socioeconomic scale, management level and ecological distribution are used.

Participatory research and work in these territories have identified that agroforestry systems in high altitude ecosystems in the inter-Andean valleys, such as the municipality of Colomi, can be classified taking into account criteria such as the physiogeographic enclave of the plot (pampas, slopes), local environmental characteristics (presence of frost, drought and hailstorms) and the socio-productive structures in place (community, union, families).

Based on these criteria, the following types of agroforestry systems have been identified:

- Agroforestry in micro-watersheds

Agroforestry in micro-watersheds is found in places locally called huaykos or t'oghos (ravine or gully in a micro-watershed). In these habitats or micro-spaces there are crops associated with forest plantations, shrubs and fruit trees such as sour cherry (Prunus acida). In these spaces, the vital components of the agroforestry system are crop diversity, horticulture and fruit growing, the association of agricultural crops and the forestry system. The combination of these four factors has allowed the families to make their agroforestry calendar more flexible by bringing forward and delaying sowing, and optimizing water use through a combined system of irrigation by cut-offs or ponds, depending on the demand of the families.

Municipality of Colomi, agroforestry systems, lagoon and productive diversification. R, Calicho

- Agroforestry with sour cherry live fences and crop diversity.

In order to protect the agroforestry production systems from late frosts and strong winds, the families have strategically established live fences around the associated crop plots.

Benefits of agroforestry for territorial resilience to climate change

The following benefits have been identified that strengthen the productive sustainability of this type of enterprise of the peasant families:

- Environmental benefits: crops in this type of agroforestry systems are protected by the reduction of climatic risks such as frost, late droughts and winds, by favoring the retention of moisture in the arable layer, protecting the crop from damage by animals and creating microclimatic spaces. Also, according to family testimonies, soil fertility has improved and now "they buy less fertilizers".
- Economic benefits: the production and productivity of biomass per unit area has increased. The production of sour cherry and broad bean is taken advantage of during the profitable season; these crops are planted twice a year; first broad bean is planted and then, after the harvest, oats or barley are planted.
- Social benefits: an agroforestry plot requires new labor force investments. This type of agroforestry system has led families to recover work exchange practices at the inter-family level, reciprocal or non-reciprocal, such as the ayni (work lent and paid) and the mink'a (work paid with food and drink). At the same time, it has improved local health by ensuring the provision of food for families and fodder for livestock.

- Cultural benefits: Plants, animals and crops are bio-indicators for climate prediction. The population has revitalized its traditional values and norms and in the high puna of Colomi considers nature, man and Pachamama, or mother earth, to be a whole that lives closely and perpetually. Man has a soul, a life force, which all plants, animals and mountains, etc. also have. The high hills, such as the Q'enti, the Machucolomi, the Wirgini, the Titiloma and the Waynacolomi, are motives for rituals to thank the apu (tutelary mountain) and the Pachamama for the spiritual help given to the farmer. The land is life, a sacred place and an integrating center for production in the community.

The climatic conditions in the Valles region are very diverse. A study that has systematized 30 years of rainfall and maximum and minimum temperatures, and climatic dynamics agrees with the testimonies of farmers: "no year is the same", "none is repeated" (Escalera, 2016)[31].

[31] J. C. Escalera. Intensive agroforestry, live fences, forest plantations.

For example, agroforestry systems in the Colomi territory have gradually consolidated the positive interactions presented by the characteristics of the local climate: extreme temperatures, winds. There is a complementarity that generates unexpected efficiencies, such as higher production levels, strengthening family and territorial resilience strategies in the face of climate changes (droughts, frosts, hailstorms). These agroecological synergies represent the basis of an integrated model of agroforestry systems in the high altitude valleys.

Irrigation for agricultural sector

Water systems and sources

Water for irrigation purposes comes from different sources, whose relative relevance we can appreciate in the results of the inventory of irrigation systems conducted by PROAGRO in 2012, comes from rivers (69%), springs (7%), wells (9%), reservoirs (13%) and wastewater (2%)[32].

Reservoir-regulated systems are distinguished between small, medium and large, depending on their crown height which can be <10m, 10-15m and >15 meters respectively. The volumes of stored water associated with these heights are typically < 0.5 million M3, 0.5-1 million M3 and > 1 million M3 respectively.

A national inventory of reservoirs was conducted in 2010 by PROAGRO[33], which recorded 287 dams in 7 departments. According to Table 7, the total volume of all these dams amounts to about 600 million cubic meters, half of which are located in the department of Cochabamba. Most of the dams (77%) are intended for irrigation, representing a total irrigated area of 39 thousand hectares.

A significant number of the dams were built in the 19th century and are past their useful life, but are still in operation. Of the total of 287 registered dams, at the date of the inventory 192 were functioning well, 80 were functioning regularly, 10 were not functioning for various reasons and 5 were under construction.

Table 7 Number of Dams by Department

Department	**Small**	**Medium**	**Large**	**Total volume (m^3)**
Chuquisaca	10	13	7	17,410,500
Cochabamba	82	9	24	323,584,300
La Paz	15	0	15	78,371,500
Oruro	8	0	1	34,669,000
Potosí	64	15	6	54,211,500
Santa Cruz	5	0	4	27,844,000
Tarija	0	1	8	60,032,500
Total:	**184**	**38**	**65**	**596,123,300**

Source: PROAGRO, 2010.

Allocation rules

[32] Ministry of Environment and Water. 2018. Multi Annual Plan for Irrigation from the Ministry of Environment and Water 2017 – 2020 (Programación Plurianual y Marco de Evaluación de Desempeño del Subsector de Riego 2017-2020).
[33] GTZ, PROAGRO. 2010. Inventario Nacional de Presas Bolivia 2010. https://www.bivica.org/files/presas-inventario_a.pdf

The recognition and granting of rights for the use and exploitation of water sources for irrigation are established in Law 2878 (8/10/2004)[34] for the Promotion and Support of the Irrigation Sector for Agricultural and Livestock Production and Forestry, which aims to establish the rules that regulate the sustainable use of water resources in irrigation activities for agricultural and livestock production and forestry, its policy, institutional, regulatory and irrigation management framework, granting and recognizing rights, establishing obligations and procedures for the resolution of conflicts, guaranteeing the security of community, family, public and private investments.

In this Law 2878, the following responsibilities are clarified with regards to the allocation of water:
ARTICLE 3 - (MINISTRY OF FARMING AND AGRICULTURAL AFFAIRS).
Ministry of Rural and Agricultural Affairs, as head of the sector, has the following attributions and obligations in the field of irrigation. a) To formulate and approve, in agreement with the Board of Directors of the National Irrigation Service (SENARI), the policies, regulations, plans and programs for the development of irrigation. b) To manage funding for the development of irrigation in the country.
b) Manage national and international cooperation funding to promote irrigation development. c) Encourage, program, promote and delegate technical assistance, human resources training, applied research and organizational programs for the management of irrigation. d) Develop, program, promote and delegate technical assistance, human resources training, applied research and organizational programs for the management of irrigation. e) Promote, program, promote and delegate technical assistance, human resources training, applied research and organizational programs for the
d) Promote participatory decentralization in irrigation development at the level of prefectures, municipalities and local or basin directorates, within the framework of the present Law and its Regulations. Regulations.
ARTICLE 4 - (MINISTRY OF SUSTAINABLE DEVELOPMENT).- The Ministry of Sustainable Development has the following responsibilities
The Ministry of Sustainable Development has the following responsibilities in relation to irrigation: a) Plan and supervise the management and rehabilitation of the hydrographic basins in agreement with the National Irrigation Service (SENARI). b) Control that irrigation works, activities or projects do not threaten the sustainability of the natural resources. c) Coordinate with the Ministry of Peasant and Agricultural Affairs, the formulation and application of environmental norms related to irrigation. d) Control the quality of water resources for irrigation, and prevent their contamination, in coordination with the competent sectoral organizations. e) Control the quality of water resources for irrigation, and prevent their contamination, in coordination with the competent sectoral organizations.

The management of the use and exploitation related to the distribution is governed by the customs and traditions, as well as the internal regulations that the irrigators or communities have for the use of water. The forms of access and use of water for irrigation is instituted in the customs and traditions of the communities or irrigators of a given territory, which begins with the request for formal constitution and granting of a right to use water[35] on the source, which could be related to a spring, river, lake, glacier, among others. Once the water use right is constituted, it is managed at the level of the irrigation community or association through a specific regulation that establishes the irrigation time for each irrigator in his plot. These times and flows are defined in the General Assembly of the Community or

[34] For more on the Law 2878: http://www.oas.org/dsd/environmentlaw/waterlaw/documents/Bolivia-Ley_2878_(2004).pdf
[35] Ley del Sistema Ley de Promocion y Apoyo al Sector Riego para la Producción Agropecuaria y Forestal Nro. 2878.

Irrigation Association, taking into account the water flow and the volume of water accumulated in its source.

There are 188,268 Agricultural Production Units (UPAs) in the project area. In summer crops, 187,094 UPAs are active, and in winter 1,719 UPAs are active. Most of the UPAs producing in summer are located in the municipalities of the department of Cochabamba (72,596), followed by the municipalities of Potosí (43,704) and Chuquisaca (40,948). Santa Cruz has 11,145 UPAs and Tarija 18,711 UPAs.

Out of a total of 248,722 ha cultivated in summer in the project area, the irrigated area has an extension of 161,982 ha. Of a total of 1,711 ha cultivated in winter, a total of 1,037 ha are irrigated. A remarkable fact is the existence of 15,342 ha of pasture cultivated by a total of 3,409 UPAs, the area with natural pasture is 751,893 ha. Importantly, over 90% of Bolivia's water use is for the agricultural sector (Figure 16). In the project area, there are nearly 100 dams and over 2000 irrigation systems in place (Table 6). Roughly, one third of agricultural land in the project area is not irrigated, demonstrating the importance of irrigation for crop production in the area.

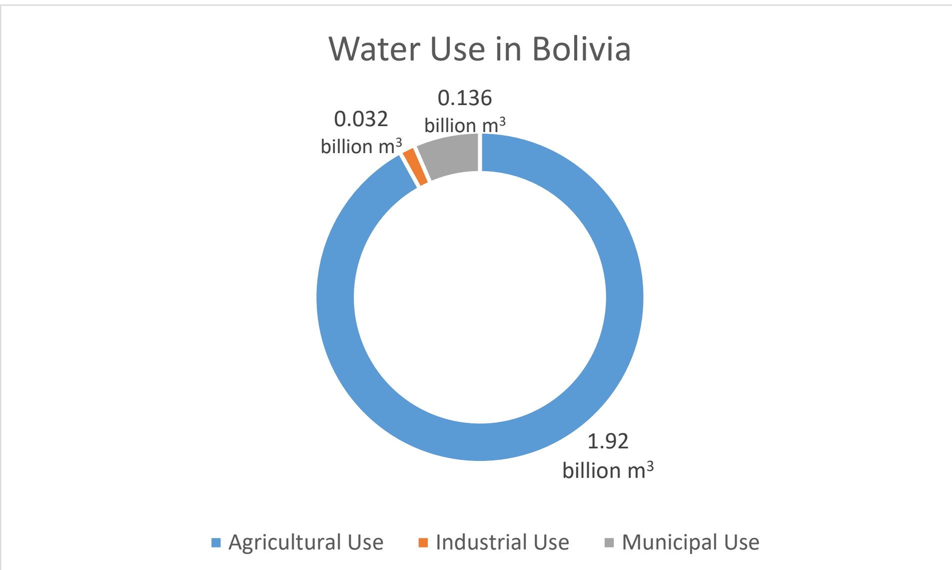

Figure 16 Water use in Bolivia (Source: Worldometer)

In relation to irrigation, the most used water sources are rivers, which are used by a total of 411,832 UPAs, equivalent to 36%, which tells us about a strong dependence on natural water sources that when their flows decrease due to climate change increase the vulnerability of rural and indigenous communities and families. On the other hand, 239,131 of the UPAs, or 21%, use spring water for irrigation, while 4% use lagoons. In total, 66% of the UPAs that irrigate for agricultural purposes depend on rivers, springs, lagoons, wetlands and curiches. This undoubtedly implies a high vulnerability.

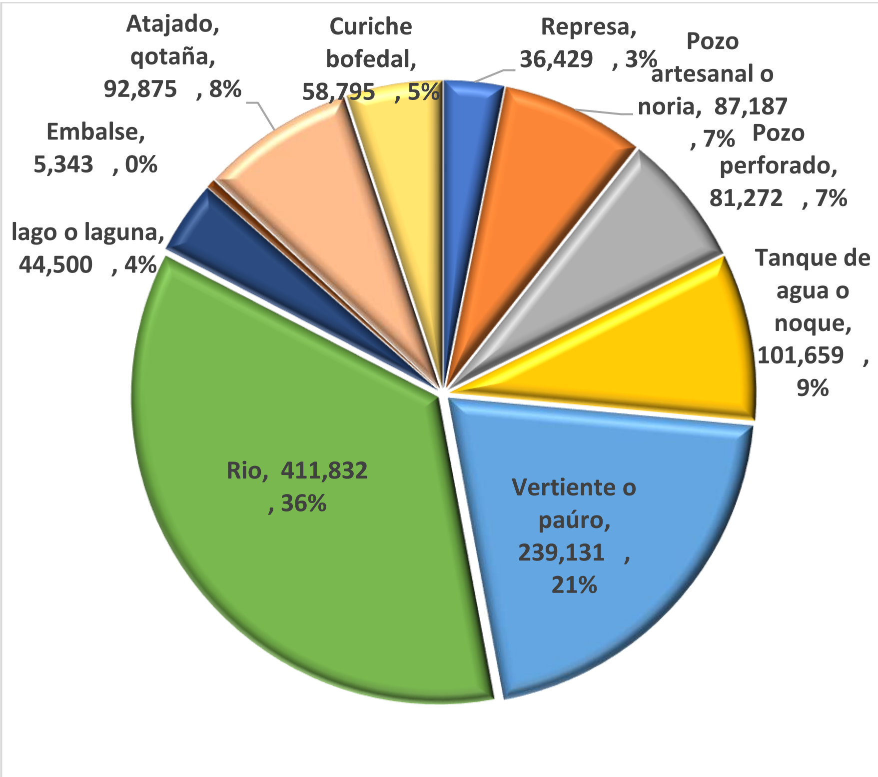

Figure 17 UPAs and the use of water source

Table 6 Irrigation statistics for the project area

No. of irrigation systems	No. of dams	Area for agriculture (ha)
2,224	95	341,155

Irrigation systems combine several types of infrastructure; in this sense, the most frequent work in the collection of water from rivers is the direct intake, which is used in both rustic and improved systems. On the other hand, it is also important to point out that there are 222 dams that can hold more than 500 million cubic meters, as shown in Table 7.

Table 7 Table 6 Types of infrastructure per department

DEPTO.	Direct intake	Diversion dam	Filtered intake	Tajamar	Toma Tirolesa	Pozo	Atajado	Tank	Storage dam
CHQ	615	53	22	18	1	3	11	15	41
CBA	596	50	50	14	39	572	75	68	97
LPZ	897	111	17	3	10	17	258	84	42
ORU	254	104	88	3	1	11	190	68	9
PTS	819	81	110	4	10	12	175	68	23
SCZ	240	24	1	6	1	25	65	79	6
TRJ	521	121	40	10	2	0	25	45	4
TOTAL:	**3.942**	**544**	**328**	**58**	**64**	**640**	**799**	**427**	**222**

Reference: Ministerio de Medio Ambiente y Agua, 2013.
Note: Tajamar, toma tirolesa, pozo and atajada refer to different kinds of lagoons, reservoirs or Wells that have been constructed and are filled up with rainwater, and if there is a possibility, with river water.

There are sporadic water storage systems in the farm and/or community, since the traditional irrigation areas are mostly fed by natural water sources and dams and/or reservoirs built by the national level in coordination and with minimal counterpart from the sub-national municipal level.

The atajados (rainfed lagoons) are generally built on family plots and allow for the storage of between 1,000 and 5,000 m3 of water during the rainy season for use in times of drought, generally by one or a few family production units. Family atajados are normally used for multiple purposes: irrigation, livestock and domestic use. With a 1,750 m3 atajado, it has been reported the use for supplementary irrigation in summer of 1 ha (rainy season) and in the dry season a second harvest of ¼ ha.

The application of atajados as a response to the vulnerability of communities with few water sources was developed in Bolivia in different regions of the inter-Andean and sub-Andean valleys, among others in the Southern Cone region and the Caine basin of Cochabamba, the regions of Central and Northern Chuquisaca, the Valles Cruceños and Northern Potosí. A model for family water harvesting and use was developed under PROAGRO II, and was embodied in the "Guide for the development of family irrigation projects" (Ministry of Environment and Water, 2013(2)).

It is estimated that there are a few thousand such systems nationwide. An evaluation of their operation and impact on the family economy was carried out by Hoogendam et al (2009) in the Municipality of Anzaldo (Cochabamba), where a high concentration of these structures built by the municipality, the governor's office and some non-governmental entities was found. Although these investments were initially not entirely successful, a thesis study conducted three years later found that the vast majority of the systems built were subsequently improved and put into operation, among others due to the support of PROAGRO and CIPCA with technical and productive assistance (Lukat, 2012) .

Types of existing irrigation systems in Bolivia - gravity

This method of irrigation is one of the oldest in agriculture. It is carried out on gently sloping land and consists of conducting the water flow from a supply source to the fields and letting it flow by gravity directly to the soil surface. Gravity irrigation can be carried out in the following ways: furrows or by drip irrigation. Currently, in gravity irrigation it is also possible to use PVC or polytubes to conduct water from the supply source to the furrows of the plot.

There are several irrigation methods, each with its own characteristics, advantages and disadvantages.

- By furrows
- Drip irrigation
- Sprinkler irrigation
- Micro-sprinkler irrigation

In the following table, we have included a description of each of the methodologies and their characteristics:

Table 8 Types of irrigation and their characteristics

	Description	Advantages	Disadvantages
Gravity irrigation - by furrows	This method consists of water flowing through small channels, wetting only a part of the soil. This system is very well adapted to row crops (vegetables, potatoes, corn, among others).	- Gravity irrigation, due to the simplicity of its infrastructure, is one of the most economical. - Wind is not a limiting factor in water distribution.	- It is not advisable to use it on uneven terrain, since the water could be diverted and impede its correct distribution. - By wetting most of the soil, it generates the appearance of weeds and diseases.

	Water is applied to the soil from a main ditch and the furrows must have a gentle and uniform slope.		- It requires more water per unit of cultivated area, so its use is excessive in relation to the water needs of the crops. - Water loss by evaporation is very high.
Drip irrigation	This method consists of dividing the land into strips or ridges by means of ridges or borders. The dimensions (width and length) and slope of the strips will be conditioned by the type of soil and the availability of flow. This type of irrigation is used in crops with high sowing density, for example, in cereals and forage crops sown "broadcast". To implement this method it is necessary to level the land, and it is recommended that the first five meters of the system is leveled with zero slope to achieve uniformity in the application of water and reduce soil erosion.	- It can be applied on sloping land and does not cause erosion. - The plant makes better use of water, because it receives it in the area where the roots grow. - Not much water is lost through evaporation. - Fertilizers can be applied together with the water. - There is good control of the amount of water applied. - The growth of weeds in the streets is reduced because only the crop is irrigated. irrigate the crop. - The attack of pests and diseases caused by excess moisture is reduced. - It is possible to enter the plot at any time, since the crop alleys remain dry. - Labor savings. - The materials are light and flexible, easy to transport.	- The hose is thin and delicate, so the useful life is short (about two years or so). - Hose holes become clogged if there is debris in the water. - Installation cost could be high (for large extensions). - Limits some work, such as hoeing, because care must be taken not to break the hoses.
Sprinkler irrigation	It is an irrigation system in which water is applied in the form of a more or less intense and uniform rain on the plot so that the water infiltrates at the same point where it falls. This requires a distribution network that allows the irrigation water to reach the emitters (sprinklers) with sufficient pressure.	- Adaptation to the terrain. It can be applied to both flat and hilly or sloping land, no land preparation is required. - It is a more convenient system for the application of fertilizers, pesticides and other products with water. - We do not have to be present at the time of irrigation. More free time. - We can prevent frost.	- It requires expensive components (high pressure hydraulic pump, pipes, sprinklers and other mechanisms and parts). - There is a risk of promoting higher incidence of pests and diseases. - In sprinkling, water losses due to evaporation are considerable.

		- It reduces the risk of soil erosion. - Significantly improves crop yields. - Can be installed permanently or mobile. - Water loss is reduced.	- Wind hinders the uniform distribution of water.

Irrigation systems require a set of structures (works and accessories) to convey water from its source to its irrigation purpose. The following describe the components of a drip irrigation system.

Pressure Source.

In the current situation,this is a storage tank or rainfed lagoon that is located at least 10 meters above the level of the land to be irrigated (favorable slope), in order to take advantage of the gravitational potential of the water.

Conduction network (adduction).

This conducts or transports the water from the existing source or from the pump to the headers, through PVC or polytube piping; it also allows the water to be conveyed to the agricultural plot where the drip tapes will be installed.

Polytubes with different diameters (1"- 1 ½" - 2", etc.) can be used depending on the flow rate to be supplied.

Irrigation head.

This is the place where we can retain the water to be filtered before distributing it through the hoses or drip tapes. Fertilizers and other agricultural products that can be applied together with the irrigation water can also be dissolved in the header. The sprinkler head is basically made up of the following elements:

- Air valve
- Fertilizer unit
- Ring filter
- Manometer.

The following described the components for installation of a sprinkler irrigation system. Sprinkler irrigation requires components similar to drip irrigation systems:

Pressure Source

In the actual situation, this is generated by the difference in height of the storage pond, river, cofferdam, which by gravity generates natural pressure. The required flow and pressure must be taken into account.

Conduction network

Consisting of a network of pipes that carries or transports the water from the existing source or from the pump to the headworks. This can be done through PVC or poly pipe.

Irrigation header

The control or irrigation head is the place where we can retain the water to be filtered before distributing it. It is generally used in drip and micro sprinkler irrigation systems.

Distribution Line

The distribution line is made up of pipes (branch network) that carry the water to the hydrants, which are located in the irrigation plots. In the distribution network, the water must arrive at the same time and with the same pressure where the sprinklers are installed in order to achieve uniform irrigation.

Sprinkler devices or emitters

These are the elements responsible for applying water in the form of rain. These devices can be perforated pipes, fixed diffusers, nozzles or sprinklers, among others. The most commonly used in agriculture are the rotating ones because they rotate around their axis and allow irrigation of a circular surface driven by water pressure. The pressure requirements of sprinklers vary greatly, depending on the type of sprinkler selected; for example, a low pressure sprinkler basically works with 0.3 to 2 bar (1 bar= 10 meters water column (m.c.a)).

Experiences with drip and sprinkler in the region

Drip irrigation systems has been implemented in the municipality of Anzaldo. To use these systems, smaller reservoirs have been installed, generally with a capacity of 650 liters. However, there is still no empirical information on this subject. According to information from the field technician, no strict efficiency measurements have been made to date, since the land in the lower area of the river has access to sufficient water sources. In any case, in general terms, it is estimated that the efficiency of water use in the Añahuani community is up to 80% for sprinkler irrigation compared to flood irrigation. The discrepancies between the efficiency of Anzaldo (90%), Torotoro (80%) and even Calamara (60%), can be explained by the method of measurement or soil texture (sandy, clay, etc.), which may vary according to each municipality, community, and even according to the monitoring plots. More recently, drip irrigation systems have also been implemented, mainly for fruit trees (papaya and citrus), vegetables (cabbage, parsley, onion, tomato, achojcha, for example) and in some cases even peanuts. However, as in Anzaldo, there are still no measurements of water use efficiency, so it will be some time before the results of this new initiative are known.

Reasons to implement technified irrigation

The loss of water volume due to infiltration and leakages, ageing of infrastructure[36], unnecessary soil saturation, evaporation and the lack of reservoirs is considerable in traditional gravity irrigation systems (furrow and line); parallel to the loss of water, the effects on the soil are also evident, which, depending on the slope, are exposed to a lesser or greater extent to the erosive effects of water.

If we consider that water is an essential resource for food production, and that its availability is becoming increasingly scarce, we must then adopt more modern systems that allow us to make a more efficient and rational use of water.

Technified irrigation systems make it possible to optimize the use of water and supply crops with the necessary amount in an efficient manner for their development, thus reducing the waste of this valuable resource, and at the same time reducing the risk of erosion. In this way, technified irrigation systems contribute to the conservation of natural resources.

[36] Jáuregui, P.T., Olivares R.A, Colque L.G. Programa de Desarrollo Agropecuario Sostenible GTZ - PROAGRO UCORE. 2008. Efectos del riego en los ingresos de las familias campesinas

The following should be taken into account when selecting an irrigation method:
- Type of crop, soil, climate.
- Quantity and quality of available water.
- Profitability of the production system.
- Available infrastructure.
- Preferences.
- Environmental impact.

There are already experiences in the country of technified irrigation. According to the latest data as of 2013, there are 291 sprinkler and drip irrigation systems:

Departamento	Gravedad		Aspersión		Goteo	
	Sistemas	Área	Sistemas	Área	Sistemas	Área
Cochabamba	1.338	95.935	173	1.470	3	27
La Paz	1.067	52.146	22	413	0	0
Santa Cruz	286	26.159	23	5.513	10	557
Oruro	466	18.263	4	146	1	12
Tarija	671	45.269	2	388	3	57
Chuquisaca	747	29.515	5	195	1	5
Potosí	1.052	27.195	44	656	0	0
TOTAL:	**5.627**	**294.481**	**273**	**8.782**	**18**	**658**

Table 9 Methods of applying irrigation to plots1

It is worth mentioning that there are numerous areas of technified irrigation in each *Mancomunidad*, which have irrigation committees and implies a certain level of knowledge of technified irrigation systems:

Mancomunidad	**Hectáreas de sistema de Riego Tecnificado**	**Capacidad de las organizaciones**
Mancomunidad de los Valles Cruceños	6020 Ha. (Se estima la mitad de este aporte para el sector valles)	Cuenta con comités de regantes
Mancomunidad Chuquisaca centro	200 Ha.	Cuenta con comités de regantes
Mancomunidad Chuquisaca norte		Cuenta con comités de regantes
Mancomunidad Los Cintis		Cuenta con comités de regantes
Mancomunidad Del cono sur	1.497 Ha.	Cuenta con comités de regantes
Mancomunidad metropolitana (RMK)		Cuenta con comités de regantes
Mancomunidad del Valle Alto		Cuenta con comités de regantes
Mancomunidad de la región andina		Cuenta con comités de regantes

Mancomunidad	Hectáreas de sistema de Riego Tecnificado	Capacidad de las organizaciones
Mancomunidad Los Chichas	656 Ha.	Cuenta con comités de regantes
Mancomunidad Gran centro de Potosí		Cuenta con comités de regantes
Mancomunidad Norte Potosí		Cuenta con comités de regantes
Mancomunidad Héroes de la independencia	200 Ha.	Cuenta con comités de regantes

Table 10 Mancomunidades with hectares of technified irrigation system and capacity of organizations

Although there is a high percentage of traditional irrigation systems (60% are traditional or rustic; 30% of the systems have been improved through public investment for their expansion and/or rehabilitation and only 10% are new systems) there are also It has been seen the need to improve these irrigation systems and make them more technical, since it greatly improves the efficient use of water for irrigation and effectively distributed to more families.

Given that the use of irrigation systems in a traditional way is based on the delivery of water by time and shifts under the figure of "rotational mono flow", which implies entire flows for a single irrigator for a certain time, which generally fluctuates between 2 to 4 hours, to then move on to another and then to another. On the other hand, the distribution scheme in technified systems is different, it entails flow management through pipes and in "multi-flow", where it is possible that two or more irrigators can irrigate their crops simultaneously. In this case, the irrigator cannot see and it is very difficult for him to calculate the volume of water that he receives and it is generated in principle of mistrust and in most cases resistance on the part of the beneficiaries of a modernization project. Therefore, the accompaniment results in a methodology and tool to assist the beneficiary and to better understand the change in the system, such as the irrigation surface to be reached, the volume of water needed, the flow of water, the irrigation time, the amount of work, among others. In the previous question, the issue of technical support and assistance was clarified and it is emphasized that it is crucial for the acceptance of the technified irrigation system and to ensure the continuity of its operation and maintenance. This can be seen in the PF Paragraph 3 where it is clarified that the participatory approach of the project includes improving capacities that later translates into training for technicians and direct beneficiaries with the field schools, exchange of experiences and support as such.

It is worth mentioning and why not say that even with a certain percentage of error, the technified irrigation systems have responded and exceeded the demands of supplying water resources to the communities; however, it is essential to reinforce knowledge, evaluate experiences, and strengthen those responsible. irrigation systems (irrigation systems already in operation) and provide priority support to beneficiaries whose irrigation systems are traditional and require their improvement or revitalization.

In terms of resources, technified irrigation contributes to the production of vegetables. On the one hand, only the savings from not buying vegetables have an approximate value of 720 bolivianos if the increase in the consumption of vegetables is taken into account thanks to the implementation of the irrigation system, the amount saved can double. In addition to savings, it is reported that at the family level, on average, annual crops generate around 3,100 bolivianos. Which, apart from supporting the family economy, contribute to the sustainability of irrigation systems.

Policy framework regarding agriculture

The National Policies of the Plurinational State of Bolivia are aimed at promoting and building a new diversified productive development model and establishing norms that regulate the sustainable use of water resources in irrigation activities for agricultural and livestock production, such as the Irrigation Law 2878 for the Promotion and Support of the Irrigation Sector for Agricultural and Forestry Production (October 8, 2004).

The National Irrigation Development Plan for Living Well (PNDR) as a participatory proposal for transforming the current irrigation situation into a future state of affairs with a new irrigation vision, where progress has been made in solving the problems and developing the country's potential and the technical, social, economic, financial and environmental conditions in the country's river basins.
In this process of policy consolidation, the Plurinational State of Bolivia has managed and received funding from international cooperation (Andean Development Corporation, World Bank, Inter-American Development Bank) to finance the More Investment for Irrigation Program - MI RIEGO, being the "Executing Agency" the Ministry of Environment and Water (MMAyA), through the Vice-Ministry of Water Resources and Irrigation (VRHR), with its Coordination and Implementation Unit of the My Irrigation Program (UCEP MI RIEGO), The objective is to increase the agricultural income of the rural households benefited in a sustainable way through an increase in the agricultural area under irrigation, improving the efficiency in the use and distribution of water for agricultural purposes, allowing the generation of jobs in rural areas and contributing to the development of the productive capacity of families in rural areas of the country, prioritizing a national demand for irrigation projects with a watershed approach in municipalities of 7 departments of the country.

Through the Technical Assistance (TA) service as facilitators in this process to irrigation beneficiaries in productive issues, watershed conservation, oriented to strengthen capacities, achieve self-management and sustainability of their irrigation systems, considering the beneficiaries as protagonists in the implementation process of irrigation projects.

The agricultural sector is currently being promoted as to increase production and productivity, in order to improve the quality of life of producers, as well as to ensure food security and guarantee production for domestic markets. Another essential element that has gained vital importance in this challenge is the active participation of producers in the different stages of a project such as planning, execution, etc. of the different programs and projects focused on the development of rural communities in the country.

In addition to these policies and programmatic actions, the goals committed by Bolivia in the Nationally Determined Contribution, related to the Water, Irrigation and Food Production Sector, is to increase resilience to extreme climate events, including to increase the irrigation area to 1 million hectares and at the same time increase food production to advance food security with sovereignty.

According to the Multi-Year Irrigation Plan 2017 - 2020, in order to achieve food sovereignty by 2025, it is necessary to promote the diversification of the country's productive matrix and thus reduce the susceptibility of the Bolivian economy to variations in raw materials. The development strategy of 41 agro-productive regions in the country would give a total increase in the agro-productive area of 1.5 million hectares, a growth of approximately 50% with respect to the area planted in 2012.

Table 11 summarizes the projections for food sovereignty by 2025, in terms of the items in which irrigation is part of the global goals proposed to increase productivity and expand the production area until 2025.

Table 11 Projections of Agricultural Production to 2025

PRODUCT	Production (miles de Tm)	Yields Tm/Ha	Surface 1000 Ha	Growth in 1000 Ha

	Baseline 2012-2013	Projection 2024-2025	Growth 2025/base	Growth annually	2013	2025	2013	2025	
Rice	360	1.335	270%	11,5%	2,2	4,0	164	334	170 *)***)
Sugarcane	8.31	13	56%	3,8%	52,3	65,0	159	200	41
Corn	910	2.524	178%	8,9%	2,8	5,0	325	505	180
Wheat	227	1.561	588%	17,4%	1,4	2,2	158	710	552
Quinoa	61	300	390%	14,2%	0,5	0,8	131	375	244
Potatoes	1.149	2.5	118%	6,7%	5,7	7,0	203	357	154 *)
Frutales	1.056	1.896	80%	5,0%			113	160	47 *)**)
Hortalizas	370	891	141%	7,6%			156	253	97 *)**)
						Total	1409	2894	1485

Source: Elaborated based on data: Presidential Representation for the Patriotic Agenda 2025, Productive Diversification and Food Sovereignty Unit, 2013.
*) Items with a strong implication of irrigation in the expansion of the production area and increase in productivity.
**) Items in which the viability of production in valleys and highlands involves technological innovation, including irrigation technology, fertigation, solar tents, etc.
***) In rice, the proposed production system is under flooding.

According to this vision, a substantial part (one million hectares) of the expansion of the agricultural area must be supported by the expansion of irrigated areas, for two reasons: 1) to guarantee the growth of the production of mass consumption crops in their traditional production areas: potatoes, cereals, legumes, vegetables, fruit trees, and 2) lack of new arable land suitable for sustainable rainfed production. Irrigation also plays a crucial role in reducing production risks caused by increasing climate variability and in controlling the expansion of agriculture through deforestation.
By expanding the area under irrigation, PA2025 seeks to consolidate sustainable and highly productive agriculture, including the plains currently used for rainfed production. This will contribute to the preservation of forests and protected areas in vulnerable life zones, so that the expansion of the irrigated area contributes to the dual purpose of climate change adaptation and mitigation of greenhouse gas emissions, two important pillars of the Framework Law of Mother Earth.

Based on this vision of agro-productive development and taking into account the potentialities and limitations of an expansion of the different types of irrigation in regions with significant potential, irrigation area expansion goals were established until 2025 (see Table 11).

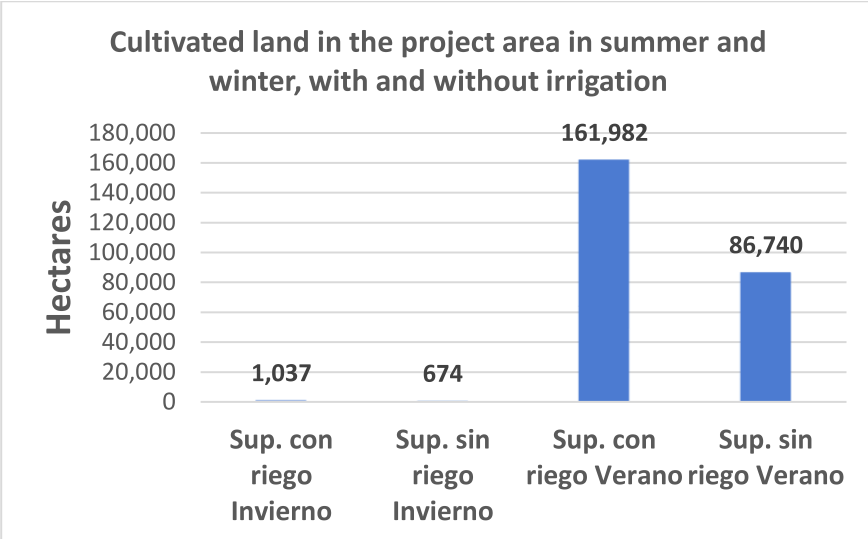

Figure 18 **Agricultural land in the winter (invierno) and summer (verano): irrigated (con riego) and non-irrigated (sin riego).**

Most farmers in Bolivia generally practice very traditional methods of agriculture. They use terraces in the slopes of hillsides and mountains. Families with lower incomes often use foot ploughs, and the vast majority of farmers have little access to modern tractors. In fact, by the last estimate, there was 1 tractor in use for every 5,000 hectares of land. This would mean that if every farmer owned three hectares, only one in about 1,600 farmers would have access to a tractor[37].

Agricultural yields in Bolivia

Yields for the Macro Valley were obtained from previous studies, based on surveys extracted from the Feasibility Study for the Yungas de Vandiola project (2003), for the High Valley. The surveys were structured by crop, in order to learn about the various techniques used in each crop and to determine the operational costs of each crop.

Table 12 Average crop yields in the Macro region

Crop	Kg/ha
Potato temporary	7,500
Potato mishka	9,000
Corn (units)	27,000
Corn kernel	1,900
Bean/ temporary	2,000
Bean / Mishka	3,000
Onions	19,500
Alfalfa	50,000
Peas	2,400
Carrot	13,500
Wheat	1,150

Agricultural yields under irrigation

[37] https://www.canr.msu.edu/news/bolivia-s-desire-for-sustainability

The increase in crop yields considered in the project schedule corresponds to additional irrigation allocations due to the improvement of catchment, conduction and application systems, until total coverage of crop water requirements is achieved and with adequate frequencies.

In addition, it is also considered that the improvement of irrigation conditions will be complemented with an integrated package that improves the other agricultural production factors, such as certified seeds, sanitary treatments, fertilization and cultural improvements, aspects that have been considered as well in this project proposal.

Figure 19 Agricultural yields with and without irrigation

RENDIMIENTOS DE CULTIVOS

No	CULTIVOS	SIN PROYECTO Kgr/Ha	CON PROYECTO Kgr/Ha	INCREMENTO [%]
1	Papa Miska	9.000	13.500	50,0%
2	Maiz Choclo	5.400	6.480	20,0%
3	Chala	6.000	7.200	20,0%
4	Maiz Grano	1.900	2.280	20,0%
5	Chala	5.000	6.000	20,0%
6	Haba Temporal	2.000	3.000	50,0%
7	Durazno	9.000	10.800	20,0%
8	Cebolla	19.500	23.400	20,0%
9	Alfaalfa	9.500	11.400	20,0%
10	Arveja Temporal	2.800	3.360	20,0%
11	Zanahoria	12.500	15.000	20,0%
12	Trigo	1.150	1.380	20,0%
13	Paja (manta)	2.200	2.640	20,0%
14	Tomate	10.000	12.000	20,0%

(*) Productos con un incremento del 50 % que responde a un criterio impulsor a estos productos para mejorar los rendimientos bajos y ampliar las areas cultivadas.

Food security

The majority of the food produced in Bolivia is grown by smallholder farmers, and 653,000 of these farmers supply 85 percent of Bolivia's food. Studies have shown that smallholder farmers are more land-efficient in food production than larger farms: Bolivian smallholders have food yields worth 2,344 USD per hectare, whereas larger farms only have yields of 521 USD per hectare[38]. Taking maize as an example, smallholder farmers produce yields of 3.9 tonnes per hectare, whereas larger farms produce 0.5 tonnes per hectare[39]. Smallholder farmers in Bolivia produce a diversified suite of crops (**Figure 20 Smallholder farm production (Source FAO: Smallholder Farmers' DataPortrait)**Figure 20).

[38] http://www.fao.org/3/i5251e/i5251e.pdf

[39] http://www.fao.org/3/i5251e/i5251e.pdf

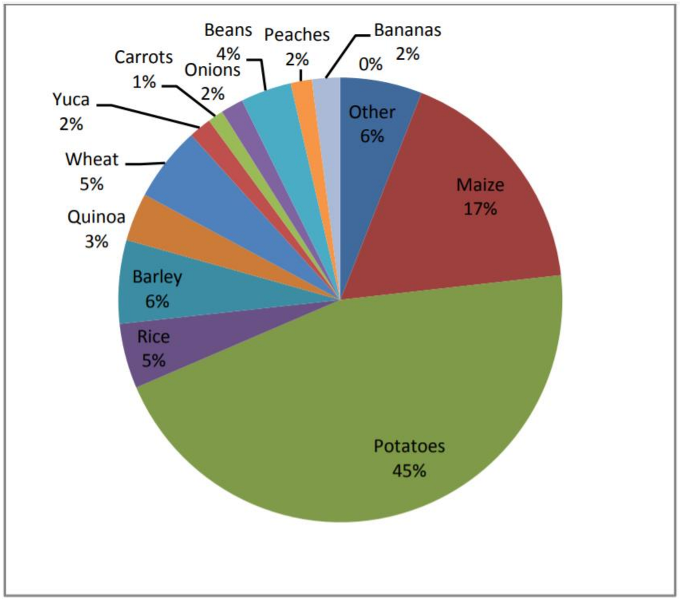

Figure 20 **Smallholder farm production (Source FAO: Smallholder Farmers' DataPortrait)**

While food security has generally been increasing in recent years, it is still below the world average in a number of indicators. The prevalence of undernourishment is at 15.5%[40]. Approximately 27% of children under the age of five are stunted due to chronic malnutrition, which is the second-highest rate in Latin America and the Caribbean[41]. At the same time, much of the diet of the Bolivian population is based around starchy and fat foods, so obesity is also a problem in the country. Compared to the other 112 countries of the Global Food Security Index, Bolivia is lagging behind in other indicators of food availability and quality as well.

Land tenure

Land tenure has been a particularly important issue in the history of Bolivia's agricultural development. By the early 1950s, just 6.3% of landowners had accumulated the possession and control of about 93 per cent of privately owned land. This led to a peasant revolution in 1952, which led to the 1953 land reform act that awarded land to the tiller, protected the rights of those living in indigenous communities, and set limits to the size of estates[42]. However, since then there have still been many debates and disputes over land tenure. In 1996 new legislation – the Ley INRA – was introduced to deal with the proliferating disputes seen mainly in the eastern lowlands as indigenous groups and those with little or no land protested their loss or lack of land. The Ley INRA of 1996 proposed to inspect, survey, map and register land and titles throughout the country and thus resolve disputes and give the rightful owners a title that would allow them to invest and develop their farms. Progress has been slow, though: by 2004 INRA only managed to process 6.44M hectares, out of more than 37M hectares of agricultural land, of which no less than 4.5M ha were awarded in just 55 TCO (Communal lands =Tierras Comunitarias de Origen) certificates[43].

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[40] https://foodsecurityindex.eiu.com/Country/Details#Bolivia

[41] https://www.iadb.org/en/news/webstories/2013-03-04/bolivia-fights-malnutrition,10320.html

[42] https://assets.publishing.service.gov.uk/media/57a08bbc40f0b652dd000e5c/IPPGDP21.pdf

[43] http://ndl.ethernet.edu.et/bitstream/123456789/26639/1/51.pdf.pdf#page=64

As a result of this process the new law is a ‘hybrid’, which only partly liberalizes the land market. It distinguishes between properties that conform to a ‘social function’ and those that have to comply with a ‘social-economic’ function. The first category includes the lands that should contribute to the well-being and economic development of their owners, according to the carrying capacity of the land:

- **The solar campesino, or residential plot**, which may not be subdivided or mortgaged but can under certain conditions be sold. An owner of the solar campesino does not pay land tax on it.
- **Small properties** that provide the owner and family with a livelihood and thus ensure their economic survival. These holdings, too, cannot be subdivided or mortgaged, but – again like the residential plot – may be sold under certain conditions, and are not subject to land tax.
- **Community properties**, which are collectively titled to the corporate unit for subsistence purposes. They cannot be sold, mortgaged or subdivided, nor do the owners have to pay land tax on such holdings.
- **Tierras comunitarias de origin**, which are the habitat of indigenous peoples (1⁄4 the original inhabitants) and communities, where they live according to their own forms of economic, social and cultural organization.

Lands that come under the rubric of a social-economic function should be dedicated to agricultural production, forestry, research, eco-tourism or biodiversity protection. In this category one finds the following kinds of unit:

- Medium-size agrarian properties, which can be sold and mortgaged and are subject to land tax.
- Commercial agribusiness enterprises, which can also be sold and mortgaged, and also have to pay land tax.

Technical support and extension institutes for farmers

Bolivia’s agriculture has suffered from some of the least advanced farming technology in South America and an insufficient network of research and extension institutions to reverse that trend[44]. In the 1980s, there was only one agricultural extension agent for each 7,000 farming households[45]. In the 2000s, a decentralized agricultural research and technology transfer system was established: the Bolivian System of Agricultural Technology (SIBTA). SIBTA tasked four regional foundations with identifying demands for research and development and directing funds to knowledge and technology providers. SIBTA also tasked the central government and Ministry of Agriculture with setting priorities and monitoring and evaluation activities. There has been debate about the way the Bolivian government has governed SIBTA among people working in and affected by the system as well as among government officials and donors. Some advocate for the government to take a stronger role, whereas others argue that the state should stay away from carrying out research and extension, as there are other independent agents who can provide these services in a more efficient way[46].

The migration of men and young people from rural to urban areas in Bolivia is high. This has resulted in women and the elderly having to take on a larger workload in agricultural activities, which has negatively

[44] http://countrystudies.us/bolivia/51.htm
[45] http://countrystudies.us/bolivia/56.htm
[46] https://www.ifpri.org/publication/innovation-systems-governance-bolivia

impacted smallholder farming productivity[47]. As men leave to seek wage labour, women tend to take over male responsibilities in the communities, which significantly increases female workloads but can also improve their access to community decision-making mechanisms. In contrast, it was not observed that men are becoming more involved in traditional female roles like domestic and reproductive tasks. These changes to gender roles are viewed by locals as more of a temporary arrangement than a permanent transition, since women are often viewed only as the man's "replacement" while he is otherwise unavailable. One survey of rural communities in Bolivia found that 31% of women live alone[48], so it has been assumed that the number of female-headed farms is around the same proportion. Even if they are not the heads of household, women are responsible for both productive and domestic activities: the same survey found that rural Bolivian women spend on average four hours a day to agricultural activities and seven hours per day to domestic tasks, for a total of 11 hours of daily work. Alternatively, men dedicate 5.4 hours a day to agriculture but only 1.4 additional hours a day to domestic tasks, for a total of 6.8 hours[49].

Specifically, the current perception and baseline of receiving technical assistance from the state are detailed below, considering the vulnerability of their agri-food systems to climatic phenomena.

Table 13 Baseline situation of Technical Assistance to farmers in the Macro region as has been discussed during the stakeholder engagements

What training and Technical Assistance (TA) services do you receive? How often and at what time? How is this TA provided?	Training is provided on the extension of knowledge and practices related to: - Improve agricultural production - Control pests and diseases. - Improve post-harvest practices Technical Assistance is received during the duration of the program/project, therefore, it is not continuous. Technical Assistance is received in groups and sometimes individually.
What results have you achieved with the training and TA received?	• - For some, the results are in process. • - Others see improvements "in quantity and quality". • - All recognize the presence of the State for the productive sector.
Who receives TA?	Interested families in the community receive TA. Everyone is socialized, but not 100% participate for different reasons (age, residents, not interested). Producer members of the association (men and women).
In what language is the TA provided?	• Spanish • Aymara • Quechua
Do you know of promoter farmers or others, who also give TA?	• - Some do not know. • - Others do know, and add that their services have a cost.
What do you recommend to provide	• - "Training and TA is good but it is not enough, we need to go deeper into aspects of drought, frost, hailstorms, floods, pests and diseases in order

[47]https://www.ifad.org/documents/38714170/39150184/Investing+in+rural+people+in+Bolivia_e.pdf/017f88cc-dd9a-4572-9b19-4646840b58d8
[48]https://openknowledge.worldbank.org/bitstream/handle/10986/27161/717360WP00PUBL00CC0Bolivia0English0.pdf
[49]https://openknowledge.worldbank.org/bitstream/handle/10986/27161/717360WP00PUBL00CC0Bolivia0English0.pdf

training and more sufficient TA?	for producers to then manage livestock health in coordination. As a community they also benefit from other collaborations." • - "Permanent presence of professionals who give permanent advice during the production cycle under technified irrigation systems, management and conservation of water sources." • - "That the TA be accompanied by the management capacity to solve other problems of the producers. For example, access to quality inputs (agrochemicals) to prevent the producer from being subject to deception by counterfeiters in the market, because they sell adulterated products." • - "The project also has to support in the market, so that we can market in a better way."

Finally, the demand for capacity building for farmers in the Valles Macro-region is also reflected in the systematization of the FPIC process and the Indigenous Peoples Plan.

4. Capacity building approaches in the agriculture sector

Farmer Field Schools (FFS)

Farmer Field Schools (FFS) is an extension methodology designed by FAO in the late 1980s. The implementation of a FFS seeks to develop participants' confidence through learning by discovery, fostering their appropriation as farmers who investigate and find the answers for themselves in their own production systems. To achieve this, the use of simple and practical tools and instruments that are applicable to the conditions of their plot-community is fundamental in the development of the process.
The Field School (FFS) is an agricultural extension methodology whose main objective is that farmers become experts in the management of productive items by obtaining the required information and making decisions. ECA is based on local conditions and is developed through participatory training through theoretical concepts and field practices. The Farmer Field School (FFS) is a methodology that places the farmer at the center of the training process to ensure the relevance of the technology to his/her needs. FFS aims to provide agroecological education through participatory learning, in a way that supports integrated decision-making in crop management and innovation for sustainable agriculture. The most widely used definition is cited by FAO (2000) and defines FFS as: "A school without walls, where a group of farmers come together on one of their plots to learn how to farm. They learn how to be better farmers by observing, analyzing and trying out new ideas in their fields".

Consequently, the Field Schools become a methodological tool for training adults, whose principle is learning by doing and by discovery; the method integrates farmer and facilitator, applying the two-way link, adoption of theoretical knowledge and perception of practical knowledge through the use of simple methodological tools. The Field Schools are based on a formative, experiential and interactive concept, which is developed with a group of producers of a community, who with the help of a facilitator analyze and investigate in a practical way in their crops in order to diagnose the state of the same in order to establish priorities to achieve a better productive performance. A Field School is based on the need to integrate existing technical information with local knowledge through a series of practical exercises chosen by the farmers. This creates a synergistic group learning process that facilitates the adoption of technologies in the short term.

The fundamentals The Farmer Field School (FFS) is based on three fundamentals, namely:
- Learning-by-doing.
- Participatory action.
- Adult education.

Learning-by-doing: Learning-by-doing is a methodology that is based on experience and seeks concrete solutions to concrete problems. Learning should be planned with reference to people's daily life, seeking to develop their analytical and reflective capacity, so that they find solutions intelligently and not by impulse or mechanical action. Herrera (1995, quoted by Universidad Casa Grande) mentions that in order to solve problems, one must learn to manage, which implies planning, organizing, controlling and evaluating a job. In the field school, horizontal communication between technicians and producers is promoted; the aim is to build an open and trusting relationship that allows active and reflective learning, which is practical throughout the implementation stage. The field school is characterized by the application and validation of knowledge in the field.

Participatory research and action: Participatory research and action is a methodology that promotes the investigation of the local context, to analyze facts and generate solutions; all in a practical and participatory manner. The objective of this process is to achieve concrete actions and generate important transformations in the community, so that the inhabitants (men and women) are the protagonists.

Adult education: Adult education provides the FFS facilitator with guidelines for planning and developing field sessions.

In recent years, some field schools have been developed in the Macroregion of the Valleys, but these were transitory and insufficient for the climatic phenomena that are affecting the agrifood systems.

FFS create a learning platform lasting one or more production cycle. Post-FFS activities ensure continuity at community level and allow groups to take leadership in rural development, interacting with community members, producer organizations and outside agencies to build local institutions. FFS experiences globall have shown that FFS empower farmers to define local actions aimed at more sustainable and profitable agriculture[50].

Replication of good practices have been achieved through FFS experiences in other countries, because FFS typically work at multiple levels to build social and human capital and broaden their collaboration with other participatory, community-based initiatives, in the case of Bolivia the FFS will complement existing mechanisms such as technical Assistance and Rural Extension mechanisms that exist. By forming a network, FFSs can better share information, engage collectively, improve access to resources and markets, participate in community projects and articulate their interests to local leadership (advocacy and lobbying). The FFS networks also act like business units which provide a sustainable exit strategy from a project. Being part of an FFS network also will provide linkages to other service providers including the private sector and linkages to other farmer organizations, cooperatives, etc[51]. In Bolivia there exist

[50] FAO. 2019. Farmers taking the lead - Thirty years of farmer field schools. Rome
[51] FAO, 2016. Farmer Field School Guidance Document. Planning for Quality Programme

already cooperatives, and these will be further strengthened through the FFS, forming networks for example with other cooperatives outside of their communities

National School of Irrigation and Universities

The National School of Irrigation (ENR) provides different training modules that respond mostly to the demands of the sectors, but there is a need to consolidate an offer that responds to the goals and objectives of irrigation systems, but above all to the mitigation and adaptation to climate change in order to advance in nutritional food security. Undoubtedly, these activities are carried out with the support of the SEDERIs (Departmental Irrigation Services), public and private universities.

A reference in irrigation capacity building is the Bolivian Catholic University "San Pablo", which includes irrigation in its professional training approach, oriented to the development of management and production capacities under irrigation, meeting the demand for technicians in the management of new and old irrigation systems, especially in view of the accelerated pace at which new technologies are being implemented. The evaluation studies on the performance of irrigation systems carried out in recent years confirm that irrigation efficiency with respect to new or old systems may present problems in some cases, in the transition to new irrigated crop practices.

The incidence as an academic entity in the irrigated agricultural sector acquires greater relevance in view of the increasing complexity of the new irrigation infrastructure that the sub-sector plans to promote in the coming years, especially the larger regulated or technified irrigation systems. The management requirements of these systems have proven in different cases to be beyond the management capacities of the irrigation organizations to whose administration they have been consigned.

For its part, ENR implements an annual training program for irrigation system promoters, whose objective is to involve local stakeholders so that they can play an important role in decision making in sustainable processes of water resources management training with an integral vision in their different parent, native, neighborhood and family organizations. It intends to train a greater number of Bolivians involved in the irrigation sector in the coming years.

The Plurinational System of Competency Certification with the support of the National School of Irrigation has developed occupational standards for irrigation users in order to identify occupational profiles that allow the development of competency certification processes and thus dignify workers in the occupational sectors in the area of irrigation.

It is worth mentioning that Supreme Decree No. 29876 of December 24, 2008, establishes the institutional framework for the operation of the National System of Competency Certification, through which the State formally recognizes the labor competencies of individuals, regardless of the socio-economic and cultural context in which they were acquired. Law No. 70 of Education "Avelino Siñani - Elizardo Pérez" of December 20, 2010, Article 82, states that the "State will recognize the labor and artistic skills of Bolivian citizens who developed skills in practice throughout life, through the Plurinational System of Certification of Competences". Undoubtedly, this recognition will allow acknowledging the technical skills of producers in irrigated production, irrigation systems, maintenance and management, integrated watershed management, among others.

Access to financing for smallholder farmers

Financial services for smallholder famers in rural Bolivia are limited. The country's National Development Plan recognizes limited financial assistance to poor smallholder farmers. As a result, the Government of Bolivia issued in August 2013 a new Financial Services Law (No. 393), aimed at regulating financial services to attend this economic segment. The law seeks to foster financial services especially for the farming segment, fishermen, timber producers, artisans and the micro, small and medium enterprise, mainly in rural and peri-urban areas of Bolivia. This law also enables the Government of Bolivia and the local Financial Supervisory Authority to determine credit allocation per economic segment and potentially establish caps on interest rates and fees charged by MFIs. This may in turn be a challenge for the MFIs if they are unable to cover their operational costs with mandatory loan portfolio allocations and caps to interest rates, hence limiting sustainability.

The main market barriers for the deployment of microfinance products for adaptation are:

1. the lack of knowledge and information on adequate adaptation measures;
2. the need for adequate financing mechanisms in terms of maturity and interest rates both for the clients and the MFI;
3. MFI risk perception of adaptation finance; and
4. Regulatory impacts of the new Financial Services Law if interest rates caps are established.

Despite their socioeconomic importance, smallholders tend to have little or no access to formal credit, which limits their capacity to invest in the technologies and inputs they need to increase their yields and incomes and reduce hunger and poverty, both their own and that of others. Financial institutions interested in serving this market face myriad risks and challenges associated with agricultural production and lending, including seasonality and the associated irregular cash flows; higher transaction costs; and systemic risks, such as floods, droughts, and plant diseases. While these challenges apply generally to smallholder lending, it is more challenging to serve some smallholders than others. With smallholders in "tight" value chains— where a strong relationship between the farmer and buyer exists—such relationships can be leveraged to reduce the costs and risks of agricultural lending through shared credit screening, monitoring and collection, and/or use of alternative collateral, such as sales contracts. The challenges become greater when trying to provide financing to smallholders in "loose" value chains, particularly for low-value staple crops, where farmers do not have strong relationships with other value chain actors. The challenges are compounded when trying to provide financing to subsistence farmers.[52]

The spectrum of financial institutions involved in financing agriculture is broad, and seemingly reflects the farmers' segmentation as the importance of banks diminishes as the farmer clientele becomes smaller in scale, and as value chains become less defined. The relative importance of different channels for different segments, however, is for the most part unknown. In particular, the evidence of microfinance institution (MFI) involvement in financing commercial and semi- commercial smallholders remains anecdotal and lacks specifics on what makes MFI lending to these segments feasible, and what restricts their reach and effectiveness.

[52] IFC, 2014. Access to Finance for Smallholder Farmers: Learning from the Experiences of Microfinance Institutions in Latin America.

An estimation of agriculture access to credit in the target communities

Overall, the targeted region of Valles accounts for 55.2% of the Agricultural and Livestock Productive Units (ALPU), which combine households (96%) and private companies (4%). In total it was estimated that in 2013, there were 459,966 ALPUs in the Valles[53] and that same year, at national level, there were 4500 commercial credits granted for agricultural and livestock purposes with on average over USD 152 000 per credit. The latest data available shows an increase of the number and amounts of credits granted at national level, but they still are relatively marginal, 6159 credits granted with on average over USD 387 000 loaned. In addition, in 2017, less then 7% of the total commercial credits granted for agricultural and livestock purposes were destined to the Valles[54]. However, there are also public agricultural and livestock loans, and loans granted by commodity traders or input providers and, adding the commercial loans in 2013, at national level they were estimated at a total of 73 413 loans. From those, only 11.9% were granted to groups and therefore 88.1% to individuals, and 71.7% were granted by financial institutions[55]. At a national level, in 2017, 95.8% of the credits required a collateral[56]. In addition, for each agricultural and livestock loan requested, 29.9% were not granted and only 23.1% of them where not granted due to the lack of collaterals[57].In 2013, the proportion of ALPUs that had adopted agricultural insurances was of 3.1% at national level. Although it is still very low in the Valles region, in the departments which have areas that are part of the Valles, they are quite heterogenous: Chiquisaca 17.9%, La Paz 0.8%; Cochabamba 2.1%; Tarija 0.3%; Santa Cruz 0.4%.[58]

Access to markets for smallholder farmers

The market assessment performed focused on a selection of agricultural products representative of two areas of economic and social interest: (i) products considered food security products (part of the "basic family basket"), and products intensive in generating employment and foreign exchange (raw materials for processing, agro-industry and/or export). The following is a detailed diagnosis of each group of products or individual products of high impact in the Macro-region of the Bolivian Valleys.

Potatoes, tomatoes, onions and carrots.

This group of products corresponds to family agriculture and semi-technified medium agriculture (particularly in the valleys of Santa Cruz and the Cochabamba valleys), and therefore faces greater susceptibility in the production and marketing links. The details are shown in the tables below.

In this group of products, there is a technological barrier that determines low productivity levels in almost all production units and areas that produce these products. In addition, there is a recurrent threat of imported or smuggled products that can have a dramatic impact on the sector, which can also be attributed by the COVI-19 pandemic.

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53 https://cipca.org.bo/publicaciones-e-investigaciones/cuadernos-de-investigacion/desmitificando-la-agricultura-familiar-en-la-economia-rural-boliviana-caracterizacion-contribucion-e-implicaciones

54 https://siip.produccion.gob.bo/noticias/files/BI_30012020ddaeb_2ccedla.pdf

55 https://ipdrs.org/images/en_papel/archivos/CENSO-AGROPECUARIO-BOLIVIA_final.pdf

56 https://datacatalog.worldbank.org/search/dataset/0038648

57 https://ipdrs.org/images/en_papel/archivos/CENSO-AGROPECUARIO-BOLIVIA_final.pdf

58 https://ipdrs.org/images/en_papel/archivos/CENSO-AGROPECUARIO-BOLIVIA_final.pdf

Table 14 Trends in prices and markets

Quantitative information	Historical evolution	Trends
Prices and markets	There was evidence of fluctuations in vegetable prices to the final consumer due to speculative traders who increased demand due to nervousness and uncertainty in the first 2 weeks of the quarantine. Retail prices increased by more than 50% in some cases, such as in the city of La Paz, In the case of tomatoes, prices rose from 3.5 Bs/pound to 6 Bs/pound, the same phenomenon occurred in almost all departments.	In winter, the price trend for vegetables is upward between May and August. However, given the dependence on intermediaries, poor transportation and very perishable products, it is expected that significant post-harvest losses are likely, that the price to the farmer will be depressed, but the price to the final consumer will rise more than expected for the season. On the other hand, international market surveys point to a probable excess production/demand in neighboring countries, so there is concern over the high import pressure of surplus agricultural products from Peru, Chile and Argentina, which implies a possible additional impact on domestic production.

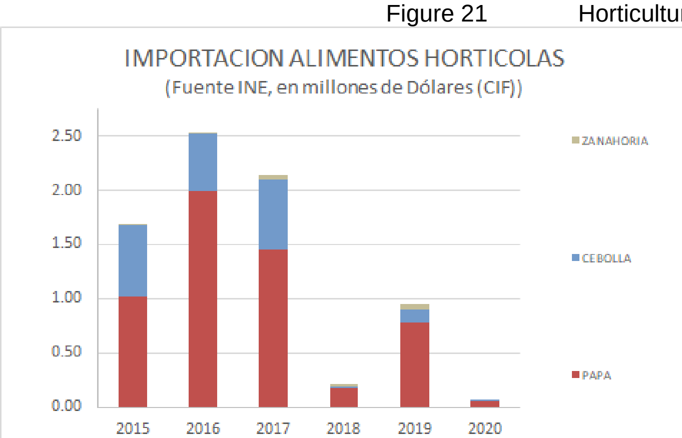
Table 15 Trends in horticultural production in Bolivia

Qualitative data (key informants, perceptions)	Actual state as a result of the COVID-19 pandemic	Possible trends
Inputs to the supply chains	n the initial phase of the pandemic, producers, mostly family farmers, were more focused on harvesting than planting, which is why they did not feel the impacts of increases or shortages of inputs such as herbicides and fertilizers.	As time goes by, possible increases in inputs may influence the production, influencing its costs. In the case of potato, the Dirección Nacional de Semillas DNS - INIAF reports a significant deficit of certified seed that becomes a direct threat for the following seasons. This deficiency is partially compensated with the use of informal seed (from the producer) and with the legal possibility of authorizing the use of emergency seed ("category B") as a palliative that does not guarantee the best productivity. A summary of the availability of certified seed of the main varieties is presented below.
Production process	Production process In the four horticultural products chosen, the volume produced during these months managed to supply the domestic market, a situation that may change due to a delay in the winter season. In the case of potatoes, it should be noted that the highlands and valleys are no longer the largest producers and Santa	Winter production faces regular constraints that may be exacerbated by the epidemic. In the production link, one of the most sensitive factors could be the timely availability of labor and/or the fear or risk of contagion. Particularly in the case of family farming, if one or more members of the family fall ill, the entire farming activity could be suspended.

	Cruz is the largest producer with the best yields.	
Marketing (distribution chain)	It faces major problems in the marketing and distribution chain because a) the products are highly perishable, b) rudimentary packaging and storage technology, c) high susceptibility to post-harvest pests, and d) high dependence on transporters, rescuers and various intermediaries. The supply of tubers, vegetables and fruits in wholesale markets nationwide faced significant transportation and distribution problems due to lack of transportation and closure of wholesale markets.	The greatest sensitivity in the coming months is linked to the means of transport and marketing channels for horticultural products, particularly for small farmers. It will be essential to develop and regulate mobile markets, zone markets and wholesale markets (which are the most at risk of contagion). The greatest probable threat is the importation of horticultural products from neighboring countries, which could foreseeably dump excess foreign production on the domestic market.

Bolivia faces a recurrent net import of horticultural products, considering that legal imports are a minor fraction of smuggled imports. In the event of an eventual reduction in domestic production or a fall in international prices, the most likely immediate scenario is that of a significant negative flow (expected through smuggling) from Peru, Chile and/or Argentina.

Figure 21 Horticultural Food Imports in Bolivia



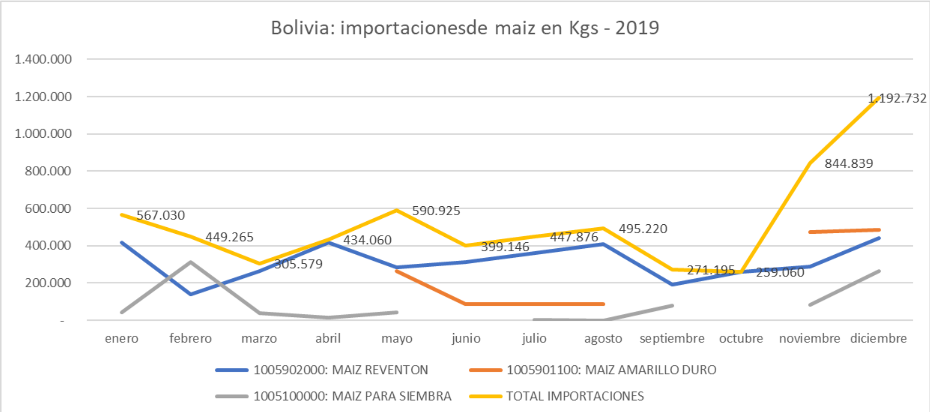
Fuente: INE 2020. Elaboración propia. El año 2020 solo se incluyen datos al mes de marzo.

Table 16 Trends for the corn supply chain

Qualitative data (key informants, perceptions)	Actual state as a result of the COVID-19 pandemic	Possible trends
Inputs to the supply chains	The inputs required for the crop season were already applied because the corn crops were already in the final stage of development prior to harvest when the COVID-19 epidemic began.	The supply of inputs such as fertilizers and agrochemicals may be affected in terms of their availability for the following crop season, due to the possible closure of foreign markets or a rise in the import prices of these inputs. The supply of seeds for the following season could also be affected by the deficit in the production of quality seeds

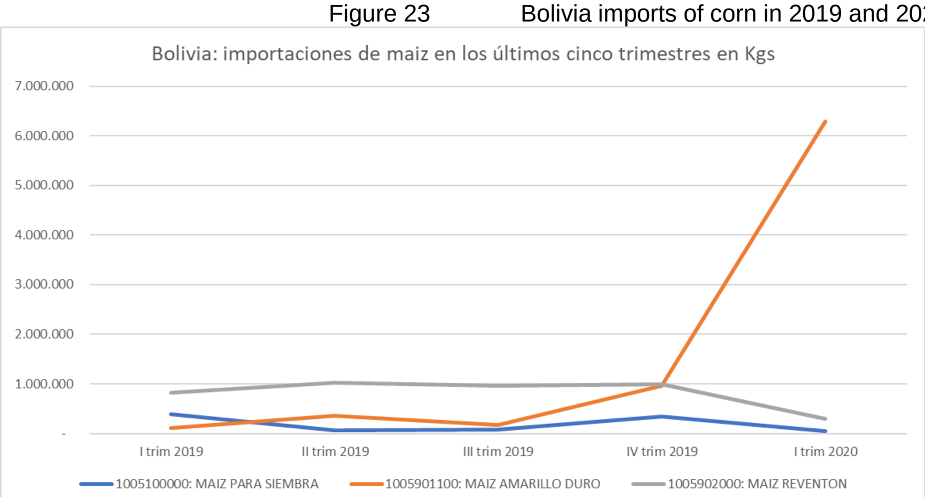
		produced in the country, which could be mitigated by seed imports.
Production process	In recent years there has been an increasing decline in corn production, possibly due to farmers switching to soybeans and sugarcane. Despite the above, the summer season corn crop is looking favorable in Bolivia. According to ANAPO estimates, the area planted to corn decreased for the third consecutive year, mainly due to the shift of farmers to soybeans, which are more remunerative and are planted at the same time. For the 2020 summer corn production to be harvested starting in April, a lower planted area is preliminarily projected to be offset by above-average yields. Planting of 2020 winter crops, including corn, is expected to take place between mid-April and June. Weather forecasts for that period point to a higher probability of above-average rainfall in most producing departments: Santa Cruz and Beni.	Production for the following agricultural season and those of winter could be affected depending on the level of intensity and permanence of the COVID-19 epidemic, due to labor shortages, because of the fear of technicians and farmers specialized in soil preparation, due to the risk of contagion and casualties of people specialized in the processes mentioned above, particularly in those family farming systems.
Marketing (distribution chain)	International corn prices in April 2020, fell for the third consecutive month, due to a context of lower demand for animal feed; lower demand and production of ethanol-based fuels; the fall in oil prices; abundant availability for export and good production prospects in South America; factors that exert a strong downward pressure on corn prices (AMIS, 2020). Corn supply in Bolivia depends in part on corn imports, mainly from Argentina and Brazil. As shown in the graph below, imports peak in May and most imports are concentrated at the end of the year, mainly November and December. The flow of imports in the last 2 years is shown in Figure 22. A strong increase in imports of hard yellow corn can be observed in the first quarter of 2020.	Adequate corn supplies are anticipated from an import perspective. Summer growing conditions in Brazil (larger season) are favorable with an increase in total planted area compared to last season. As of early February, the official forecast puts 2020 corn production at about 100 million tons, similar to 2019's record output, as expected drought-related yield declines in some regions are likely to be offset by a slight increase in planted area (FAO, 2020). In Argentina, corn production in 2020 is likely to reach a level close to the 2019 record high, Planting is forecast at 9 million hectares. Reflecting above-average plantings and good yield prospects, the initial forecast for corn production in Argentina in 2020 is set at a level similar to the all-time high of 2019.

Figure 22 1Bolivia corn imports in Kgs - 2019



Fuente: INE. Elaboración propia

Figure 23 Bolivia imports of corn in 2019 and 2020 in kg.



Fuente: INE. Elaboración propia

Situation in the domestic market

The domestic market supply was already experiencing problems before the sanitary crisis. There were strong regional asymmetries in supply, high logistics costs and archaic marketing structures that prevented balanced trade between producers and consumers, resulting in low purchase prices for the former and high purchase prices for the latter. Although information systems and a series of logistical supports have been developed, distortions have in fact increased in almost all agricultural and livestock markets. These distortions have created privileged groups of producers, asymmetrical price structures and increased the cost of seeking information.

Before the onset of the sanitary emergency, efforts were being made to eliminate some of these distortions, for example, the National Logistics Council, which, however, was more export-oriented. The creation of the Committee for the fight against smuggling, however, has tried to protect the highly distorted local market. The best defense for Bolivian producers is to increase their productivity, which is still far from being achieved.

The sanitary emergency interrupted many of the actions that were being carried out. In addition, in the face of the emergency, there was competition among producers to access better forms of marketing.

The implementation of mobile markets from the beginning of the pandemic in several departments fulfilled the objective of decongesting the influx of people in the markets. However, it was observed in the markets that most of the traders did not comply with the biosecurity measures; therefore, the authorities exercised greater control in wholesale and retail centers for the sale of food products. The monthly variation of the main prioritized products of the basic family food basket is summarized in the following table at the final consumer level. The potential for farmers to bring their products directly to the consumer was also affected, which caused prices to the final consumer to decrease considerably.

Table 17 Retail price variation by the Ministry of Agriculture for 2020 – main products for family households in Bolivia
Note: The meaning of the colors in the tables below: red color: price increases, yellow color: maintains and green color: decreases prices.

		El ALTO			LA PAZ			COCHABAMBA			SANTA CRUZ		
PRODUCTOS Y SUS CARACTERISTICAS	UNIDAD	14-05-20	21-05-20	VAR %	14-05-20	21-05-20	VAR %	14-05-20	21-05-20	VAR %	14-05-20	21-05-20	VAR %
TUBERCULOS - RAICES													
Papa Desiree (Mediana)	@	42.50	42.50	0,00	40.00	46.00	15,00	36.50	36.50	0,00	32.00	36.38	13,69
Papa Huaycha o Imilla (Mediana)	@	33.75	35.00	3,70	34.33	40.00	16,52	32.50	29.00	-10,77	36.75	39.50	7,48
HORTALIZAS													
Cebolla cabeza Roja (Mediana)	6 lb.	9.25	9.25	0,00	10.17	9.50	-6,56	9.00	9.00	0,00	10.50	10.00	-4,76
Tomate Perita Híbrido (Mediano)	lb.	3.38	3.38	0,00	3.58	3.58	0,00	2.58	2.58	0,00	3.44	3.69	7,27
Zanahoria (sin clasificar)	Kg.	2.33	2.33	0,00	2.85	2.33	-18,13	3.00	3.00	0,00	4.09	4.50	10,11
FRUTAS													
Banana Cavendish (Mediana)	25 unid.	10.50	10.00	-4,76	12.50	12.50	0,00	11.00	11.00	0,00	14.06	14.85	5,63
Limón Sutil (Mediano)	25 unid.	15.25	16.50	8,20	16.33	17.33	6,10	15.50	15.50	0,00	11.25	12.00	6,67
Limón Tahití (Mediano)	25 unid.	19.00	19.00	0,00	14.92	14.92	0,00	16.00	15.50	-3,13	12.25	12.13	-0,98
Mandarina Criolla (Mediana)	25 unid.	10.00	10.00	0,00	13.04	10.00	-23,31	10.00	9.00	-10,00	11.00	11.00	0,00
Naranja Injerto (Mediano)	25 unid.	17.00	15.00	-11,76	12.67	15.00	18,42	10.00	10.00	0,00	n.i.o.	13.13	
Piña Pucallpa (Mediana)	unid.	10.00	13.50	35,00	8.89	9.50	6,87	6.50	6.50	0,00	6.38	6.88	7,84
Plátano (Mediano)	25 unid.	15.00	15.00	0,00	15.50	15.50	0,00	13.50	13.50	0,00	16.15	16.42	1,68
CARNES - HUEVOS													
Carne de Pollo entero eviscerado	Kg.	9.25	8.50	-8,11	10.02	8.80	-12,18	7.50	7.25	-3,33	7.31	7.82	6,98
Carne de res (Corte Chuleta)	Kg.	35.75	35.00	-2,10	32.33	31.00	-4,12	31.00	31.00	0,00	27.60	27.60	0,00
Carne de Cerdo (Corte Chuleta)	Kg.	14.00	15.00	7,14	14.75	16.00	8,47	18.00	19.00	5,56	22.75	21.13	-7,12
Huevo	Unidad	0.86	0.90	4,65	0.83	0.88	5,60	0.75	0.75	0,00	0.83	0.82	-2,00
AGROINDUSTRIALES													
Arroz de segunda	Kg.	7.00	7.00	0,00	7.94	7.94	0,00	6.33	5.67	-10,53	7.13	7.00	-1,82
Harina blanca IMPORTADO	Kg.	6.00	7.00	16,67	5.64	5.64	0,00	5.50	5.17	-6,06	4.38	6.00	36,99

PRODUCTOS Y SUS CARACTERISTICAS	UNIDAD	ORURO			TARIJA			SUCRE			POTOSI		
		14-05-20	21-05-20	VAR %	14-05-20	21-05-20	VAR %	14-05-20	21-05-20	VAR %	14-05-20	21-05-20	VAR %
TUBERCULOS - RAICES													
Papa Desiree (Mediana)	@	30.67	30.67	0,00	23.50	23.50	0,00	26.00	26.00	0,00	30.00	25.00	-16,67
Papa Huaycha o Imilla (Mediana)	@	31.67	34.00	7,37	106.00	106.00	0.00	34.33	34.33	0,00	37.50	37.50	0,00
HORTALIZAS													
Cebolla cabeza Roja (Mediana)	6 lb.	8.00	8.00	0,00	4.50	4.50	0,00	7.67	6.67	-13,04	4.50	4.50	0,00
Tomate Perita Híbrido (Mediano)	lb.	4.17	3.67	-11,88	1.50	1.50	0,00	2.45	2.39	-2,29	2.00	2.75	37,50
Zanahoria (sin clasificar)	Kg.	1.78	1.83	3,00	1.50	1.50	0,00	1.78	1.67	-6,19	1.50	1.67	11,11
FRUTAS													
Banana Cavendish (Mediana)	25 unid.	9.33	9.33	0,00	13.54	13.54	0,00	6.33	6.33	0,00	13.00	12.00	-7,69
Limón Sutil (Mediano)	25 unid.	20.00	20.00	0,00	15.63	15.63	0,00	9.33	9.33	0,00	18.00	n.i.o.	
Limón Tahití (Mediano)	25 unid.	19.00	19.00	0,00	13.54	13.54	0.00	14.00	15.00	7,14	20.00	20.00	0,00
Mandarina Criolla (Mediana)	25 unid.	8.67	10.00	15,38	10.00	10.00	0,00	6.67	6.67	0,00	11.00	9.00	-18,18
Naranja Injerto (Mediano)	25 unid.	10.00	10.00	0,00	10.00	10.00	0,00	n.i.o.	12.00		10.00	10.00	0,00
Piña Pucallpa (Mediana)	unid.	12.00	12.00	0,00	13.50	13.50	0,00	8.67	8.67	0,00	11.00	11.00	0,00
Plátano (Mediano)	25 unid.	18.33	16.67	-9,09	25.00	25.00	0,00	8.67	8.67	0,00	25.00	25.00	0,00
CARNES - HUEVOS													
Carne de Pollo entero eviscerado	Kg.	9.33	9.92	6,29	9.50	9.00	-5,26	10.00	9.67	-3,33	8.50	9.00	5,88
Carne de res (Corte Chuleta)	Kg.	29.33	29.33	0,00	30.00	30.00	0,00	30.67	30.67	0,00	29.00	29.00	0,00
Carne de Cerdo (Corte Chuleta)	Kg.	22.00	22.00	0,00	21.00	21.00	0,00	19.33	20.00	3,47	16.00	15.00	-6,25
Huevo	Unidad	0.78	0.78	0,00	0.92	0.92	0,00	0.72	0.72	0,00	0.80	0.80	0,00
AGROINDUSTRIALES													
Arroz de segunda	Kg.	7.00	7.00	0,00	6.50	6.50	0,00	7.00	7.00	0,00	5.67	5.67	0,00
Harina blanca IMPORTADO	Kg.	5.33	5.33	0,00	6.00	6.00	0,00	6.00	6.00	0,00	5.00	5.00	0,00

Fuente: OAP- MDRyT

Based on information from OAP, it is known that wholesale prices for two of the selected products are as follows.

Table 18 Wholesale prices in central cities (may 2019 – May 2020) Bolivia for main agricultural products
Note: Meaning of the colors: red color - price increase and green color - price decrease.

PRODUCTOS Y SUS CARACTERISTICAS	UNIDAD	La Paz			Cochabamba			Santa Cruz			Global		
		Mayo 2019	Mayo 2020	VAR %	Mayo 2019	Mayo 2020	VAR %	Mayo 2019	Mayo 2020	VAR %	Mayo 2019	Mayo 2020	VAR %
TUBERCULOS - RAICES													
Papa Huaycha precio mayorista	@	31.94	26.11	-22.33	26.07	23.75	-9.77	24.56	32.52	24.48	27.52	27.46	-0.23
Papa Huaycha precio minorista	@	35.11	37.54	6.47	34.31	31.33	-9.51	32.23	37.67	14.44	33.88	35.51	4.59
Papa Desiree precio mayorista	@	27.22	37.55	27.51	35.47	26.86	-32.06	19.04	26.50	28.15	27.24	30.30	10.10
Papa Desiree precio minorista	@	41.80	42.61	1.90	37.85	36.50	-3.70	23.12	34.34	32.67	34.26	37.82	9.41
TUBERCULOS - RAICES													
Cebolla cabeza Roja precio mayorista	@	43.81	12.86	-240.67	33.64	17.68	-90.27	35.62	22.50	-58.31	37.69	17.68	-113.18
Cebolla cabeza Roja precio minorista	@	58.41	45.06	-29.63	54.17	36.00	-50.47	42.37	43.00	1.47	51.65	41.35	-24.90
Tomate perita hibrido precio mayorista	Lb.	1.37	2.89	52.60	1.27	2.22	42.79	0.77	2.67	71.16	1.14	2.59	56.17
Tomate perita hibridoprecio minorista	Lb.	2.00	3.64	45.05	1.74	2.78	37.41	1.69	3.67	53.95	1.81	3.36	46.18
Zanahoria precio mayorista	@	23.00	13.13	-75.17	18.89	13.12	-43.98	26.04	13.50	-92.89	22.64	13.25	-70.89
Zanahoria precio minorista	@	34.54	32.01	-7.90	39.42	34.50	-14.26	55.13	47.93	-15.02	43.03	38.15	-12.80

Fuente: Elaboración propia con datos de OAP- MDRyT

5. Climate change profile

Altitudinal gradients and the orographic configuration in Bolivia determine the different climate variations throughout the region. These orographic and climate features also determine the principal ecosystem zones in Bolivia: the Puna highland grasslands; the tropical humid montane forests of the Yunga; the Tucumano forest; the humid to sub-humid semi-deciduous forests of Chiquitania, or the deciduous Chaco to the south (Navarro and Ferreira 2004). Temperature disparities across the country are primarily the result of altitudinal differences, with average lowland temperatures of approximately 15°C higher than in the highlands. Nevertheless, Bolivia is located sufficiently far from the equator to experience seasonal temperature variations. Maximum daily temperatures are several degrees higher in the southern summer than they are in the southern winter (Seiler et al. 2013a).

The climate in different parts of Bolivia is determined by altitude and orientation with respect to the flow of humidity coming from the Amazon basin.

Precipitation is influenced both by orographic altitude and slope orientation with respect to seasonal air flowing toward the hinterlands of the country, which are part of the South American monsoon system (Garreaud et al. 2009). During the southern summer, a movement toward the southern zone of tropical convergence reinforces the winds blowing from the east, which, due to the north-south barrier formed by the Andes, are diverted, further strengthening their movement toward the south. This situation brings extremely high rainfall rates to the slopes north of the Andes, reaching as much as 5000 mm/year (SENHAMI 2009), especially in the cloud forest located above 2,100 m and up to the timber line typically located at 3,200 to 3,400 m (Gerold et al. 2008). Nevertheless, this flow of humidity is also responsible for most of the annual precipitation in the remaining climate zones, of which the northern lowlands along the southwest edge of the Amazon basin receive most of the precipitation, followed by the more arid lowlands in the south, the foothills facing the east of the southern Andes, and, finally, the Altiplano (highlands) (Seiler et al. 2013), since most of the atmospheric humidity is lost as it rises before reaching the highest flatlands. Nevertheless, within the Altiplano, there is also a north-south gradient in precipitation, with the highest levels found around the Lake Titicaca area to the north. During the southern summer, the South American monsoon weakens and the winds from the west dominate, which, due to the barrier of the Andes mountains, bring very little humidity to the inland parts of the country. Rather, there is only precipitation when cold fronts from the south run up, occasionally, against warm tropical air masses (Garreaud et al. 2009, SENHAMI 2009).

On the inter-annual timescale, it was found that the climate in Bolivia is influenced by the El Niño-Southern Oscillation (ENSO) phenomenon, an irregular but predictable pattern of temperature fluctuations on the surface of the Pacific Ocean. Warm El Niño events tend to bring higher temperatures to the Altiplano (Garreaud et al., 2009; confirmed by Seiler et al., 2013a).

The impact of ENSO precipitation in Bolivia is less clear, because the country is located between a zone where precipitation descends during El Niño, along the equatorial portion of the Amazon basin, and a zone where precipitation increases during El Niño events, along the Atlantic coast to the south of the 20th parallel South (Garreaud et al. 2009). Notably, Seiler et al. (2013A) found greater annual precipitation during both warm events (El Niño) and cold events (La Niña) in the northern lowlands. This sits in clear contrast with the situation in the main Amazon basin, which exhibits the opposite trend for humidity convergence (and therefore precipitation) for the El Niño and La Niña events (Seiler et al. 2013a, higher values during La Niña and lower during El Niño). In fact, Ronchail and Gallaire (2006), and, earlier, Vuille et al. (2000), found this same pattern in the Amazon – greater precipitation in La Niña and less in El Niño, which is also observed in the Altiplano.

Annual precipitation across all of Bolivia showed a clear upward trend between 1965 and 1984 and a clear downward trend between 1984 and 2004, closely following Pacific Decadal Oscillation (PDO; Seiler et al. 2013a). The PDO is a pattern of sea surface temperature changes in the North Pacific, which shows remarkably slow variations (Barnett et al. 1999), for which there is still no physical explanation. The empirical correlation between the PDO and precipitation in Bolivia is caused primarily by rainfall in the northern lowlands during the southern summer, while the correlations are far less evident during the southern winter, or in the southern lowlands, the Altiplano, the Andes foothills (Seiler et al. 2013a). In recent years, the PDO has entered a positive phase that is expected to bring more rainfall to Bolivia (http://research.jisao.washington.edu/pdo/).

Historical climate trends

The climate of Bolivia depends fundamentally on the South American monsoon, the (mountainous) relief and the presence of the Amazon[59]. There are primarily two seasons: a wet or rainy season from November to March, and a dry season from May to October. In the Valles Macro-region, production systems vary according to altitude, ranging from 1,400 to 3,800 msl, with average annual precipitation from 300 to 1,200 mm/year, and average temperatures from 8° to 20°C. Most of the precipitation occurs in the wet season with around 60% to 80%, while in the dry season the annual precipitation ranges between 0% to 20%.

Bolivia is already experiencing climate change impacts[60], including a national average increase in temperature of 0.10°C per decade from 1939 to 2009, with an increase of 0.32°C in the last 25 years.[61] In comparison to local changes, trends in temperature at the national level[62] are less marked but nonetheless show an increase in standardized temperature anomalies, with most stations having detected a temperature increase of 0.1°C per decade during the period 1965 to 2004, corresponding to an overall increase of 0.4°C over the last 40 years.

The country is also experiencing rainfall variability. According to the baseline period 1961-1990, there is an upward precipitation gradient from the southwest (highlands) to the northeast (eastern plains). For the 1971-2000 period, precipitation decreased in the altiplano region in the southeast of the country (Potosí), in the northeast of the department of Oruro, in the southeast of the department of La Paz and

[59] Montes de Oca 1995; Marengo et al., 2004, Zhou & Lau 1998, Xue et al., 2006, Chou & Neelin, 2001

[60] Vuille, M., Bradley, R. S. (2000). Mean annual temperature trends and their vertical structure in the tropical Andes. *Geophysical Research Letters*, *27*(23): 3885-3888.

[61] GoB, 2020. Third National Climate Change Communication to UNFCCC. https://unfccc.int/sites/default/files/resource/NC3%20Bolivia.pdf

[62] Seiler, C., Hutjes, R. W., Kabat, P. (2013). Climate variability and trends in Bolivia. *Journal of Applied Meteorology and Climatology*, *52*(1): 130-146.

in the southeast of Chuquisaca (southern valley), and increased precipitation in the eastern plains (Chapare, Cochabamba) and in the Amazon (Pando). For the period 1981-2010, a decrease in precipitation is observed from the southwest (altiplano), the northeast of the department of Tarija and the southwest of the department of Cochabamba (northern valleys). On the other hand, an increase in precipitation in the eastern plains (Chapare, Cochabamba).[63]Existing assessments lack precise quantitative information on the historical trends for rainfall variability. Figures 14 and 15 show the baseline for temperature, precipitation and solar radiation for the project area

Extreme events

Bolivia has historically been exposed to floods and droughts. Approximately four out of 10 people live in flood-prone plots, and more than 16 percent of the population live in areas at risk of drought.[64] During the last decade, the magnitude of Bolivia's weather patterns has undergone significant changes; extreme rainfall, floods, landslides, and droughts have been pushing the poorest and most marginalized communities beyond their ability to respond. Bolivia's worst drought for 25 years took place between November 2016 and February 2017. A state of emergency was declared after over half of Bolivia's. About 339 municipalities declared their own emergencies related to the drought. Official estimates suggested that the drought affected 125,000 families, 290,000 hectares of agricultural land and 360,000 heads of cattle.[65]

Events such as El Niño and La Niña drastically modify climatic behavior in many regions of the Bolivian territory. During El Niño, the Altiplano generally suffers a decrease in rainfall, while the lowland regions experience a relative increase in precipitation (which is already high).

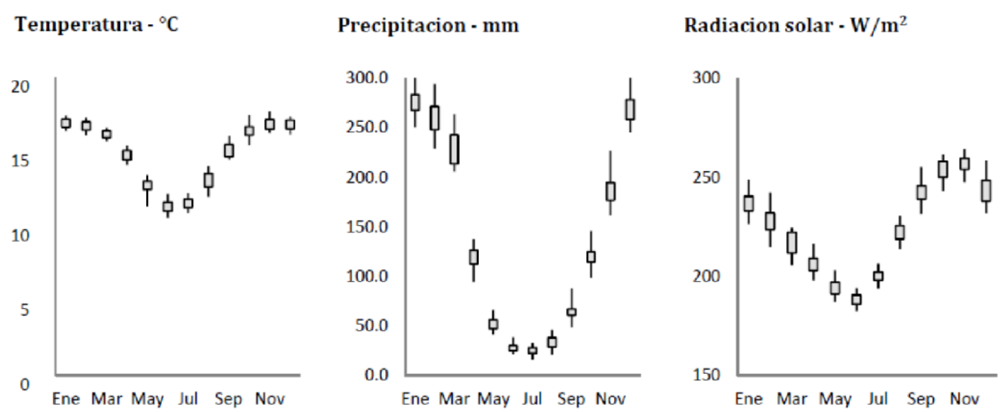


Figure 24 **Baseline for temperature, precipitation and solar radiation for the project area**

[63] GoB, 2020. *Ibid.*

[64] Estimates based on the Municipal Risk Index (MRI) developed by the Ministry of Development Planning (MPD) of Bolivia and the World Bank in 2012 (World Bank, 2014).

[65] The Guardian, 2016. Available online: https://www.theguardian.com/world/2016/nov/21/bolivia-drought-state-of-emergency-water-shortages

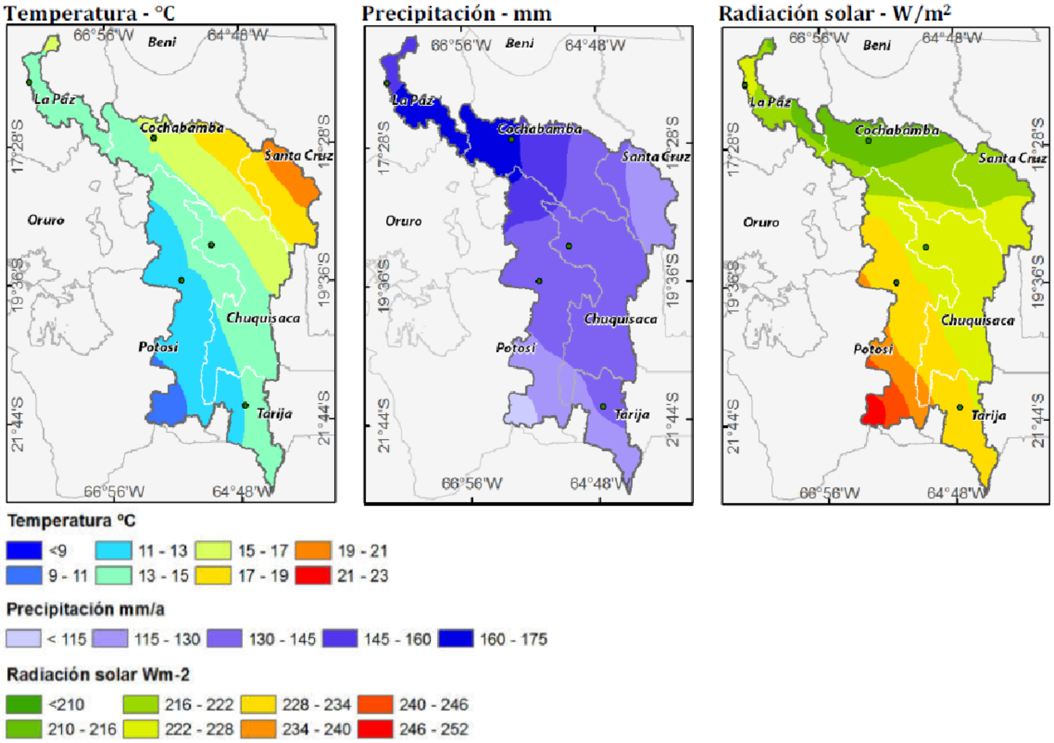


Figure 25 Baseline for temperature, precipitation and solar radiation for the project area

Evidence from the Central Valley of Tarija, demonstrated that in the last four agricultural seasons, frost and hail resulted in a reduction of between 12% and 39% of total production.[66]

The increase in the intensity and frequency of extreme weather events has become one of the main challenges for agriculture and has resulted in an increase in public spending on response and rehabilitation of productive capacities that is becoming unsustainable for the States.

On the other hand, each dollar invested in early action to prevent and mitigate impacts of an adverse climate forecast in the agricultural sector generates an estimated return of between US$2.5 and 7.1 in avoided losses and damages and added benefits. It is essential to develop public policies, institutional capacities and coordination mechanisms for DRM and climate change in the institutional framework that deals with agriculture and natural resources.

One of the key aspects for reducing the damage and economic losses resulting from disasters is to quantify these damages and losses. Knowing this reality promotes and informs the design and implementation of policies to reduce these impacts. Today, governments and multilateral organizations assess damages and losses when major disasters occur, but they do not use methodologies that allow them to capture the specificities of the agricultural sector. It is therefore difficult to achieve accurate assessments. Moreover, there is no capacity in place at the national level to do so systematically. As a result, data are usually only available for large-scale emergencies, and the real economic loss suffered by the sector is underestimated when all adverse events are added together.

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[66] Estudio de Identificación, Mapeo y Análisis Competitivo del Cluster de Uvas, Vinos y Singanis en Bolivia; CAF Alejandro Paniagua, 2012.

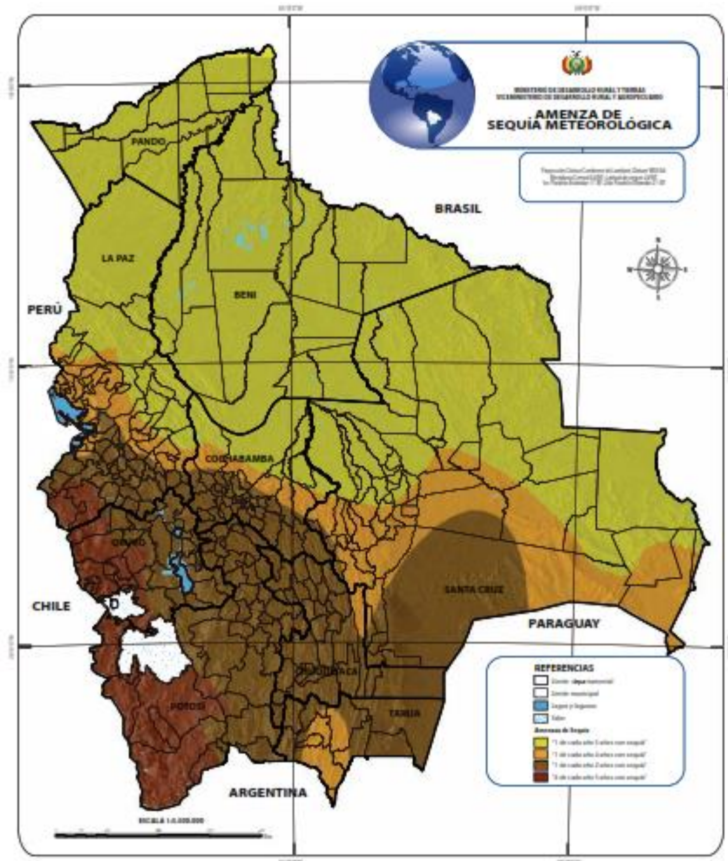
For this reason, the Food and Agriculture Organization of the United Nations (FAO) has developed a methodology to assess the damage and economic losses of small, medium and large-scale emergencies in all agricultural sectors (crops, livestock, forestry, fisheries and aquaculture). Since 2016 FAO has been supporting countries to become familiar with the methodology, understand its complementarity with other tools and how it facilitates the reporting of damage and loss indicators of the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals (SDGs).

To support capacity building in damage and loss assessment, FAO now offers a free online course in Spanish so that public service technicians, academics, insurance companies and other interested parties can learn more about the subject and understand its link with disaster risk management, emergency management, other methodologies and international frameworks. In addition, there is an advanced course that provides all the technical guidelines necessary for its practical application.

The findings reveal that in Bolivia there are currently many institutions that generate data on agriculture, forestry and fisheries, but there is still a need to harmonize methods and variables to consolidate the information or database to estimate these damages and losses.

In the last two decades, the agricultural sector and in particular family farmers and small and medium-scale agricultural and livestock sub-sectors have been affected by the aggravation of droughts, hailstorms, overflowing rivers, floods and frosts. These are causing diseases and pests that affect productivity conditions, consequently impacting food security, a situation associated with climate change and variability.

According to INSA (2021), the 2015-2016 agricultural season was the most affected by droughts in the regions of the valleys and the Altiplano. The following map shows the drought threat map.



Source: Atlas de Riesgo Agropecuario y Cambio Climático para la Soberanía Alimentaria (Agricultural Risk and Climate Change Atlas for Food Sovereignty).

The country's geographical location and the diversity of ecological levels determine a complex distribution of climate types, with social, economic and productive particularities. In this context, the agricultural sector is the most sensitive to the effects of disaster risk because it is highly dependent on interannual climate variability influenced by the ENSO phenomenon (El Niño Southern Oscillation) and by the incidence of extreme weather events due to climate change.

According to the MDRyT, and the analysis of events reported at the historical level, summarizes the total number of events recorded by department between 2002-2015 with a total of 4,770 events with an average of 530 records per year mainly due to hailstorms, frost, floods and droughts.

In this sense, within the framework of the methodology of damages and losses, information will be generated to make it possible to compensate the damage caused by the extreme weather phenomenon through the application of agricultural insurance, the generation of voluntary compensations, among other elements that restore at least the investment generated by the farmer in the affected agri-food production system.

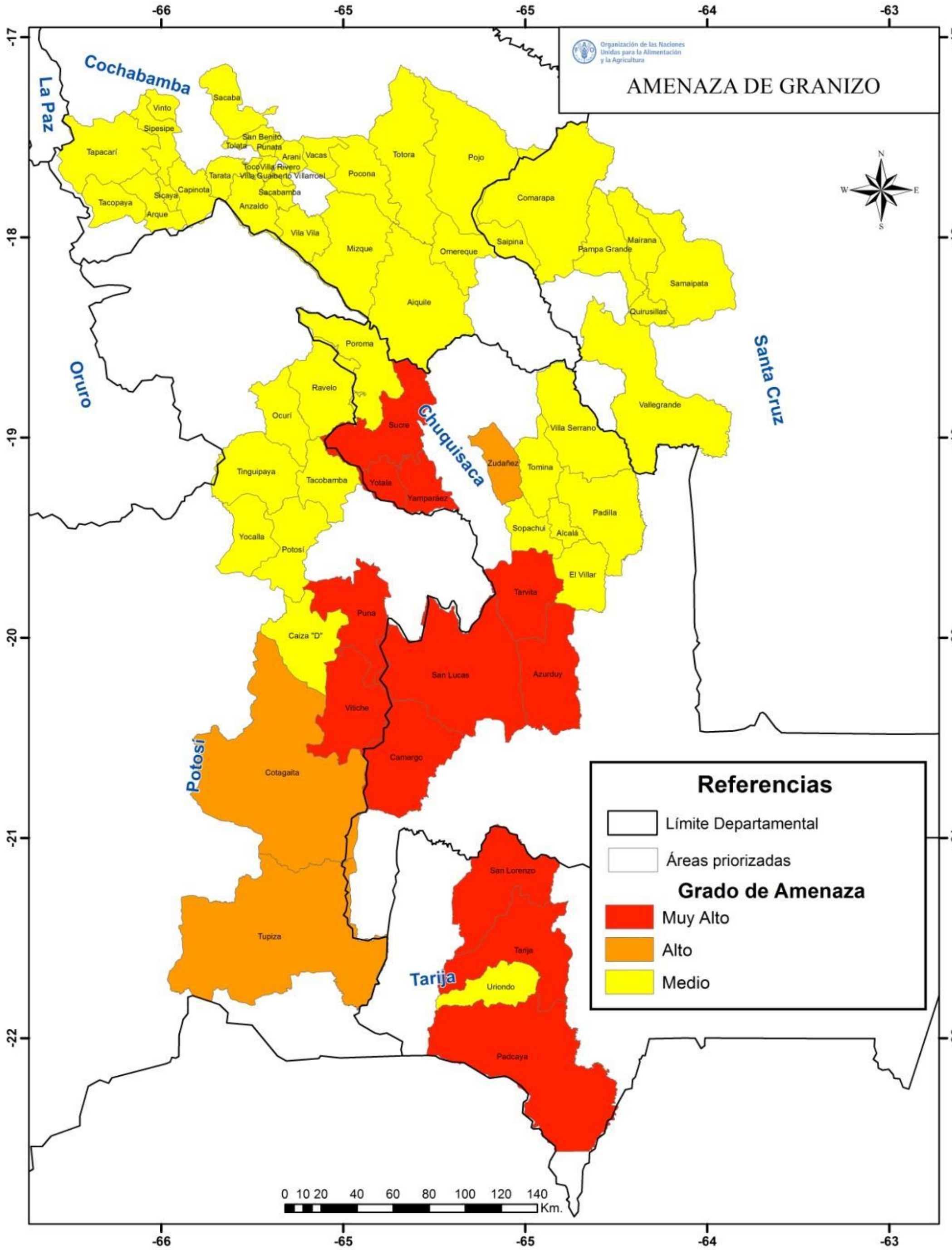


Figure 26 Map with municipalities in Valles Macro-region with highest risk to frost and hail.

6. Climate change projections: Data sources and methodology

For the purposes of this Feasibility Study, Fundación Amigos de la Naturaleza (FAN) prepared a climate analysis in 2018 and updated it in 2021 for the Valles Macroregion. The climate projections used for **baseline years 1980 to 2009** and projection **periods 2050 and 2100 using RCP4.5 and RCP8.5**.

Given the lack of regional models and the low representativeness, quality and consistency of climate data at meteorological stations, Global Circulation Models (GCM) were used to ensure technical relevance in the applied processes, where the mesoscale representativeness and resolution (1km2, ~ 30 arc seconds) of the climate dataset in the Valles Macroregion is fundamental in climate change impact assessments.

In a first phase, model screening was carried out, where the spatial patterns of about 30 of the 75 available models for the RCP4.5 and RCP8.5 scenarios (www.ccafs-climate.org/data_spatial_downscaling/) were evaluated in raster format from the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) database of the International Centre for Tropical Agriculture (CIAT) using Spatial downscaling Data where the data processing provides seamless and continuous future climate surfaces. These data are part of the Fifth Assessment Report (AR5) of the IPCC (Intergovernmental Panel on Climate Change), and for their selection they were prioritised under the criterion of highest correlation with the rainfall and temperature patterns of Bolivia and the Valles Macroregion, to guarantee the correspondence of the future scenarios with the very heterogeneous natural climate variability influenced by the Andean mountain ranges.

In the model selection process, a spatial analysis of climate patterns was carried out according to geospatial distribution, seasonal and temporal behaviour of temperatures (maximum, minimum and average) and precipitation, defining the degree of correlation with current climate trends using the SENAMHI weather station database (1971-2015) where the geospatial dimension of temperature climate patterns was analysed with data available from WorldClim (Global Climate Data). To better characterize and represent the spatial distribution of precipitation, the climate data measured by stations were adjusted with the NASA (National Aeronautics and Space Administration) Tropical Rain Measurement Mission (TRMM) mapping database. This adjustment process was done on a regional scale to calibrate the data with stations close to the Valles Macroregion because there are few weather stations operating in the area. The current climate patterns of temperature and precipitation called baseline or current climate were the basis for evaluating the models that best represent the climate changes and effects that will occur in the future, for which they were correlated with the SRES (Special Reports on Emission Scenarios) emissions projections for the year 2050 in the RCP4.5 and RCP8.5 scenarios generated by the Intergovernmental Panel on Climate Change (IPCC) (CGIAR, 2015).

Five models were selected from this analysis process due to their high correspondence with the current climate; 1) CSIRO-Mk3.6.0 (Collier MA et al. 2011), 2) HadGEM2-ES (Collins WJ et al. 2011), 3) IPSL-CM5A-MR (Dufresne JL et al. 2013), MIROC5 (Watanabe M et al. 2010), MRI-CGCM3 (Yukimoto S. 2012). This information base was integrated by determining for each pixel (1km2) the average of the five global atmospheric circulation models (GCM) of the CMIP5 experiment (Coupled Model Intercomparison Project) determining the monthly temperature (maximum, minimum, and mean) and monthly precipitation for the year 2050 (scenarios RCP4.5 and RCP8.5). The calculation of the average of the five selected models was carried out to moderate extreme trends, making it possible to better assess possible future impacts while maintaining the consistency of current trends in terms of rainfall and temperature distribution patterns that are highly variable due to the topography (from 600 to 6,300 m above sea level) and steep slopes (above 30 degrees of inclination), to which was added the expertise of climate knowledge in the region to ensure the consistency of results according to climatic heterogeneity of ecological floors in the Valleys Macro region.

Table 19 List of the selected climate models

Nombre del modelo	Institución	Resolución espacial en grados geográficos	Autores
CSIRO-Mk3.6.0	Commonwealth Scientific and Industrial Research Organisation and the Queensland Climate Change Centre of Excellence	1.875 x 1.875	Collier MA et al. (2011) The CSIROMk3.6.0 Atmosphere-Ocean GCM: participation in CMIP5 and data publication. MODSIM 2011, Perth, 12–16 December 2011
HadGEM2-ES	Met Office Hadley Centre	1.2414 x 1.875	Collins WJ et al. (2011). Development and evaluation of an Earth-System model-HadGEM2. GMD 4(4):1051–1075.
IPSL-CM5A-MR	Institut Pierre-Simon Laplace	1.2587 x 2.5	Dufresne JL et al. (2013). Climate change projections using the IPSL-CM5 Earth System Model: from CMIP3 to CMIP5. Climate Dynamics, 1-43.
MIROC5	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies	1.4063 x 1.4063	Watanabe M et al. (2010). Improved Climate Simulation by MIROC5: Mean States, Variability, and Climate Sensitivity. J. Climate, 23, 6312–6335.
MRI-CGCM3	Meteorological Research Institute	1.125 x 1.125	Yukimoto S (2012). A new global climate model of Meteorological Research Institute: MRI-CGCM3 – Model description and basic performance. J. Meteorol. Soc. Jpn., 90a, 23–64

Current trends and projected climate changes in Valles Macroregion

Mean annual temperature

In the Valleys Macroregion, the historical average monthly temperature is between -5°C and 25°C. The lowest temperatures of the year occur between May and September. The climate change scenarios show significant increases in the annual average temperature, mainly in the valleys where it will reach 25°C (RCP4.5) and 28°C (RCP8.5) of annual average temperature, meaning an approximate increase of up to 2.5°C (RCP4.5) and 3.4°C (RCP 8.5) until the year 2050, with a greater increase at the end of the dry season. These trends will undoubtedly impact the natural ecology of ecosystems and the production systems of local populations.

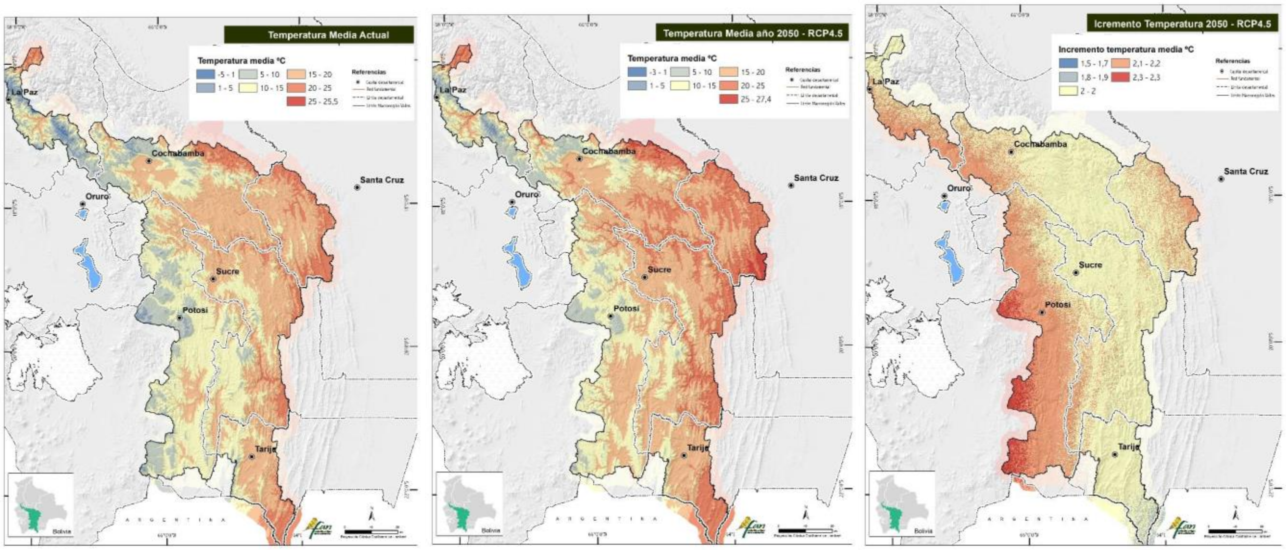


Figure 27 Baseline and climate scenarios for temperature according to RCP 4.5: (a) Mean temperature for baseline 1950 to 2000, (b) climate scenario for mean temperature for 2050 and (c) Change in temperature for 2050 in the Valles Macro-region.

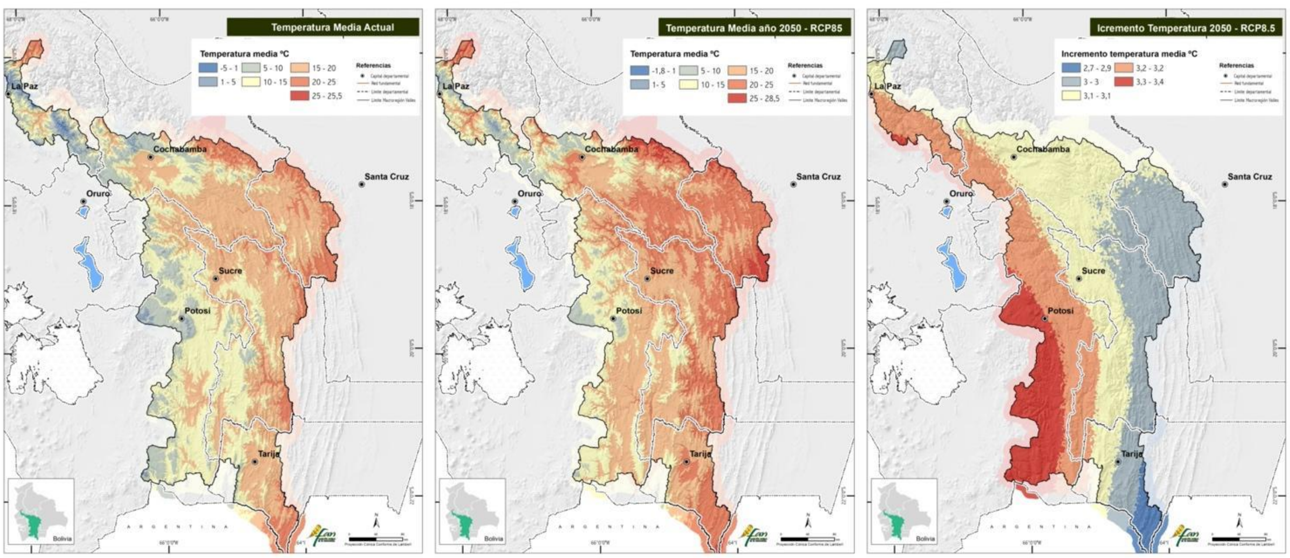


Figure 28 Baseline and climate scenarios for temperature according to RCP 8.5: (a) Mean temperature for baseline 1950 to 2000, (b) climate scenario for mean temperature for 2050 and (c) Change in temperature for 2050 in the Valles Macro-region.

Precipitation

The precipitation follows a pattern of higher rainfall in the northern region of the Valles Macroregion. The areas with the highest rainfall are concentrated in the Carrasco protected area and in the southern region of the Chapare, where it usually exceeds 2,500 mm per year. In the highlands, the preponderant rainfall is less than 600 mm per year. In the middle zone, from 600 to 900 mm per year, and in the lower part, in the valleys, rainfall is between 900 and 1,200 mm per year. By 2050, rainfall is expected to decrease by up to -21% according to the RCP4.5 scenario and -29% according to the RCP8.5 scenario. The current precipitation tends to decrease by an average of -17%, this trend will become more pronounced by 2050 and will make water supply critical.

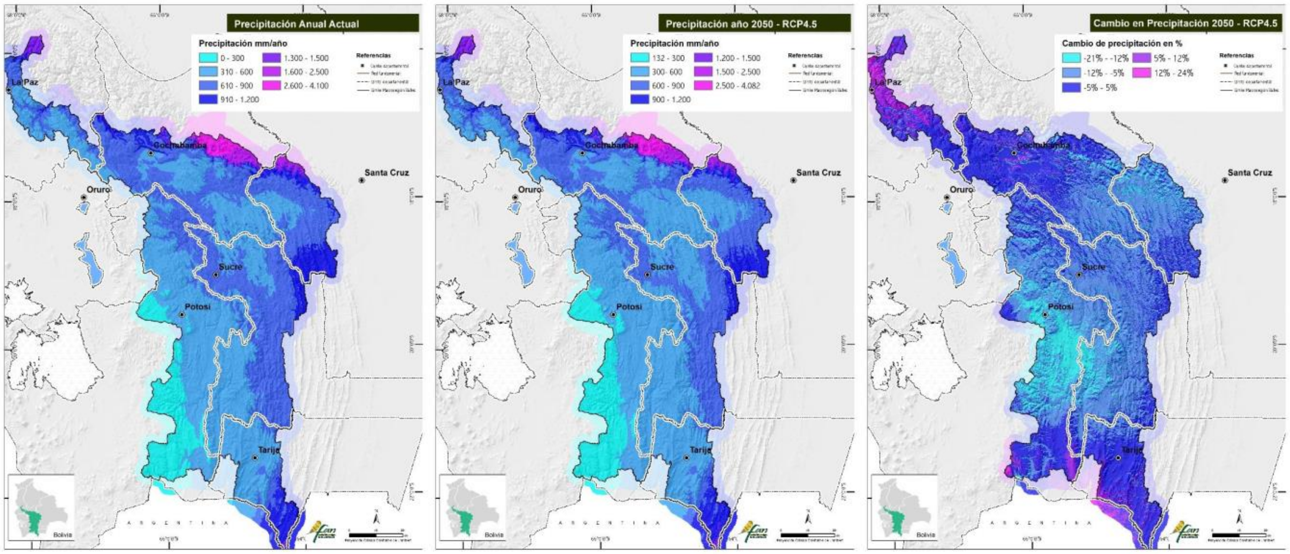


Figure 29 Baseline and climate scenarios for precipitation according to RCP 4.5: (a) Mean precipitation for baseline 1950 to 2000, (b) climate scenario for annual precipitation for 2050 in the Valles Macro-region.

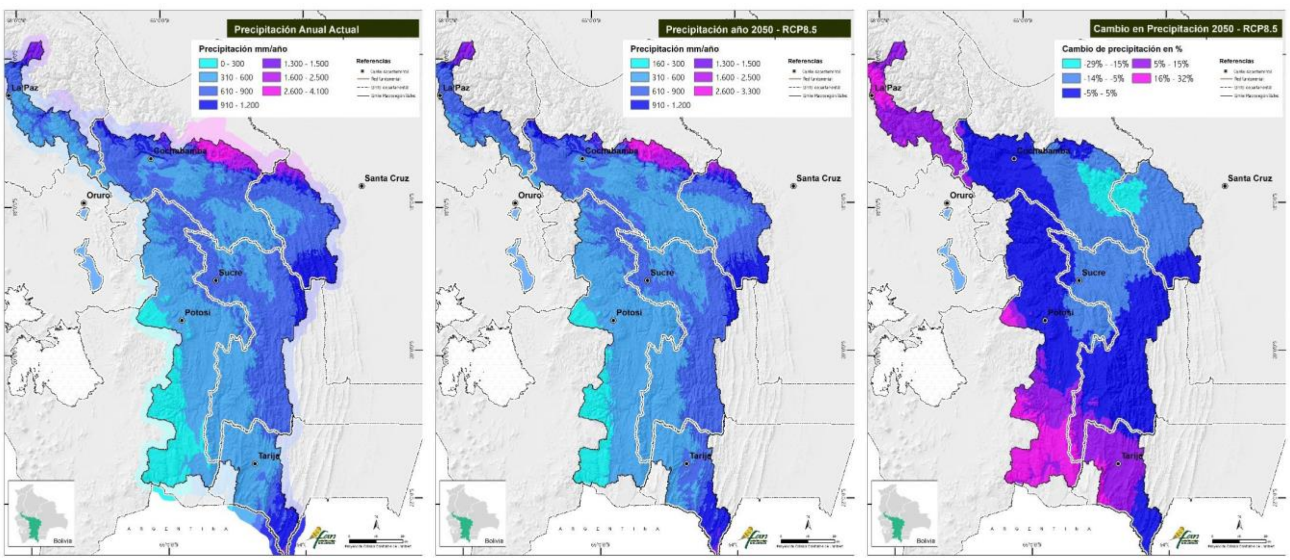


Figure 30 Baseline and climate scenarios for precipitation according to RCP 8.5: (a) Mean precipitation for baseline 1950 to 2000, (b) climate scenario for annual precipitation for 2050 in the Valles Macro-region.

Water balance

The determination of areas with greater and lesser water availability was carried out by calculating the water balance using a hydro climatic algorithm based on a mathematical model that relates the volume of water precipitated on the land surface to the volume of water evaporated from the soil and vegetation (transpiration). The geospatial representation of the water balance determined for the Valleys Macroregion uses the distribution of precipitation and temperature at monthly and annual levels, determining evapotranspiration and runoff according to the hydrological response at a pixel scale of 90 m spatial resolution according to the different types of vegetation, which play a fundamental role in the interception of rainfall and infiltration of water into the soils. Evapotranspiration (ET), a fundamental component of the water cycle, is a physical process that combines two processes; evaporation from the soil and from the surface covered by plants through transpiration from plant leaves.

The water balance determined for the Valles Macroregion follows the water balance equation (GUGK and Academy of Sciences of the USSR, 1964; Poveda et al, 2007; Spickenbom, 2016 unpublished), which in addition to combining precipitation and temperature factors, includes variables such as solar radiation (mm/day) determined in GIS according to the roughness of the altitudinal floors, the crop and vegetation coefficient according to water requirements (according to FAO guidelines), average wind speed (m/s) and minimum relative humidity.

Evapotranspiration and its natural behaviour patterns are closely related to the temporal dynamics of temperature and vegetation. In the current scenario, this process reaches up to 1,300 mm/year in regions such as the High Valley of Cochabamba, the central valley of Tarija and the central and western regions of the Valley Macroregion. The increase in temperature is altering the natural dynamics of evapotranspiration due to the accelerated evaporation of moisture from soils and vegetation, resulting in scenarios where accelerated moisture loss will generate a high water deficit and an imbalance in the water cycle. By 2050, evapotranspiration is projected to undergo changes towards 40% increase under RCP4.5 and 50% increase under RCP8.5, meaning that ecosystems will release more moisture causing imbalances in infiltration and runoff processes.

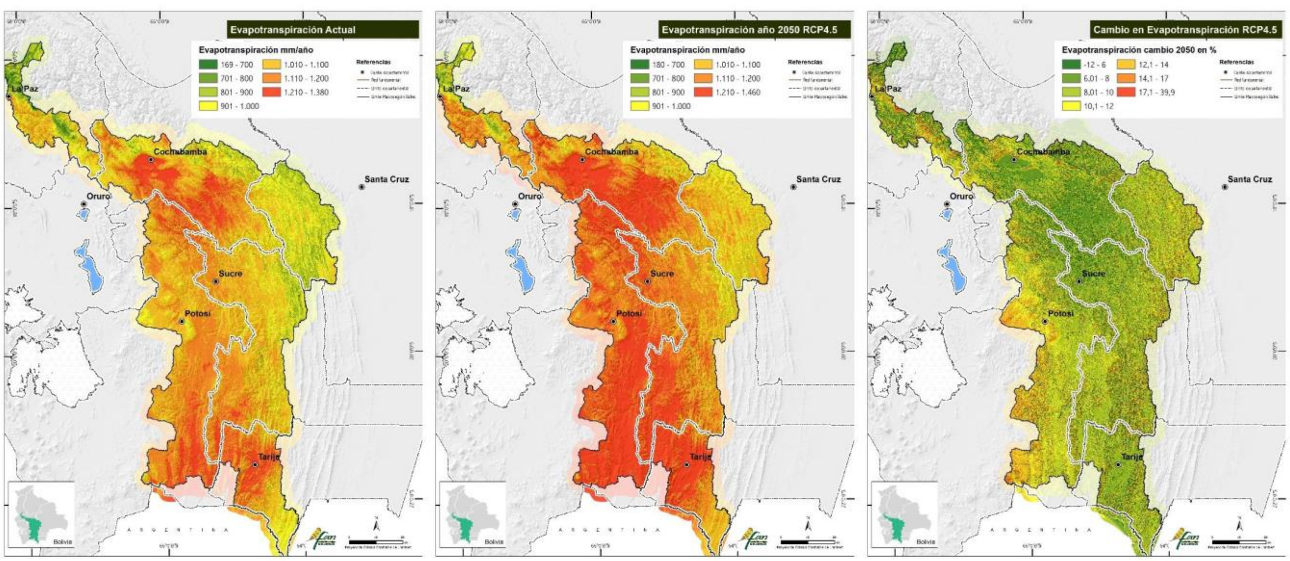


Figure 31 Baseline and climate scenarios for water balance according to RCP 8.5: (a) Water balance for baseline 1950 to 2000, (b) Water balance for 2050 in the Valles Macro-region.

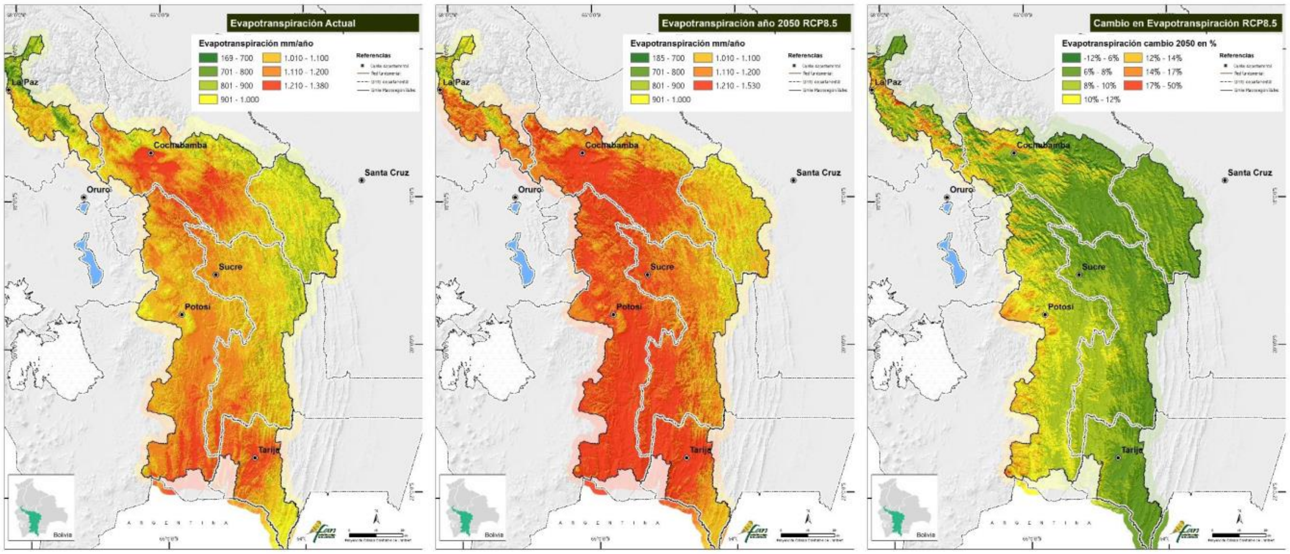


Figure 32 Baseline and climate scenarios for water balance according to RCP 8.5: (a) Water balance for baseline 1950 to 2000, (b) Water balance for 2050 in the Valles Macro-region.

Both the valleys and the highlands, made up of mountains and sierras, are home to Andean forests, many of which are sub-humid and characteristic of the region. The densest forests are densely concentrated in the northern region of the Yungas and to the east in the Bolivian-Tucuman jungle region. Forests throughout the region play a fundamental role in the generation and maintenance of the water cycle, forming important biological corridors, which provide important climatic benefits such as water uptake by plant interception processes, and infiltration of water into the soil profiles through the roots; in the wet season, the forest strata contribute to the generation of a positive and/or surplus water balance.

For production, water availability is fundamental, mainly for crops that contribute to food security in the region, therefore, the results reflected through the current water balance delimit areas of high importance according to surplus water levels (greater than 400 mm/year) located mostly in the northern and eastern region of the study area. The water balance highlights the preponderant water deficit in the Valleys Macroregion, currently up to -1,000 mm/year and this will become more critical reaching -1,240 mm/year in the RCP 4.5 scenario and -1,250 mm/year in the RCP8.5 scenario, mostly exacerbated in the highlands.

The vulnerability of the water provision and the agricultural (crops and livestock) sectors to climate change impacts is high[67] since hydrological cycles are highly impacted by rainfall and temperature variability.[68] Recent studies predict that the crop and livestock sectors will be among the most affected, facing losses of 6-14% of sectoral GDP.[69] This is anticipated primarily due to the predicted declines in productivity, which for a number of key staple crops could reach 17%[70]. Smallholder farmers are particularly vulnerable as their current crop yields are very low —the average potato yield is 5.7 t/ha, the lowest in the Andean region; and the average maize yield is only 2.2 t/ha[71]. These impacts are exacerbated with unsustainable land use change (e.g. particularly deforestation), and management (e.g.

[67] PNUD (2011). Tras las huellas del cambio climático en Bolivia: estado del arte del conocimiento sobre adaptación al cambio climático, agua y seguridad alimentaria. La Paz: PNUD.
[68] Íbid footnote 23.
[69] ECLAC (2014). Social Panorama of Latin America 2019. Santiago de Chile: CEPAL.
[70] Rambal et al. (2015). Garantía de Acceso al Agua como un Derecho Fundamental. Madrid: Rambal.
[71] Ministerio de Medio Ambiente y Agua (2017). Plan Plurianual de Riego 2017-2020.

intense mono-cropping) because of the deterioration of ecosystem functions that they foster, decreasing climate resilience, particularly in regards to water and nutrient cycling.

7. Hydrological balance

Data and methodology

The hydrological modelling is based on a study conducted in November 2021, which used the methodology and input data of the Bolivian Surface Water Balance (BHSB) executed in 2017 under the leadership of the Ministry of Environment and Water (MMAyA).

The Bolivian Surface Water Balance was generated using the WEAP platform, which requires input data on climate, vegetation cover and soil. The BHSB was generated for the main macro-basins of the country including the Altiplano basin, the Plata basin, and the Amazon basin generating calibrated balances in 77 closing basins and reported in 96 hydrographic units according to the continental Pffastteter classification called Hydrobasin. Following is a summarized description of the data used and the methodological approach for the hydrological modelling. Detailed information is included in Appendix 3.

Precipitation and temperature

The meteorological grid developed for the surface water balance is based on the GMET methodology described in detail in Newman et al., 2015.[72] This methodology recognizes the inherent uncertainty of precipitation and temperature interpolation products due to sparse observations, representativeness of observations and measurement errors. Recognizing this uncertainty, the proposed method produces a daily time-step precipitation and temperature ensemble based on existing observations.

A total of 384 individual temperature and precipitation stations were considered for interpolation. The data from these stations were processed and filled in. GMET was run for the territory of Bolivia using these stations to obtain a final product of a spatial resolution of 0.05° (cell) at daily time scale for the hydrological period 1980-2016 which implies starting in September 1980 and ending in August 2016. The method followed the guidance of Clark and Slater (2006). Spatially Correlated Random Fields (SCRFs) were used to generate the ensemble for each day independently for each of the variables: precipitation, mean temperature and diurnal range (difference between daily maximum and minimum temperature). Using SCRF allowed more extreme events than observations to occur in sections of the grid where there are no observations. This is a key point with respect to any scheme based on interpolations where each grid point is constrained by the maximum value of the observations, which is not always correct and even worse in terrain with a lot of orographic influence. **In total 30 monthly ensemble members were developed for the period 1980-2016 with their mean and standard deviation.**

In addition to the stations used for the grid, 131 stations were obtained for validation, which include less than 15 years of data and were discarded for use in the GMET run because of their short duration shorter than the 1980-2016 period required for this study. Since these stations were not used in the GMET algorithm, but were used for the validation step, then the total number of stations for grid validation was 384+131 = 515. To increase the accuracy and quality of the GMET estimate over the Bolivian domain, some stations were added in a buffer zone outside the Bolivian territory. These stations included meteorological stations in Brazil, Paraguay, Argentina, Chile and Peru. In addition, in the northwestern part of Bolivia where there are no stations inside or outside Bolivia, 12 Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) sampling points were added to the GMET run to increase its quality using satellite-based precipitation data (Figure 33).

[72] Newman et al., 2015

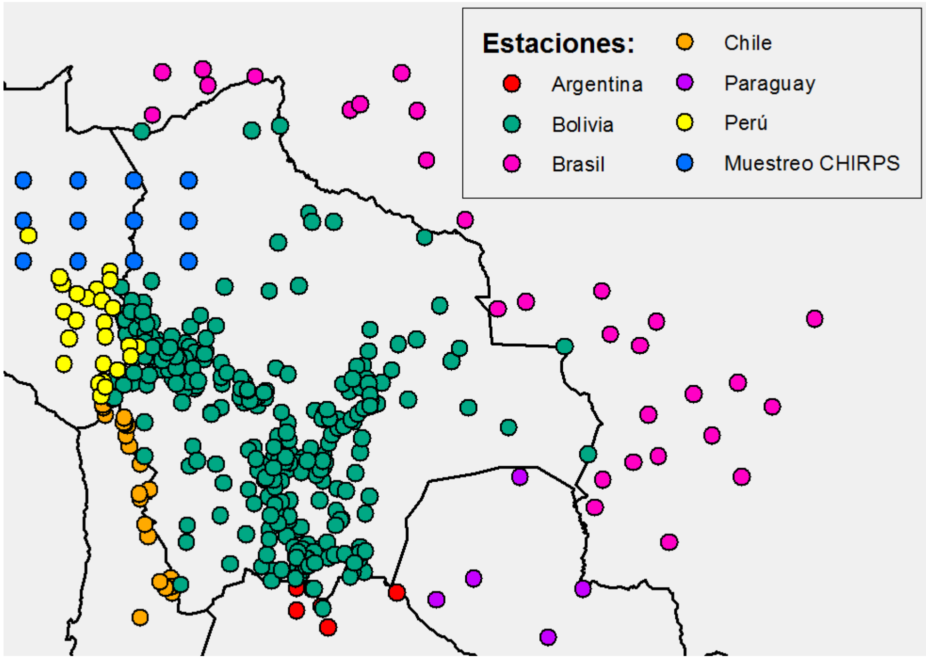


Figure 33 GMET validation stations inside and outside Bolivia, including CHIRPS sampling (Source: MMAyA, 2017)

Evapotranspiration

The WEAP hydrological model, Soil Moisture (SM), for estimating ETP uses the modified version of the Penman-Monteith method for a 0.12 m high crop or grass with a surface resistance of 69 s/m, and is defined as follows (Maidment, 1993):

$E_{rc}=\frac{\Delta}{\Delta-\gamma^*}(R_n-G)+\frac{\gamma}{\Delta-\gamma^*}\frac{900}{T+275}U_2 D$ where:

E_{rc} = Reference evapotranspiration, mm dia^{-1}.
R_n = Net radiation exchange for crop cover, mm dia^{-1}
G = Measured or estimated ground heat flux, mm dia^{-1}
T =Average air temperature, °C
U_2 = Wind speed at 2 m height, m s^{-1}
D = Vapour pressure deficit, kPa
Δ = Slope of vapour pressure curve, kPa $°C^{-1}$
γ = Psychometric constant, kPa $°C^{-1}$
$\gamma^*=\gamma(1+0.33 U_2)$

The method requires data on radiation, mean air temperature, atmospheric humidity, and wind speed. According to Allen, Pereira, Raes, & Smith (1998) the use of mean temperature instead of maximum and minimum temperature results in a lower saturation pressure, hence a lower vapour pressure deficit, which results in the underestimation of reference evapotranspiration. On the other hand, it is common not to have measured solar radiation data. The WEAP SM uses the Angstrom formula that relates solar radiation to extraterrestrial radiation and the relative duration of insolation, the algorithm can be found in Maidment (1993) and Richard G Allen et al (1998). To estimate radiation the WEAP SM requires latitude and cloud fraction data, the latter given by the relation n/N where n is the actual insolation duration [hours] and N is the maximum possible insolation duration [hours].

When measured atmospheric humidity data (real daily average vapour pressure) is not available, it can be derived from other climate variables such as maximum and minimum relative humidity. The WEAP SM basically uses mean relative humidity and mean temperature to estimate the actual vapour pressure and the algorithms used can be found in Maidment (1993) and Allen et al. (1998). In summary, the following variables are needed to estimate reference evapotranspiration in WEAP SM: mean air temperature [°C], mean relative humidity [%], wind speed [m s^(-1)], cloud fraction, and latitude. The climatic variables have to be adjusted to a height of 2 m.

Due to simplifications of the input data, the reference evapotranspiration estimate may have inaccuracies, e.g. the use of mean air temperature may underestimate the ETP. Another disadvantage to consider is that the algorithm works on a daily level and when the input data are monthly, the WEAP SM repeats the value for all days of a given month.

In this context, when ETP estimates are performed internally in WEAP the Kc parameter should be considered as a correction factor and not necessarily with its original interpretation in the literature. In the specific case of this water balance study, the correction factor was defined based on comparisons of WEAP ETP results with other studies at both national and regional scales, where there is evidence that ETP estimates are relatively reliable. In addition, it was compared with the ETP estimated from evaporation data in tank type A.

Considerations on irrigation demand and land use changes over time in the WEAP model
Population demand is estimated according to data from the 2012 National Population and Housing Census, described in section 5.2. To simulate the change in irrigation demand, percentages of growth in coverage are assumed, according to (FAO, 2018)[73] two possible growth scenarios are handled, as shown in Table 20

Table 20 Percentage increase in agricultural coverage

Scenario	**Increase**
Toward Sustainability / RCP 4.5	4.80 %
Stratified Societies / RCP 8.5	17.60 %

In these scenarios, presented in FAO, 2018, the 2 scenarios have a number of assumptions, such as:
Toward Sustainability scenario: Land and water use Low-input processes lead water intensity to substantially decrease and energy intensity to substantially improve against the levels seen under the BAU scenario. Regarding land-use intensity, the quantity of land per unit of output drops with respect to current levels, thanks to sustainable agricultural intensification and/or other practices aimed at improving resource efficiency. This helps to preserve soil quality and restore degraded and/or eroded land. Agricultural land is no longer substantially expanded and land degradation is tackled. Water abstraction is limited to a smaller fraction of available water resources.

Water balance under climate change scenario

The projected water balance for 2050 is expected to result in a devastating water shortage in Bolivia. Sustained supply of water will be restricted to the areas with the highest vegetation cover in the Northwest and Southern regions of the Valles Macro-region. Changes to temperature and precipitation will include lags or delays in the onset of dry and wet seasons; this will modify the agricultural calendar in

[73] FAO. 2018. The future of food and agriculture – Alternative pathways to 2050. Rome. 224 pp. Licence: CC BY-NC-SA 3.0 IGO.

the Macro-region[74]. Figure 34 shows the current and projected water balance in the Valles Macro-region. Results from the modelling show that close to 90% of the region is at high to very-high risk of desertification[75].

The hydrological modelling carried out by FAN (2021) using WAEP, compares the hydrological demand and supply for the Valles Macro-region under climate scenarios for the period demand for the period 2036 - 2065, with the climate change scenarios: MIROC5 RCP_4.5 and MIROC5 RCP_8.5 in the Amazon region; CCCma-CanESM2 RCP_8.5 and ICHEC-EC-EARTH RCP_4.5 in the Plata region. For a detailed description of the methodology, data use and results see Appendix 3.

The average water supply in the Amazon region is equivalent to 1230.53 m^3/s, the irrigation demand was estimated at 438.80 m3/s and the population demand at 1.50 m^3/s, giving a total demand of 440.30 m^3/s. Figure 34shows the monthly distribution, where it can be observed that between the months of August to October the demand exceeds the water supply, generating a deficit of 12.91%. The average water supply in the La Plata region is equivalent to 253.32 m^3/s, the irrigation demand was estimated at 124.49 m3/s and the population demand at 0.57 m^3/s, giving a total demand of 125.06 m3/s. The analysis shows that between the months of June to November the demand exceeds the water supply, generating a deficit of 35.71%.

In the Amazon region the total demand for the current condition is 440.30 m^3/s (Figure 34a and Table 21a). For future conditions a population demand of 2.26 m^3/s is estimated, the irrigation demand according to the RCP 4.5 increase scenario is 457.76 m^3/s and for the RCP 8.5 scenario it is 508.31 m^3/s, resulting in a total demand of 460.02 m^3/s and 510.57 m3/s respectively. The water supply according to the MIROC5 RCP_4.5 scenario is 947.23 m^3/s, Figure 34a shows the monthly distribution, where it is observed that between the months of July to November the demands exceed the water supply, generating a deficit of 21.12 % for the RCP 4.5 increase scenario and 24.38% for the RCP 8.5 scenario. The water supply according to the MIROC5 RCP_8.5 scenario is 928.65 m^3/s, Figure 34a shows the monthly distribution, where it is observed that between the months of May to October the demands exceed the water supply, generating a deficit of 23.54% for the RCP 4.5 increase scenario and 25.85% for the RCP 8.5 scenario.

In the La Plata region the total demand for the current condition is 125.06 m^3/s (Figure 34b and Table 21b). For future conditions a population demand of 1.83 m^3/s is estimated, the irrigation demand according to the RCP 4.5 increase scenario is 129.87 m^3/s and for the RCP 8.5 scenario it is 144.22 m^3/s, resulting in a total demand of 131.70 m^3/s and 146.04 m^3/s respectively. The water supply according to the CCCma-CanESM2 RCP_ 8.5 scenario is 250.35 m^3/s. Figure 34 shows the monthly distribution, where it can be observed that between the months of May and November the demands exceed the water supply, generating a deficit of 36.13% for the RCP 4.5 increase scenario and 39.08% for the RCP 8.5 scenario. The water supply according to the ICHEC-EC-EARTH RCP_4.5 scenario is 226.23 m^3/s, Figure 34 shows the monthly distribution, where it is observed that between the months of May to November the demands exceed the water supply, generating a deficit of 37.02 % for the RCP 4.5 increase scenario and 39.89 % for the RCP 8.5 scenario.

[74] *Ibid*, footnote 7.

[75] Fundación Amigos de la Naturaleza (FAN) (2018). Estudio de la Línea Base Ambiental de la Macro-región Valles. Santa Cruz: FAN.

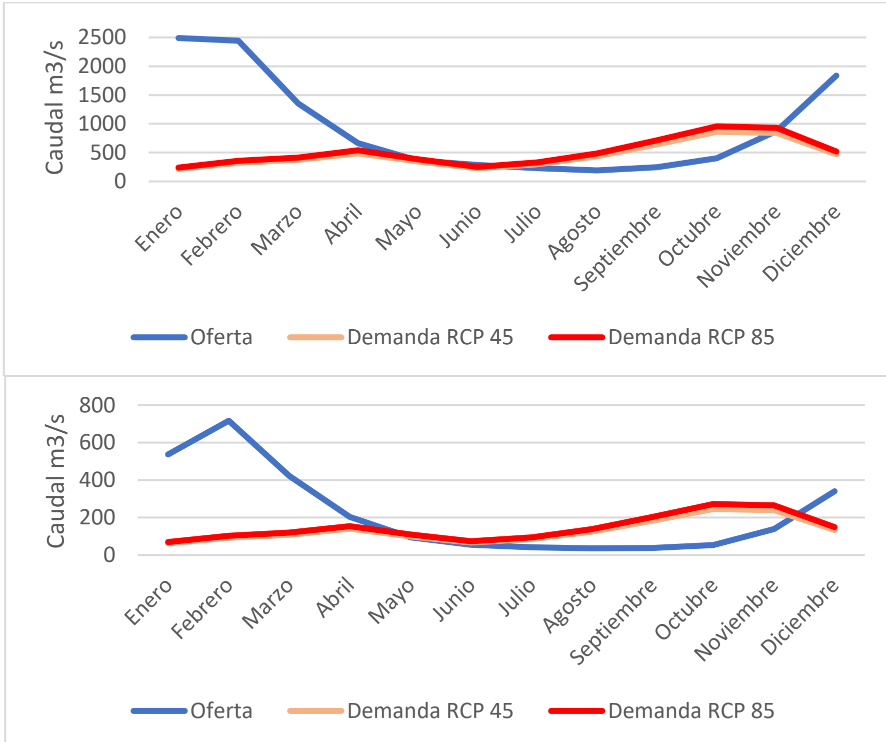


Figure 34: Mass balance ICHEC-EC-EARTH RCP 4.5 climate scenario for horizon 2036 – 2065 (a) Amazon river and (b) Plata river.

Table 21 Mass balance ICHEC-EC-EARTH RCP 4.5 climate scenario for horizon 2036 – 2065:

(a) Amazon river

m^3/s	JAN	FEB	MAR	ABR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Anual
Supply	2489.27	2441.03	1351.33	662.02	362.61	282.99	231.04	191.18	247.85	400.45	872.99	1834.03	947.23
Demand RCP4.5	216.84	322.80	374.27	488.07	346.78	228.45	297.71	435.73	641.83	861.12	840.16	466.47	460.02
Demand RCP4.5	240.54	358.20	415.35	541.71	384.82	253.43	330.34	483.60	712.46	955.96	932.69	517.73	510.57
Deficit RCP 4.5	0.00	0.00	0.00	0.00	0.00	0.00	66.68	244.55	393.98	460.67	0.00	0.00	97.16
Deficit RCP 8.5	0.00	0.00	0.00	0.00	22.21	0.00	99.30	292.42	464.61	555.51	59.70	0.00	124.48

(b) Plata river

m^3/s	JAN	FEB	MAR	ABR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Anual
Supply	2489.27	2441.03	1351.33	662.02	362.61	282.99	231.04	191.18	247.85	400.45	872.99	1834.03	947.23
Demand RCP4.5	216.84	322.80	374.27	488.07	346.78	228.45	297.71	435.73	641.83	861.12	840.16	466.47	460.02
Demand RCP4.5	240.54	358.20	415.35	541.71	384.82	253.43	330.34	483.60	712.46	955.96	932.69	517.73	510.57
Deficit RCP 4.5	0.00	0.00	0.00	0.00	0.00	0.00	66.68	244.55	393.98	460.67	0.00	0.00	97.16
Deficit RCP 8.5	0.00	0.00	0.00	0.00	22.21	0.00	99.30	292.42	464.61	555.51	59.70	0.00	124.48

In conclusion, it is observed that the deficit increases under future conditions. **In the Amazon region a current deficit of 12.91% is estimated, for the RCP 4.5 increase scenario it is estimated to be between 21.12% and 23.45%, while for the RCP 8.5 increase scenario it is estimated to be between 24.38% and 25.85%. In the La Plata region a current deficit of 35.71 % is estimated, for the RCP 4.5 increment scenario it is estimated between 36.13 % and 37.02 %, while for the RCP 8.5 increment scenario it is estimated between 39.08 % and 39.89 %.**

Impacts of non-climatic factors on the hydrological cycle

To understand the influence of anthropogenic actions versus climate change over the hydrological cycle, the effect of changes in land use and land cover resulting from anthropogenic activities was modeled.

This was done by simulating the average hydrologic cycle for the climate of 1980-2015 combined with the land cover situation of 2010 and comparing this with the hydrologic cycle for the landcover situation of 2020.

Results shows that while there are significant changes in land cover over the period 2010 – 2020 (for example an increase in agricultural area of 3.72 % in the Plata basin), the changes in modelled discharge are below 0.01% (in the Plata basin an increase in discharge of 0.004% is modelled).

The analysis concludes that compared to the expected changes due to the influence of climate change, changes in water supply due to changes in agriculture coverage over 10 years, considering the 2010 and 2020 maps, play a very insignificant role. **The analysis confirms that climate change is the responsible of droughts.**

Details of the methodology and results of these findings are provided bellow.

A hydrological simulation was carried out with different land covers with a 10-year time lag (Figure 35). It was used the same period of time for the simulations (1980-2015) in this way the evaluation of the changes in the hydrologic results is only due to use and coved of land changes.

The land cover information corresponds to the ESA-CCI-LC product. In April 2017, the Climate Change and Land Cover (CCI-LC) initiative of the European Space Agency (ESA) published a set of consistent land cover maps. The product is accompanied by a Product User Guide (PUG) that provides detailed information on its creation and features, which is available on the JRC website where the data can also be downloaded. The data are available in GeoTIFF and NetCDF formats. The ESA-CCI-LC product is based on Medium Resolution Imaging Spectrometer (MERIS) and PROBA-V satellite data and a combination of AVHRR and SPOT-VGT data to create a comprehensive land cover classification covering the period 1992-2020 (29 years) at 300 m resolution.

The land cover information assembled in the hydrological model currently used in the water supply modeling corresponds to the year 2010, which is the one used in the 2017 Bolivian Surface Water Balance, so updated data corresponding to the year 2020 has been downloaded.

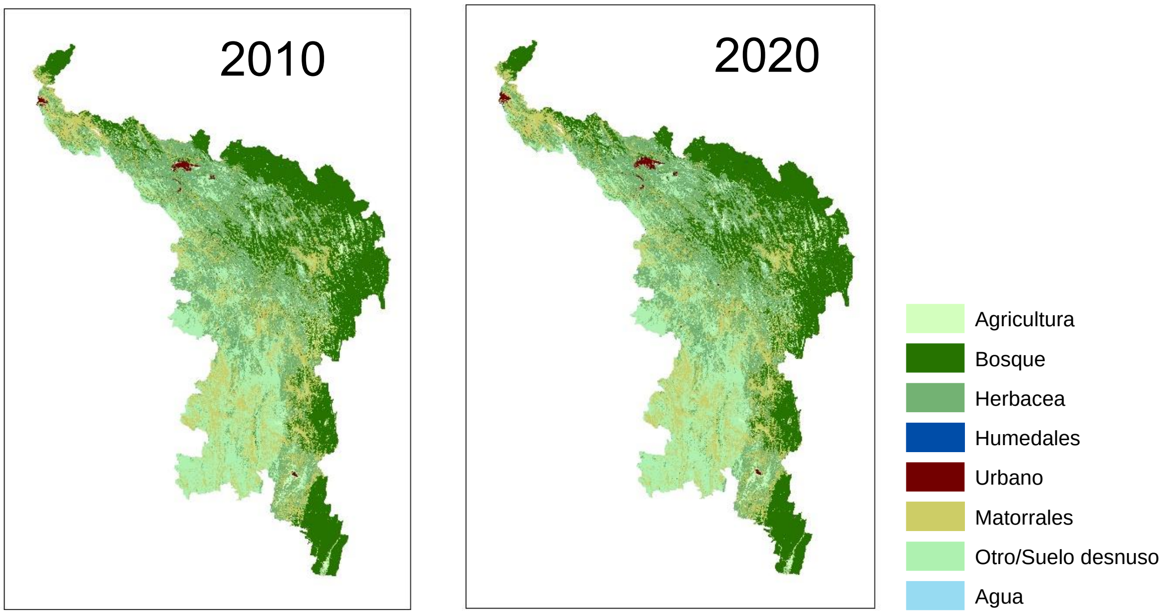


Figure 35: *Vegetation cover of the ESA*

With this information, the changes in land cover types in the two macro-basins of the study area is identified, as shown in Table 22.

Figure 36 and Figure 37 show the histograms with the areas in km^2 of each land cover in the valleys region of the Amazon and Plata macro-basins, respectively.

Table 22: Land cover type changes (%)

Land Cover Type	% of change in valles Amazonas	% of change in valles Plata
Agricultural Land	0.22	3.72
Water	2.84	0.00
Forest	2.54	1.71
Herbaceous	-2.81	-5.71
Ice/Snow	-0.70	0.00
Wetlands	9.42	0.00
Bushlands	-3.30	-0.70
Other/Bare land	0.77	2.63
Urban	26.68	24.10

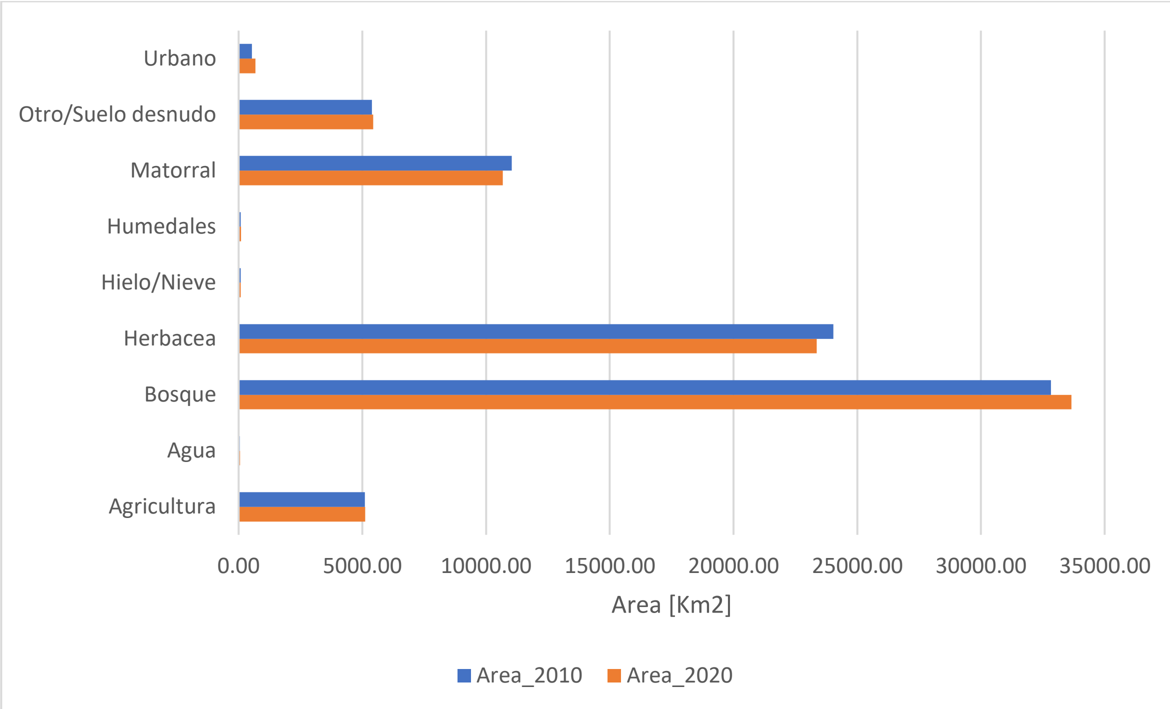


Figure 36 Histogram of growth in coverage of Amazon valley

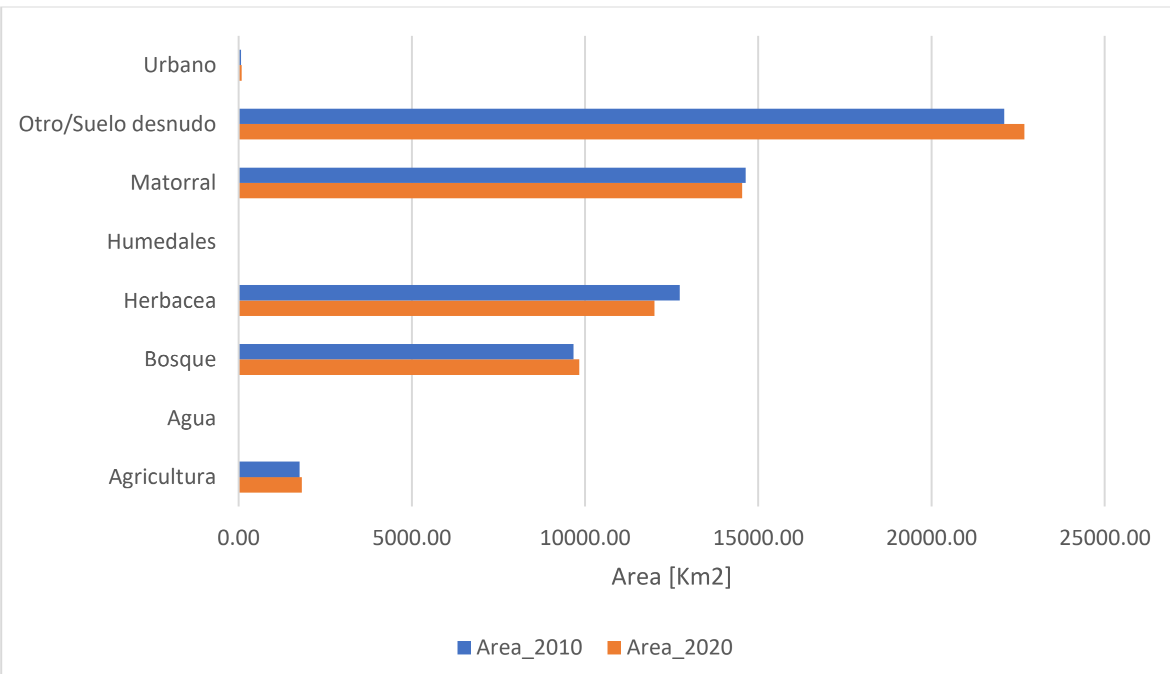


Figure 37 Histogram of growth in coverage of Silver valley

Using the 2010 and 2020 land cover information, the WEAP model was parameterized and run taking into account the changes in areas for the different land cover classes Figure 38 shows the flow obtained for the Silver valley basin for the two land cover layers, where it is observed that the average monthly flow for the 2010 coverage is 1230.53 m^3/s and 1235.91 m^3/s for the 2020 coverage, showing a very slight increase of 0.004 %.

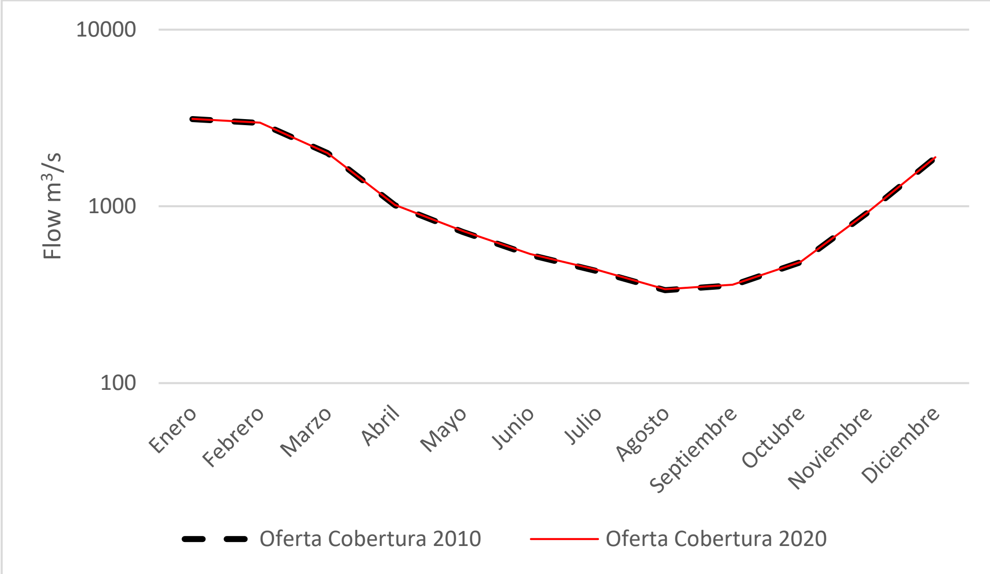


Figure 38 Amazon valley flow rate

Figure 39 shows the flow obtained for the Amazon valley basin for the two land cover layers, where it can be observed that the average monthly flow for the 2010 coverage is 253.32 m3/s and 253.94 m3/s for the 2020 coverage, showing a very slight increase of 0.002 %.

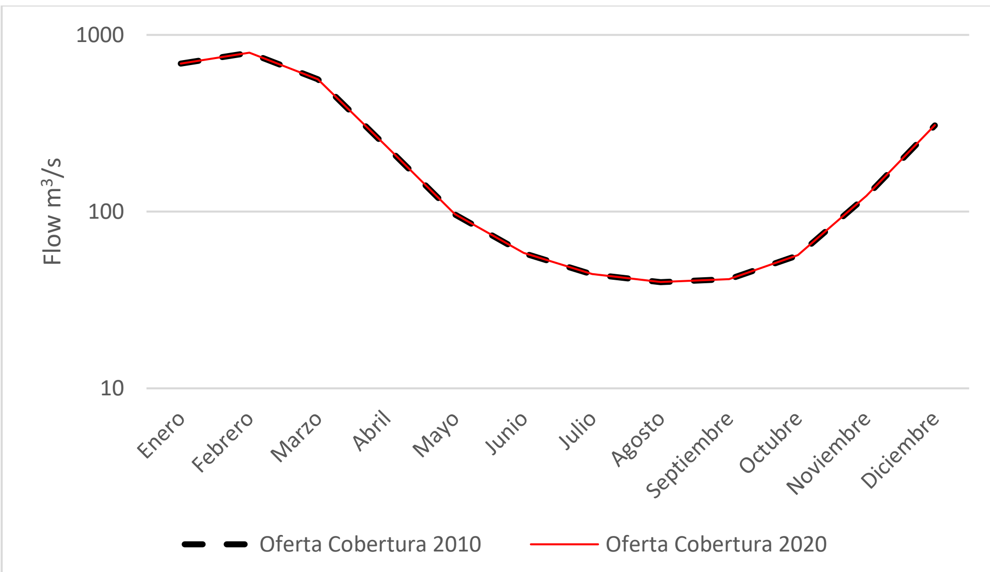


Figure 39 Silver valley flow rate

From these two model runs, we can conclude that the observed changes in land cover in the years from 2010 and 2020 do not result in significant changes in river discharges for the two basins. Therefore, it can be assumed that more important changes in river discharges for the different scenarios can be attributed to climate change as opposed to socio-economic developments.

The changes finded in the water balance due to climate change are more important because it affects the precipitation that is the principal variable in the calculation of the water supply. In the other hands, the changes in coverages that has been tested in a period of 10 years seemsnot to be that import for this study.

8. Climate vulnerability and impacts in the Valles Macro-region

Methodology

The vulnerability of the water provision and the agricultural (crops and livestock) sectors to climate change impacts is high[76] since hydrological cycles are highly impacted by rainfall and temperature variability.[77] Recent studies predict that the crop and livestock sectors will be among the most affected, facing losses of 6-14% of sectoral GDP.[78] This is anticipated primarily by the corresponding predicted declines in productivity, which for a number of key staple crops could reach 17%[79]. Smallholder farmers are particularly vulnerable as their current crop yields are very low —the average potato yield is 5.7 t/ha, the lowest in the Andean region; and the average maize yield is only 2.2 t/ha[80]. These impacts are exacerbated with unsustainable land use change (e.g. particularly deforestation), and management (e.g. intense mono-cropping) because of the deterioration of ecosystem functions that they foster, decreasing the possibility to climate resilience, particularly in regards to water and nutrient cycling.

The indicators that define the climatic exposure in the Valleys Macroregion were spatially determined in GIS with the ArcGIS 10.3 programme, covering the entire geographical scope of the 111 municipalities in the research area. To identify more precisely the exposure in relation to the agricultural and livestock production sector, the three indicators are based on the water balance at the annual level and at the monthly level in the months of February and August as the most extreme (higher and lower precipitation) to identify changes in water availability for the future, very essential information for agricultural production and the implementation of irrigation and water supply programmes for food security and water security.
Absolute changes in temperature and precipitation are indirectly represented in this water balance, respectively in evapotranspiration. For the vulnerability assessment, averages of the indicators were extracted for the 111 municipalities. In order to standardize the absolute values of the indicators, the values were normalized in a prioritization range from 1 to 5, where 1 represents the value with the highest exposure and 5 the value with the lowest exposure. Figure 40shows a summary of the indicators used for the vulnerability assessment conducted for the Valles Macro-region.

[76] PNUD (2011). Tras las huellas del cambio climático en Bolivia: estado del arte del conocimiento sobre adaptación al cambio climático, agua y seguridad alimentaria. La Paz: PNUD.
[77] Íbid footnote 23.
[78] ECLAC (2014). Social Panorama of Latin America 2019. Santiago de Chile: CEPAL.
[79] Rambal et al. (2015). Garantía de Acceso al Agua como un Derecho Fundamental. Madrid: Rambal.
[80] Ministerio de Medio Ambiente y Agua (2017). Plan Plurianual de Riego 2017-2020.

Exposure

- Change in the water balance
- Change in the water balance in February
- Change in the water balance in August

Sensitivity

- Erosion threat
- Desertification threat
- Biomass
- Hydrological supply
- Soil humidity

Adaptive capacity

- Area under irrigation
- Percentage of the population living in poverty
- Activity in the primary sector
- Availability of electricity
- Access to piped drinking water
- Number of tractors per 100 people in an APU
- Ratio of wooden ploughs to mechanized ploughs
- Water demand

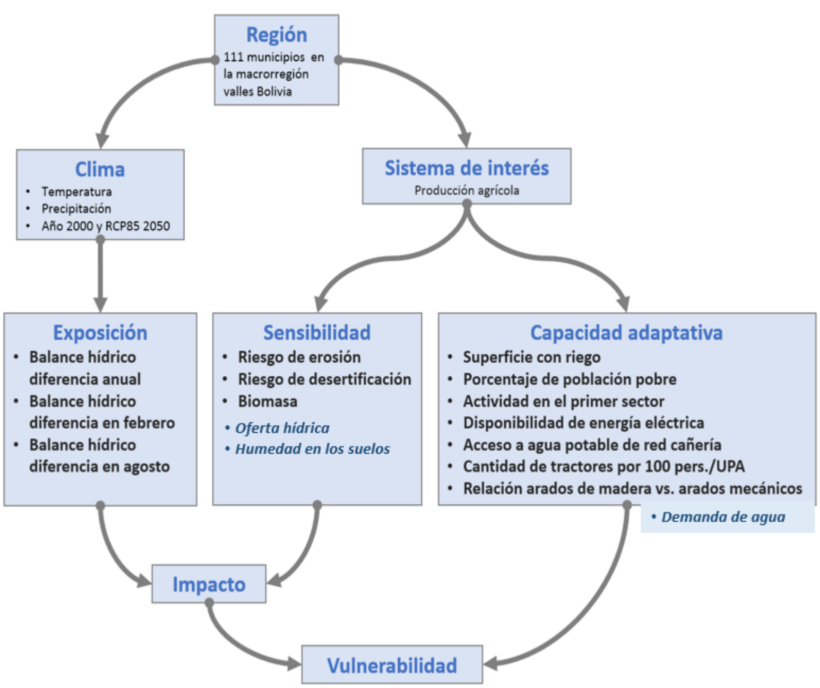


Figure 40 Methodology for vulnerability assessment in the Valles Macro-region.

- **Change in annual water balance: baseline vs. future scenario**

This indicator represents an estimate of the change in annual water availability between the baseline period (year 2000) and the future period (year 2050, scenario RCP4.5) based on the climatic water balance for each municipality in the area of influence of the Valleys Macroregion. This methodological process consisted of standardizing through water balance indices, differentiating the periods analyzed. Subsequently, the percentage change between the baseline indices and the year 2050 (scenario RCP4.5) was determined. It is important to mention that the methodology used does not represent an absolute value of availability, but an approach to estimate areas with higher or lower water availability in general.

An accurate water availability analysis requires more data to be collected from the field to determine aquifer recharge in relation to biophysical conditions, such as soil types, detailed vegetation cover and groundwater levels. However, the applied methodology allows assessing the general and spatial situation of water availability in the investigated municipalities in relation to changes between the baseline and the future scenario RCP4.5 (year 2050). In the vulnerability analysis, the change of the annual water balance is entered as the average for each municipality in the research area.

- **Change in water balance in the wettest month and the driest month: current vs. future scenario**

For the assessment of the impacts of changes in water availability on agricultural production, it is important to obtain data on seasonal differences in precipitation and evapotranspiration. In this sense, indices have been calculated for the months of February and August because they represent the change in water availability during the agricultural calendar, this analysis was carried out for the baseline (year 2000) and future scenario (year 2050 (RCP4.5). As the relationship between precipitation and evapotranspiration is highly variable and depends on their absolute values, an algorithm was established that normalizes these variations and represents not only the percentage difference between precipitation and evapotranspiration, but also considers the absolute values. In the vulnerability analysis, the change in water availability in February and August represents the average for each of the 111 municipalities.

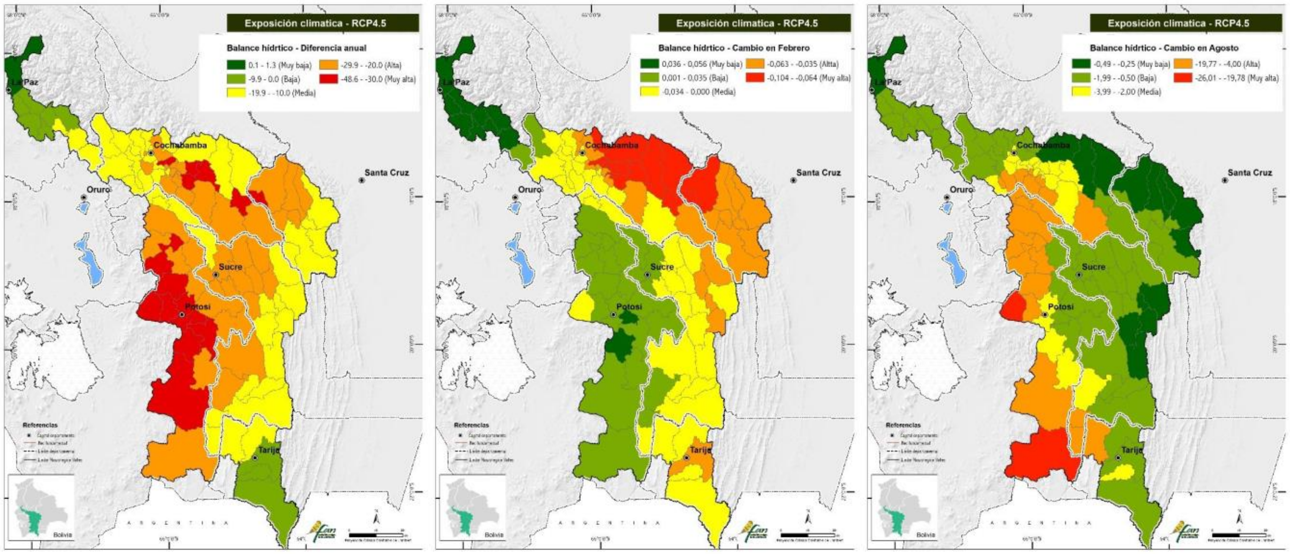


Figure 41 Climate Change Exposure Factors future scenario RCP4.5 2050 (annual, Febrero y Agosto)

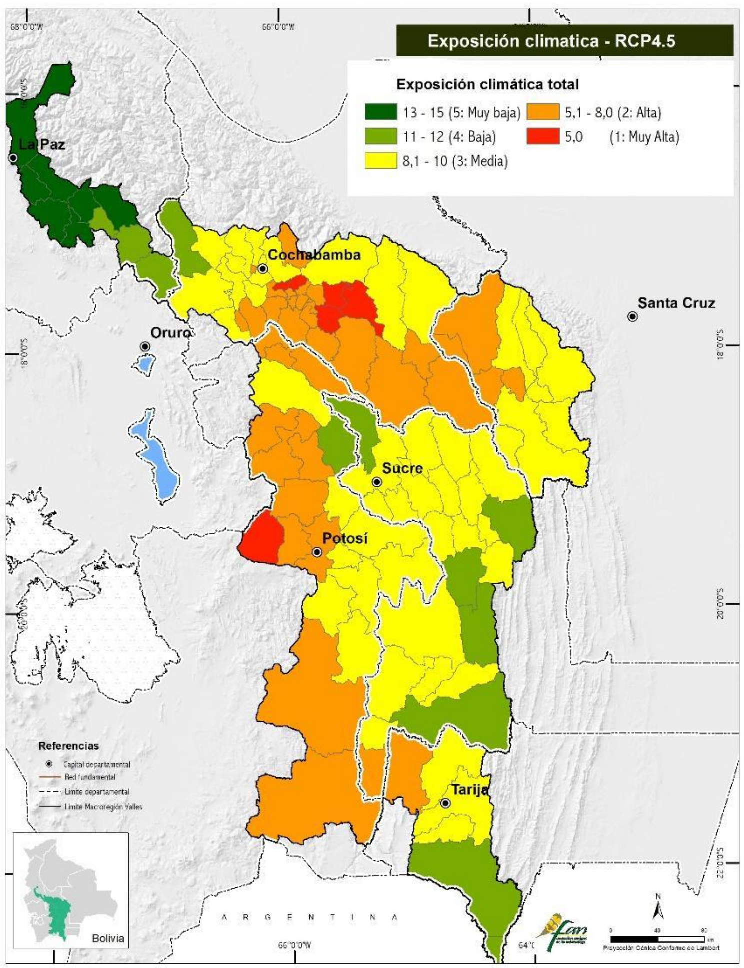


Figure 42 Exposure to climate change future scenario RCP4.5 2050

Changes in the annual water balance show the greatest changes in municipalities in Potosí and the upper Cochabamba valley, with a reduction of up to -48%. In the rainiest month, February's monthly water balance, the municipalities that will suffer the greatest alteration are the municipalities of the upper Cochabamba valley and part of the valleys of Santa Cruz. For the month of August, future changes in the monthly water balance are expected to have the greatest impact in the south and north of Potosí (Figure 41).

The combination of factors defining climate exposure in the Valleys Macroregion for the RCP4.5 scenario (Figure 42) indicate very high and high climate exposure in municipalities of Potosí and Cochabamba. The ten municipalities that will be highly exposed to the effects of climate change, according to the prioritization hierarchy, are detailed in the following table.

Table 23 The ten municipalities with the highest climate exposure according to the RCP 4.5 scenario (2050)

Range	Municipalidad	Departament
1	Pocona	Cochabamba
2	Vacas	Cochabamba
3	San Benito	Cochabamba
4	Alalay	Cochabamba
5	Tolata	Cochabamba
6	Arani	Cochabamba
7	Villa Rivero	Cochabamba
8	Punata	Cochabamba
9	Belén de Urmiri	Potosí
10	Las Carretas	Chuquisaca

Sensitivity to climate change impacts

The indicators defining sensitivity, as well as exposure, were developed at the spatial level with ArcGIS 10.3. For their evaluation, averages of the indicators for the 111 municipalities were extracted. To standardise the absolute values, each indicator was normalised in a prioritisation range from 1 to 5, with 1 representing the value with the highest sensitivity and 5 the value with the lowest sensitivity.

- **Erosion risk**

Erosion is an important factor in agricultural production systems because it generates considerable impacts on crop yields and soil management. Being normally a very complex and difficult parameter to determine, for this study the erosion risk calculation methodology has been applied considering the vegetation cover of the surface in the form of NDVI (Normalized differenced Vegetation Index) and the slopes in the watersheds. Erosion risk was determined with a spatial resolution of 30mx30m. The Valleys Macroregion due to its high heterogeneity of altitudinal levels is highly exposed to erosion when the natural land cover is transformed.

- **Desertification risk**

The desertification is mostly related to the degradation of the soils and the increase of the presence of droughts. In the Macroregion Valleys desertification is defined by the high water deficit determined with the water balance and by the conservation state of the ecosystems according to the degree of disturbance by anthropogenic activities (populated centres, roads, change of use of soil, deforestation, urbanizations and settlements). Intensification of land use without conservation and restoration practices accelerates ecosystem degradation leading to desertification processes.

- **Biomass**

Biomass is a parameter that represents the vegetation cover and density found at a location on the land surface. Biomass is an indicator of the presence of ecosystem services provided by vegetation for its environment, not only for greenhouse effect mitigation, but also for soil protection and key water recharge for water supply. A biomass density of more than 80 tonnes per hectare is considered a significant ecosystem contribution, with Andean forests and native shrublands contributing in this biomass range. The ecosystem services that support and strengthen agricultural production and the daily livelihood of farmers are closely related to the biomass of native vegetation. Water regulation in watersheds is defined by the presence of biomass, contributing to higher water infiltration rates, increased protection of soils against erosion, flood buffering and drought mitigation. In addition, forests provide food and medicinal plants, as well as supplying the local population with wood for construction and firewood. Therefore, the higher presence of biomass results in a lower sensitivity to the effects of climate change in the Valleys Macroregion.

- **Water supply**

The availability of water resources for the supply of water for crop production, livestock, human consumption and industry is a key factor in coping with the effects of climate change. According to the water modelling carried out in WEAP, the areas with the highest water supply are located in the municipalities of the Amazon basin, reaching up to 5,330 hm3 per year. Those with the lowest water supply are in the southern region of the departments of Potosí and Tarija in the northwest.

- **Soil moisture**

The soils in the Valleys Macroregion, as a result of infiltration and percolation processes, are saturated with moisture, which contributes to the water recharge of the hydrological systems in the study area. Soil moisture determined from the NDWI index in the month of greatest water stress, August, indicates that the soils are in ideal conditions as a result of water recharge in southern Potosí, northern Tarija and southern La Paz.

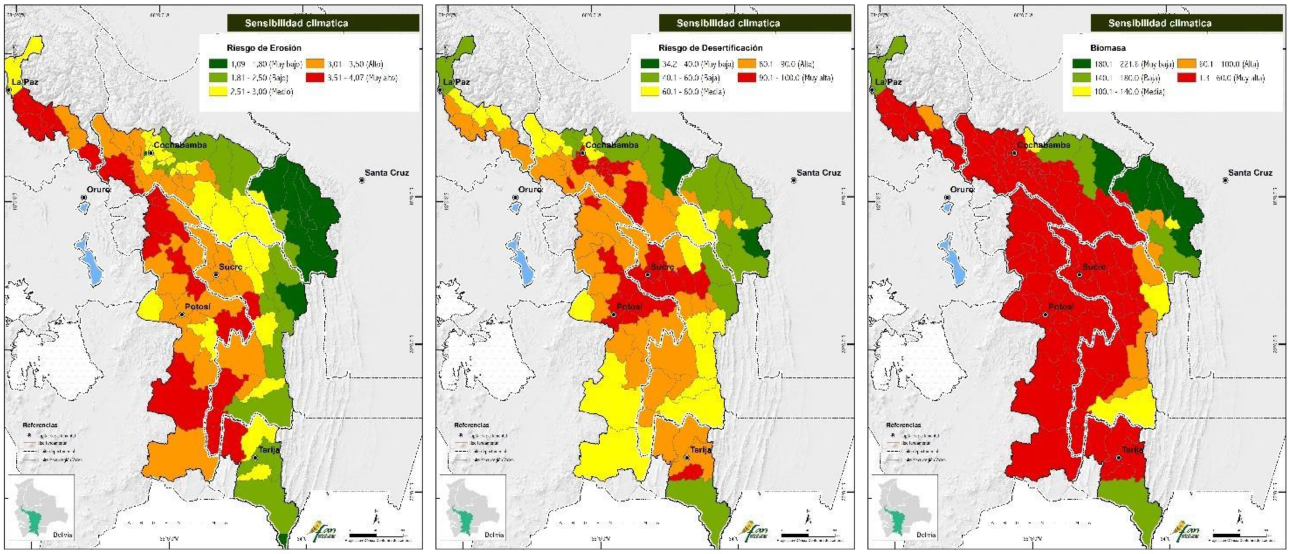


Figure 43 Sensitivity to climate change: a) Erosion Risk, b) Desertification Risk, c) Biomass

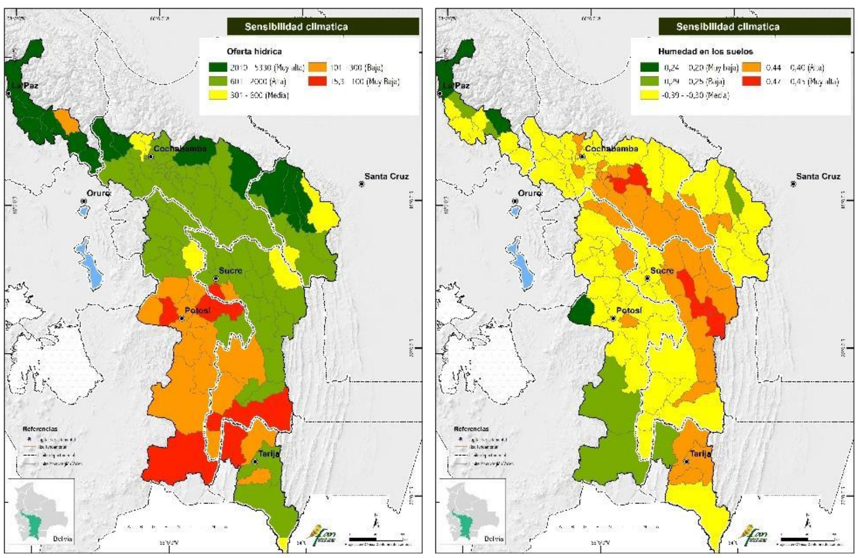


Figure 44 Sensitivity to climate change: (d) Water supply and (e) Soil moisture

The combination of the five factors: Erosion Risk, Desertification Risk, Biomass, Water Supply and Soil Moisture results in the sensitivity to the effects of climate change determined at the municipal scale. The prioritized municipalities indicate high and very high sensitivity in the departments of Cochabamba, Chuquisaca, Potosí and Tarija.

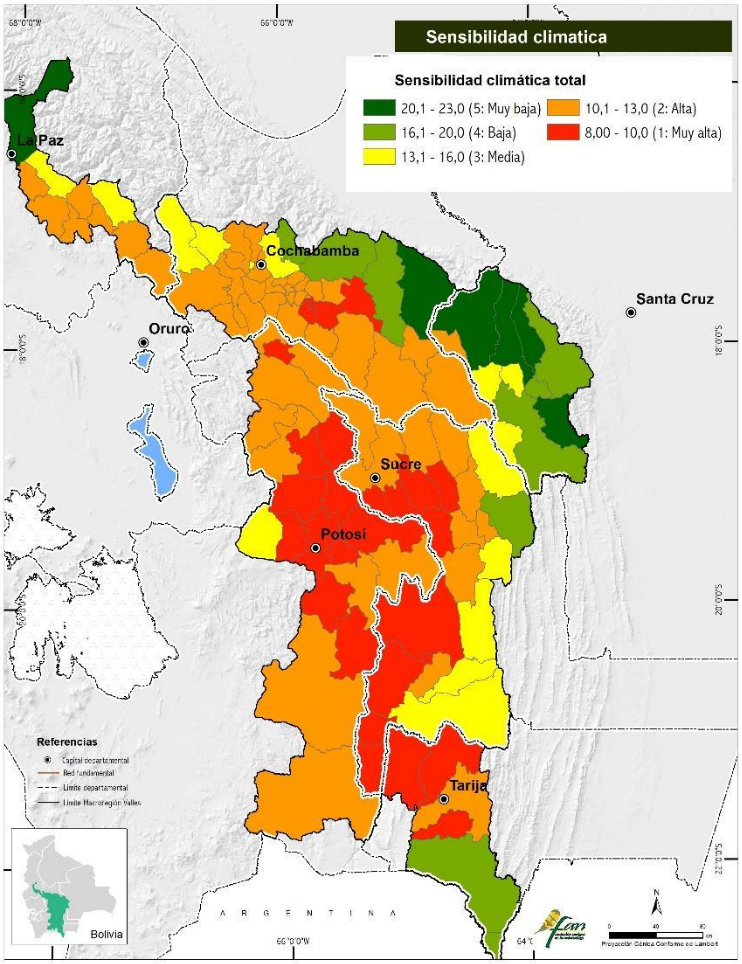


Figure 45 **Sensitivity to climate change**

The ten municipalities with the highest climate sensitivity according to the five indicators are as follows:

Table 24 The ten municipalities with the highest climate sensitivity

Rank	Municipalidad	Departament
1	Pocona	Cochabamba
2	Cuchumuela	Cochabamba
3	Las Carretas	Chuquisaca
4	Yotala	Chuquisaca
5	Camargo	Chuquisaca
6	San Lucas	Chuquisaca
7	Tinguipaya	Potosí
8	Yocalla	Potosí
9	Potosí	Potosí
10	Uriondo	Tarija

Climate change impacts

The combination of climate exposure and sensitivity indicates that under the RCP4.5 scenario the municipalities that will be most impacted by climate change effects will be in the municipalities of southern Cochabamba, eastern Potosí and western Chuquisaca and northern Tarija.

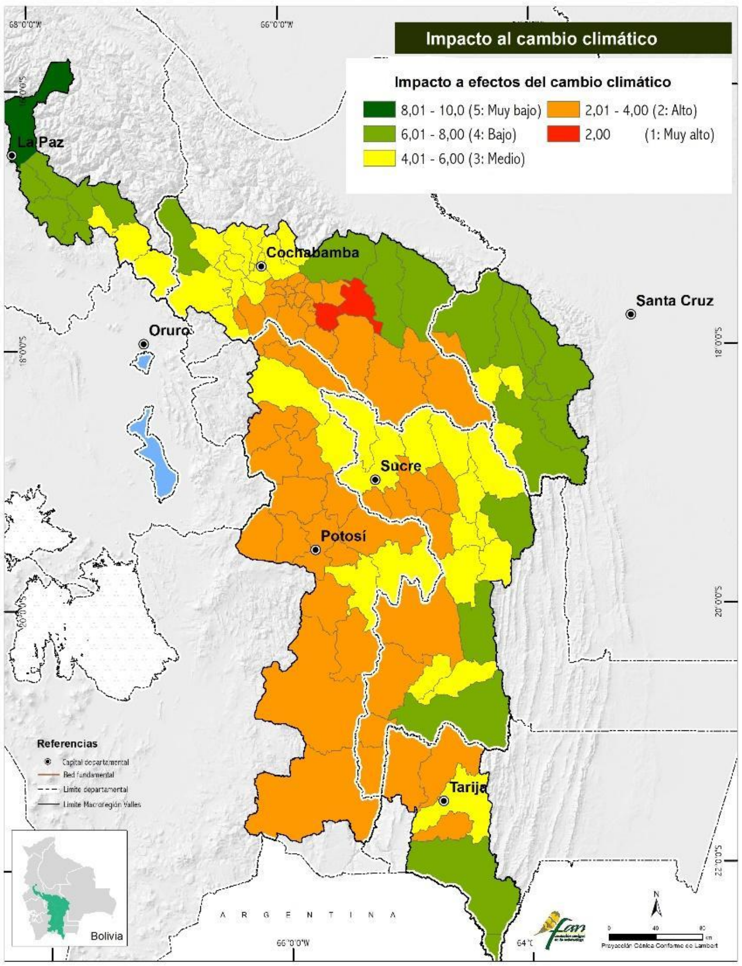


Figure 46 Impact of climate change

Adaptive capacity

For the assessment of adaptive capacity to climate change impacts, it has been essential to define quantifiable and measurable variables and indicators to achieve replicable and understandable results. Socio-environmental information to assess adaptive capacities to impacts at detailed scales is limited, so the municipal scale works due to the information available from population censuses. For the Valleys Macroregion, indicators have been extracted from official databases of the Bolivian National Institute of Statistics (INE) using information from the 2012 Population and Living Census and the 2013 Agricultural Census, which provide data at the level of municipalities for the whole of Bolivia. Eight indicators have been selected to indirectly represent the management, knowledge, technology and financial resources of the population and the agricultural sector. For standardisation, the absolute values of the indicators were normalised in a range from 1 to 5, with 1 representing the value with the lowest adaptive capacity and 5 the value with the highest adaptive capacity.

a) Crops under irrigation

Crop area is a variable extracted from the 2013 Agricultural Census and is considered suitable to identify whether a municipality has already implemented measures to adapt to climate change and extreme weather conditions in the agricultural sector. A higher percentage of irrigated area means that in general agricultural producers have the possibility to regulate and plan the use of their water resources, thus indicating that their adaptive capacity is higher than municipalities with less irrigated areas.

b) Poor population

This indicator is part of the 2012 Population and Housing Census, it represents the sum of the percentage of the total municipal population that falls into the categories of moderate, indigent and marginal poverty. Poverty is a suitable indicator to estimate the state of development and the availability of financial resources of the population in a municipality. A municipality with a higher percentage of poor population would be less able to adapt to the impacts of climate change due to lack of resources.

c) Economic activity in the first sector

Cenco Population and Living 2012 determines the economic activities of the population of the municipalities in the different categories agriculture, livestock, hunting, fishing and forestry, activities in mining and hydrocarbons, activities in manufacturing industry, electricity, gas, water, waste, activities in construction, trade, transport, warehousing, and activities in other services.

Based on the theory of the three economic sectors (Allan G.B. Fisher 1935, Colin G. Clark 1940) which separates economic activities into primary production and extraction of natural resources (first sector), industrial and manufacturing production (second sector) and services (third sector), the number of people with activities in the first sector (agriculture, livestock, hunting, fishing and forestry, mining and hydrocarbon activities) has been added for each municipality and the percentage in relation to the total population has been calculated.

This indicator is used to evaluate the overall development in relation to the generalised economic activities, which allow an estimation of the income of the population and the generation of added value of the municipality. A higher percentage of activities in the first sector is related to a lower adaptive capacity of the municipality to climate change.

d) Availability of electricity

A significant indicator for the development of a municipality is the availability of electricity from the 2012 Population and Housing Census, which allows the use of devices and equipment such as household appliances that facilitate daily life, food preservation, communication and work in the dark. Municipalities and populations without availability of electricity can be considered with low attention to development projects and programmes with very simple and precarious living and production conditions, resulting in a highly poor population with low capacity to adapt to the impacts of climate change.

e) Access to piped drinking water

Access to drinking water is essential for feeding and food preparation of the population and it makes a considerable difference whether drinking water is obtained by piped water in the house, from area sewers or from watershed springs. The easier and safer the access, the less time, investment and effort is required to obtain water. That is why access to piped drinking water is a strong indicator for assessing the degree of development and the adaptive capacity of the population in a municipality.

f) Number of tractors per 100 UPA persons

Technology plays an important role in agricultural production. Better equipment and devices facilitate the transport of produce, harvesting, sowing, selling and general access. Based on data from the Agricultural Census (2013), the availability of tractors per 100 people in an Agricultural Production Unit (UPA) has been calculated, which allows an estimation of the access to technology for the production of the population in the municipalities. Tractors are multifunctional machines, which can be used for transport, on-farm production up to the marketing of products, which makes them a suitable indicator for the assessment of adaptive capacity. A higher number of tractors per 100 persons in a UPA is considered to provide a higher adaptive capacity, as they have better possibilities to react faster and more flexibly to the impacts of climate change with the available technology.

g) Number of wooden ploughs in relation to number of mechanical ploughs

Another indicator for assessing access to technology in agricultural production is the availability of more advanced and durable ploughs. Extracted from the 2013 Agricultural Census, the number of animal-drawn wooden ploughs has been related to the number of mechanical ploughs, which represent a higher investment with better yields and greater durability. A municipality with a better ratio of mechanical ploughs versus wooden ploughs is considered to have a higher adaptive capacity to climate change impacts.

h) Water demand

Water demand is undoubtedly a determining factor in adaptive capacity, the higher the demand, the greater the pressure on the hydrological systems of the Valleys Macroregion. According to the results of the hydrological modelling in WEAP, the demand is more accentuated in the municipalities of the south of Cochabamba, reaching up to 2,040 hm3 per year. The higher the demand for water, the lower the adaptive capacity will be due to the pressure that will be exerted on the water resource.

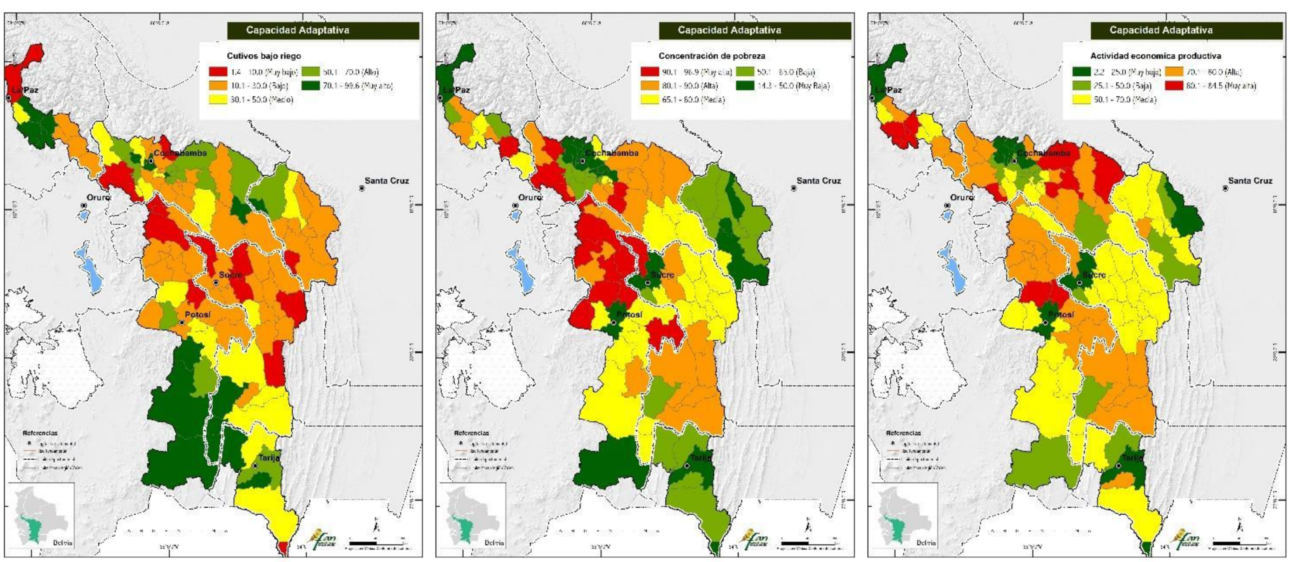


Figure 47 Adaptive capacity: a) Crops under irrigation, b) Poverty, c) Productive economic activity

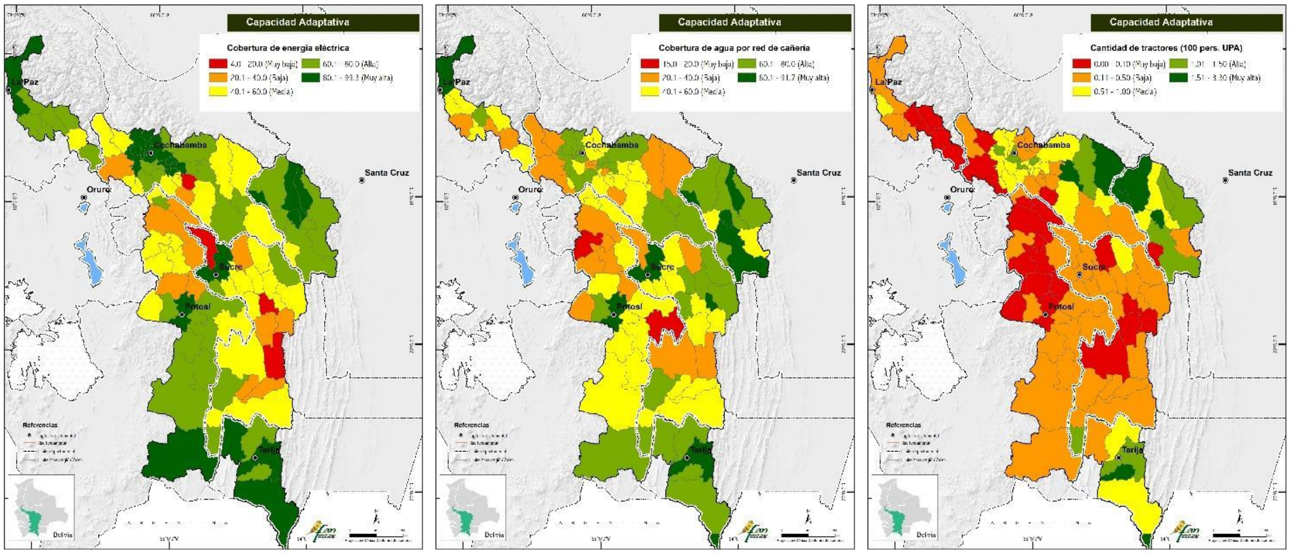


Figure 48 Sensitivity to climate change: c) Electricity coverage, d) Water coverage by piped water network, e) Number of tractors

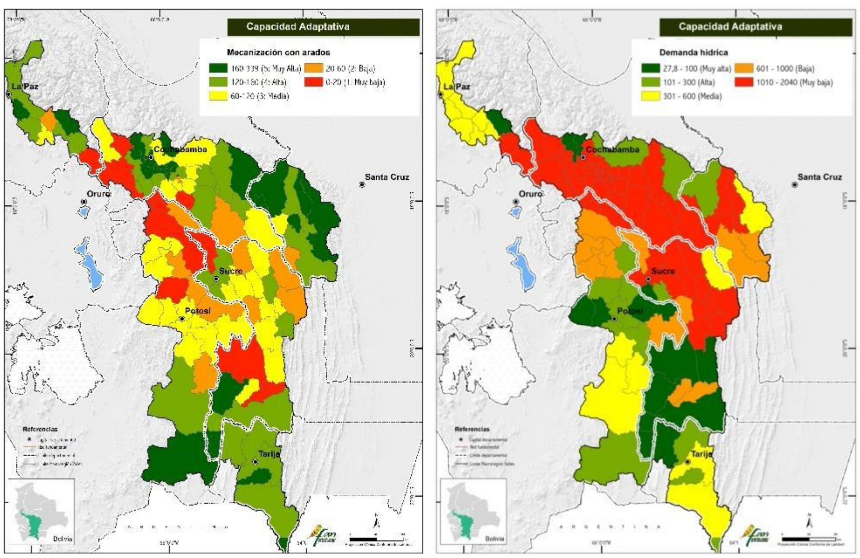


Figure 49 Sensitivity to climate change: (f) Mechanisation with ploughs, (d) Water demand

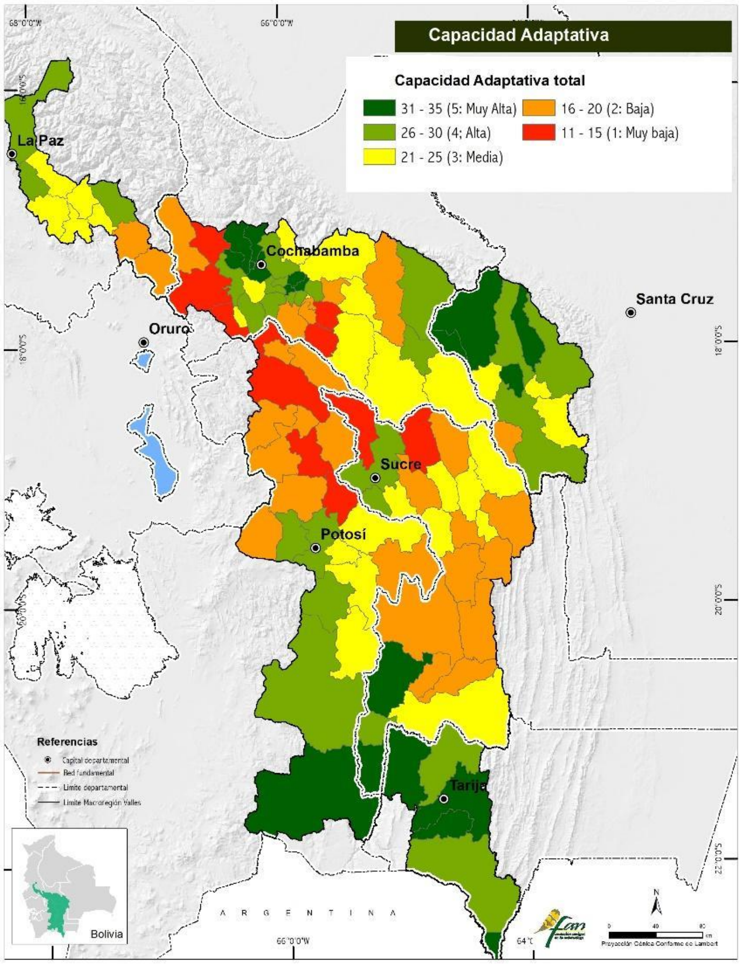


Figure 50 Adaptive capacity to the effects of climate change

The combination of indicators that define adaptive capacity in the Valleys Macroregion, define the municipalities located in the southwest region of Cochabamba (municipalities with high poverty and lack of coverage of basic services), municipalities in the north of Potosí and in the western region of Chuquisaca as areas with a low possibility of facing the effects of climate change.
Depending on the measures implemented in these municipalities in terms of development projects that overcome poverty levels and improve the technification of agricultural production, the adaptive capacity of these municipalities could improve and their capacity to cope with the effects of climate change would be higher.

Among the ten municipalities with low capacity to cope with the effects and impacts of climate change are concentrated in the departments of Chuquisaca, Cochabamba and Potosí, see Table 25
The ten municipalities with the lowest adaptive capacity to the effects of climate changeTable 25.

Table 25 The ten municipalities with the lowest adaptive capacity to the effects of climate change

Rank	Municipality	Departament
1	Poroma	Chuquisaca
2	Presto	Chuquisaca
3	Tapacarí	Cochabamba

4	Alalay	Cochabamba
5	Vila Vila	Cochabamba
6	San Pedro de Buena Vista	Potosí
7	Arampampa	Potosí
8	Ocuri	Potosí
9	Tacobamba	Potosí
10	Vila Vila	Potosí

Vulnerability to climate change

In order to obtain a simple and comprehensible value in the vulnerability analysis all indicators of the factors exposure, sensitivity and adaptive capacity are aggregated as the average of the corresponding factor. The impact is defined as the average of sensitivity and exposure, while the final vulnerability is defined as the average of impact and adaptive capacity. In this way the final results are presented and visualised with a range from 1 to 5, respectively from bad to good.

Vulnerability to the effects of climate change under scenario RCP4. 5 indicate that the municipalities of southern Cochabamba and northern Potosí will suffer high impacts because they are highly exposed and more sensitive to climate change, adding that their adaptive capacity is low, this reality could change if timely measures are implemented in the ten most vulnerable municipalities of the valley macro-region: Pocona, Vacas, Cuchumuela, Sacabamba, Alalay, Tinguipaya, Acasio, Arampampa, Tacobamba and Ocuri (table 11).

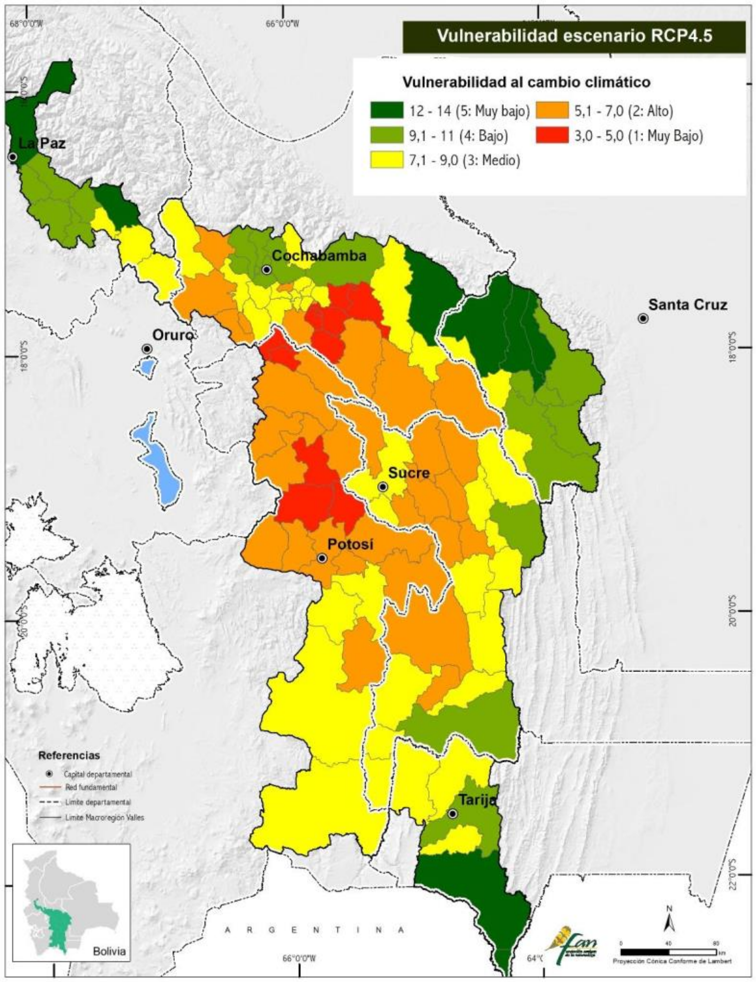


Figure 51 Vulnerability to climate change effects under the RCP 4.5 scenario

Table 26 The ten municipalities with the highest vulnerability to the effects of climate change according to scenario RCP4.5.

Rango	Municipio	Departamento
1	Pocona	Cochabamba
2	Vacas	Cochabamba
3	Cuchumuela	Cochabamba
4	Sacabamba	Cochabamba
5	Alalay	Cochabamba
6	Tinguipaya	Potosi
7	Acasio	Potosi
8	Arampampa	Potosi
9	Tacobamba	Potosi
10	Ocuri	Potosi

Climate change and agriculture

Climate has a large impact on the productivity of agriculture in Bolivia. The main changes projected for the scenarios analyzed give evidence of an upward movement of vegetation along altitudinal gradients of vegetation along the altitudinal gradients between 100 and 500 m. Therefore, altitudinal changes in vegetation types are expected to be the most important feature of the climate impact on ecosystems Valleys macroregion, see Figure 52 Change in the type of vegetation (left) and the average vegetation height (m) for RCP 4.5 in 2050Figure 52.

The Andean forests are located within the relatively narrow band of Andean slopes at altitudes between 800 and 3200 m (Seiler & al. 2014), these forests would be pushed to higher elevations (Seiler & al. 2014). The semi-humid Puna (Ibisch, et al 2003) with predominantly herbaceous vegetation type C3 has the lowest projected change for future scenarios. A considerable increase in woody vegetation is woody vegetation is evident only for the RCP 8.5 scenario and by 2100, primarily due to temperature increases and increase in tree height.

The grasses and xeric vegetation of the dry inter-Andean valleys will occupy the drier parts of the region. of the region, shrubs and other low vegetation adapted to drought (Navarro & Ferreira 2004). A change in the structure and composition of the forest is expected due to the invasion of woody species in the higher elevations. Shade-intolerant trees are pioneer species adapted to forest clearings. Therefore, pioneer species in general are expected to increase in abundance in a period of continuous change.

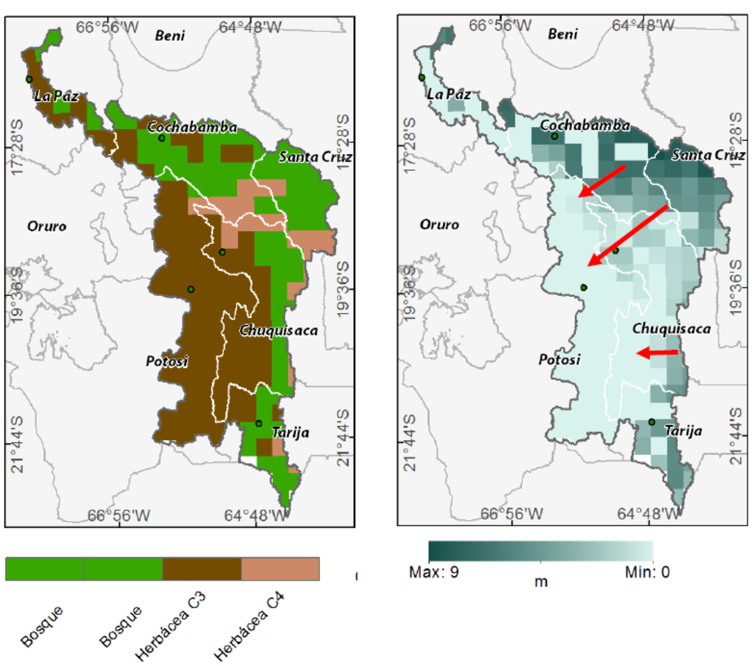


Figure 52 Change in the type of vegetation (left) and the average vegetation height (m) for RCP 4.5 in 2050

The increase in runoff despite the decrease in precipitation may be due to both reduced water use as vegetation becomes more efficient due to higher atmospheric CO_2 concentration and a reduction in the number of rainy days, such that rain falls in more concentrated amounts, causing more runoff due to oversaturation of soils. Consequently, in some areas, such as in the department of Cochabamba and part of Cochabamba department and part of Tarija, surface water runoff will increase. This will cause flooding and the risk of water erosion in these regions (Figure 53).

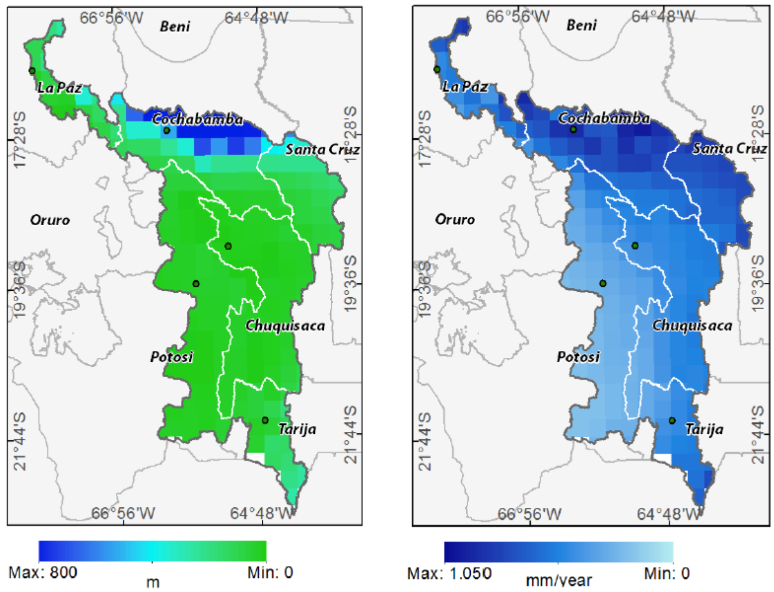


Figure 53 Total runoff (m) for RCP 4.5 in 2050 (left) and evapotranspiration (mm)/year for RCP 4.5 en 2050

Living vegetation and soils are important reservoirs of carbon and, by increasing the carbon content, act as a sink for greenhouse gas CO2 (Seiler et al., 2013)[81]. Cooler and higher altitude ecosystems are generally associated with a higher proportion of carbon in soils (Zaehle and Dalmonech. 2011)[82]. Within the study area the highest proportion of carbon is found in Puna and to a lesser extent for the forest (Figure 54). All ecosystems show a marked increase in live carbon concentrations over time, driven by the concentrations over time, driven mainly by CO2 fertilization, but there is little change in soil carbon (Seiler et al., 2015)[83].

[81] Seiler, C., Hutjes, R. W., y Kabat, P. (2013a). Climate variability and trends in Bolivia, Journal of Applied Meteorology and Climatology, 52, 130-146.
[82] Zaehle, S., y Dalmonech, D. (2011) Carbon–nitrogen interactions on land at global scales: current understanding in modelling climate biosphere feedbacks, Current Opinion in Environmental Sustainability, 3, 311-320.
[83] Seiler, C., Hutjes, R., Kruijt, B., y Hickler, T. (2015). The sensitivity of wet and dry tropical forests to climate change in Bolivia, Journal of Geophysical Research: Biogeosciences, 120, 399-413.

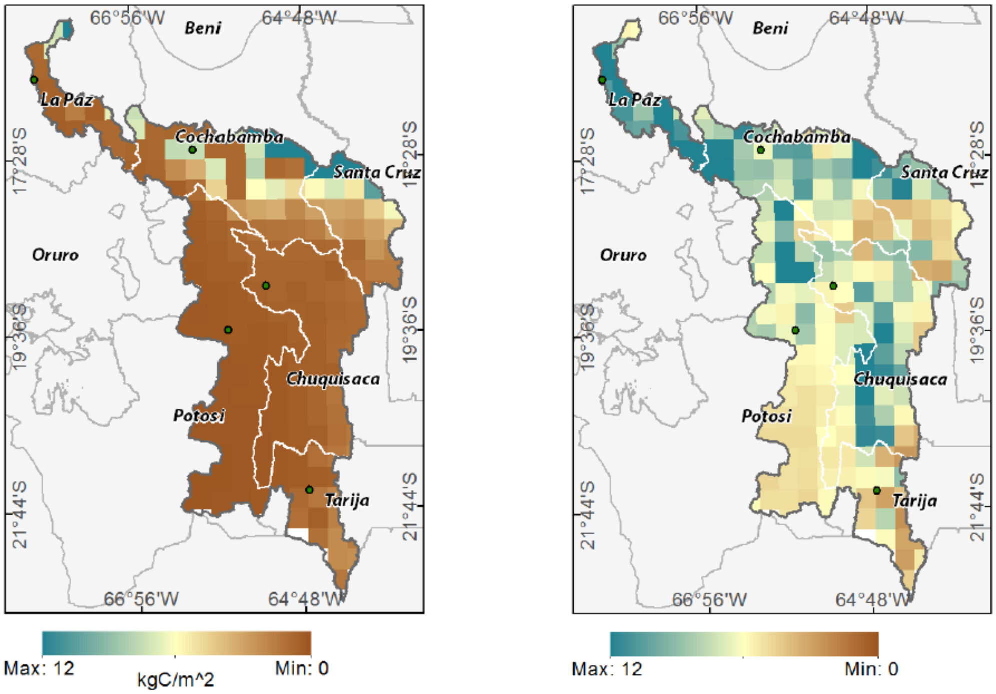


Figure 54 Total carbon in vegetation (kgC/m2) for RCP 4.5 in 2050, and total carbon in soils (kgC/m2) for RCP 4.5 in 2050

The decrease in precipitation in much of the region would directly affect agricultural production. The increase in solar radiation and decrease in precipitation reduces crop production, mainly in the central zone of the study area. The increase in temperatures will alter the suitability of areas for specific crops and cropping systems. Field studies simulated temperature increases of 1.3 °C and 2.6 °C (at different elevations) in the Peruvian Andes region for different traditional varieties of potato and maize. The results showed that maize yield decreased by 29% in response to the new soil conditions. The maize and potato production decreased by more than 87%, mainly as a result of the attack of new pests (Tito et al, 2018)[84].

In summary, an increase of 1.5 to 2°C is expected in a moderate scenario, and if current trends continue, it could reach up to 4°C. Warming is expected to be greatest at the end of the dry season and beginning of the wet season (August to November). Most simulations project a precipitation change amounting to less than 10% of current levels. Concentration of precipitation in the rainy season and decrease in the dry season would be the main characteristic of this valley macro-region.

Changes in runoff would cause different effects in the region. Uncovered or sparsely vegetated slopes would be more prone to erosion due to increased runoff. Also, there is a considerable risk of large increases in progressive flood events in the future. A greater than 20% decrease in runoff would result in increased periods of drought. Such an Component would be further exacerbated by melting glaciers, which could even seriously affect the water supply in the region.

In order to maintain yields, farmers may be forced to change cropping practices, the timing of cultivation practices, or even the type of crops. Alternatively, farmers may change location to higher elevations to track suitable climates, in which case plants will have to grow in different soil types. By changing crop

[84] Tito R, Vasconcelos HL, Feeley KJ. (2018). Global climate change increases risk of crop yield losses and food insecurity in the tropical Andes. Glob Change Biol. ;24:e592–e602.

conditions, they may have to deal with new pests. There is a real and imminent threat to agriculture and there is a need to develop effective management effective management strategies to reduce yield losses and prevent food insecurity.

Natural disasters

Since Bolivia is so dependent on agriculture, the effects of natural disasters on this sector are catastrophic and result in considerable social and economic losses. The number of droughts has been increasing over the last few decades. One drought alone, from 2016, cost Bolivia USD 450 million and affected 665,000 people living in the country[85]. Another drought in 2019 damaged more than a third of the land cultivated in soybeans (350,000 of 1.02 million hectares of land sown with soybeans), resulting in losses of 550,000 tons of soybeans valued at over 168 million USD[86]. There is a strong linkage between gender roles in rural Bolivia and the differentiated climate vulnerabilities and adaptation strategies identified by women and men[87], so gender is an important aspect when considering climate change vulnerabilities and adaptation in the context of agriculture.

It is important to note that spring frost, hail, wind and sun damage are the most important climatic adversities that cause damage to fruit production. The use of anti-hail netting in fruit growing is the only effective method of protection against this climatic adversity and is being used in different production areas for protection against hail and sun damage. The netting prevents damage to the production at the time of the storm and also prevents damage to the fruit tree. The main limitation of this technology for producers is economic (high investment), so it is recommended to install it in places where the risk of hail is very high.

[85] https://reliefweb.int/sites/reliefweb.int/files/resources/adsr_2016.pdf
[86] https://www.efe.com/efe/english/business/bolivian-farmers-crushed-by-drought-and-debt/50000265-3929408
[87] https://openknowledge.worldbank.org/bitstream/handle/10986/27161/717360WP00PUBL00CC0Bolivia0English0.pdf

9. Policy and Institutional context

This section describes the legal framework for the preservation and restitution of environmental functions, water security, irrigation, and family agricultural production.

Policy and legal framework

Political Constitution of Bolivia. Enacted in 2009 the Constitution lays the legal foundation for a new environmental regulation, which has not yet been completed. Regarding Protected Areas (Art. 385), the Constitution establishes that these constitute a common good, form part of the natural and cultural heritage of the country and fulfil environmental, cultural, social, and economic functions for sustainable development. Regarding forests (Art. 385), the Constitution establishes the promotion of conservation activities and the sustainable use of such, the generation of added value to their products, and the rehabilitation and reforestation of degraded areas. In addition, it issues a mandate to recover biodiversity in the areas that were previously indicated. Finally, it prohibits planning in spaces (other than where legally permitted) and issues a mandate to zone capacities for greater use of forest lands. Furthermore, it issues Art. 398 specifies that converting forest land for agriculture or other productive activities may only proceed where legally permitted, in accordance with planning policies and with the Law. Regarding water and its uses (Art. 374), the Constitution establishes that the State – through its regulatory and administrative entities – has the obligation to guarantee the use of water for human consumption and agricultural and forestry irrigation, also known as the use of water for life, and also has the responsibility to regulate, protect and plan the use of water resources. The Constitution promotes the economy of agricultural smallholder farmers and the economy of families and the community as a whole, as well as strengthening native indigenous communities as agricultural and forestry producers. In accordance with the provisions regarding Sustainable Integrated Rural Development (Art. 405), this is a fundamental part of the state's economic politics and prioritizes its actions to promote all community economic enterprises and of rural actors, with an emphasis on security and food sovereignty.

Nationally Determined Contribution of the Plurinational State of Bolivia (NDC): Part of the framework of global commitments that were agreed by UNFCCC to provide solutions to the current climate crisis (commitment to mitigate and adapt to climate change). The NDC of the Plurinational State of Bolivia was officially submitted to UNFCCC in 2016. This establishes results through an integrated focus on three main areas: water, energy and forests (see Table 12).

Table 27 Overview of nationally determined contribution

Results of National Efforts	Results with International Cooperation	Actions
• Water storage capacity has tripled (3 779 million m^3) by 2030, compared to 596 million m^3 in 2010. • 100% of drinkable water coverage has been reached	• The water storage capacity has quadrupled by 2030 (3 779 million m^3) compared to 2010 (596 million m^3).	• Develop resilient infrastructures for productive and service sectors. • Construct drinking water and sewage networks. • Re-use water for productive purposes to increase food production. • Restore vegetation (trees, grasslands, wetlands and others) to avoid erosion

in 2025, with resilient service delivery systems. • The water component of the Unsatisfied Basic Needs (UBN) will be reduced to 0.02% by 2030. • The surface area of irrigation has tripled, exceeding 1 million hectares by 2030 compared to the 296 368 hectares in 2010. Doubling food production through irrigation by 2020 and tripling by 2030, compared to the 1.69 million MT of 2010. This way, resilient agricultural systems will have been achieved. • Significant progress has been made in regards to social participation for local water management. Increasing to 80% of organizations focusing on the social management of resilient water systems compared to the 35% found in 2010. • The production of food using irrigation has increased by more than 6 million TM in 2030 compared to 2010. • The Gross Domestic Product (GDP) has increased to 5.37% by 2030, because of the contribution of potable water and resilient irrigation systems. • Water vulnerability has been reduced to 0.51 to 0.30 units by 2030 compared to 2010. This is measured through the National Index of Water Vulnerability of the country which considers aspects related to exposure (threats), the sensitivity of water distribution systems (water scarcity) and adaptability. • Adaptation capacity has increased from 0.23 units of 2010 to 0.69 units by 2030. This is measured though the National Index of Water Adaptation Capacity.	• The surface area of agriculture being irrigated has increased to 1.5 million hectares by 2030 compared to 296 million hectares in 2010. • Agricultural production being irrigated has quadrupled by 2030 (9.49 million MT) compared to 2010 (1.69 million MT). • Local management of water by social organizations has increased to 90% by 2030.	and damage from adverse climate events. • Increase the surface area irrigated through technified irrigation systems, irrigation with dams, water harvesting, multipurpose projects and water re-use. • Construct multipurpose hydroelectric plants to expand water storage capacity. • Domestic and industrial wastewater treatment plants to reduce their contribution of methane to the atmosphere. • Strengthen community and cooperative management and local climate change adaptation capacities. Including the community management of irrigation and collective administration of water services. • Apply practices and ancestral knowledge, within the framework of the integrated management of water. • Risk management to mitigate recurrent threats of droughts and floods. • Install hydro meteorological, geological and seismic stations at the national level. • Manage the quality of services and reduction of losses, including promoting the use of low consumption water appliances, efficient sanitary systems and alternative technologies. • Rainwater harvesting as well as the re-use of greywater from showers, sinks, laundries and downspouts for different domestic uses, except for human consumption. • Wider use of water-harvesting technologies, conservation of soil moisture and efficient water use (irrigation and livestock) (as well as how to stock up when there is a shortage or how to store when there is plenty). • Implement treatment and potable water systems for better quality water for human consumption. • Actions to treat contaminated water from mining, industrial activities and other productive areas. • Strengthen administrative, technical and management capacities of the social and public water systems.

Bolivia does not have a NAP; however, the government is planning to develop one in the near future.

In this sense, this project has the potential to serve as stepping stone to mainstreaming climate adaptation in policy and planning documents at national and sub-national level.

There is potential for the project to pioneer in supporting the implementation of activities related to the NDC goals on forest and water by enabling ecosystem restoration following a micro-watershed approach.

Social and Economic Development Plan. Through the Social and Economic Development Plan (SEDP) several national investments have been made on climate change mitigation and adaptation.

- **Investment in water and basic sanitation.** One of the main priorities of the 2006-2017 government was to offer solutions to water shortages due to a lack of drinking water and sanitation facilities, and the weak institutional capacities of the service providers. Regarding investments made between 2006 and 2016, Bs. 9,295 million were invested in potable water and basic sanitation, while Bs. 2,645 billion were invested in 2,845 irrigation and drinking water projects for the MI AGUA I, II and III programmes between 2011 and 2015.
- **Investment in irrigation.** Bolivia has made significant improvements on irrigation since 2005, however, there are still some major challenges to be overcome, which are covered in the Patriotic Agenda, the SEDP and the sectoral plans at the national and sub-national levels. Investment on irrigation in Bolivia took a leap forward from Bs. 843 million invested during the period 1987-2005, to Bs. 5,354 billion during the period 2006 – 2015 (an increase of 816%). In 2015 alone, Bs. 1,481 billion were invested in irrigation projects, of which over Bs. 1,306 billion were used on major investments in damns, reservoirs, modernized irrigation catchment, reservoirs and channels, and new projects to improve and expand systems. These investments expanded irrigation services to an additional area of around 32,736 ha of farmland. This progress was made possible by all different levels of government (national and sub-national), EMAGUA and FPS at the forefront of ensuring this great leap forward. Over 100,000 families benefitted from irrigation projects between 2006 and 2015, bringing the number of families benefitting from investment in irrigation between 1987 and 2015 to a total of 144,327.

Law No. 300. Law of Mother Earth and Integral Development for Living Well. Law No. 300 of Mother Earth and Integral Development for Living Well of 2012 establishes the political, technical, and legal guidelines to guarantee sustainable development and the restoration and regeneration of the life zones of Mother Earth. In relation to the conservation of biological and cultural diversity (Art. 23), the Law promotes conserving and protecting water recharge zones, headwaters, watersheds, the country's borders, and areas with high conservation value through the framework of the integrated management of watersheds. Regarding agriculture, fishing and cattle raising (Art. 24), the Law indicates that the maximum limits of use and exploitation of the components of Mother Earth should be established according to each zone and life system, and that harmonious, adequate, responsible and participatory management policies for agricultural production should be developed according to the characteristics and regional vocation of each life system. In relation to Forests (Art. 25), it indicates that the surface area of total forests and their functions should be identified, updated, and classified for the use and planned harvesting of timber and non-timber products, and the protection of primary forests. In article 27, the Law indicates that the conservation, protection, preservation, restoration, sustainable use, and the integrated management of glacial, wetlands, underground, and other water sources must be guaranteed, prioritizing the use of water for life.

Paragraph I of Article 53 of Law No. 300 Framework of Mother Earth and Integral Development for Living Well provides for the constitution of the Plurinational Authority of Mother Earth (APMT) as a strategic and autarchic entity of public law with administrative, technical and economic management autonomy, under the Ministry of Environment and Water (MMAyA).

Paragraph IV of Article 53 of Law No. 300 defines that the APMT operates technically through the following mechanisms: Joint Mitigation and Adaptation Mechanism for the Integral and Sustainable Management of Forests and Mother Earth; Mitigation Mechanism for Living Well; and Adaptation Mechanism for Living Well.
Supreme Decree 1696 regulating Law No. 300 Framework of Mother Earth and Integral Development for Living Well has established five areas of intervention within the framework of the mechanisms for adaptation, mitigation and integrated and sustainable management of forests, according to the following detail:

- Scope of governance of forests and life systems of Mother Earth.
- Scope of participatory processes of territorial management in the framework of the management of life systems, with a focus on mitigation and adaptation to climate change.
- Scope for the coordination of local territorial agreements regarding objectives and/or goals for the development of sustainable productive systems with a focus on mitigation and adaptation to climate change.
- Scope of integral support to sustainable productive systems and to the integral and sustainable management of forests and life systems of Mother Earth, promoting environmental, food, energy, technological and productive sovereignty with diversification.
- Scope of information and integral monitoring of the components, environmental functions and life systems of Mother Earth,

Law 031. The "Andrés Ibáñez" Framework Law on Autonomous Entities and Decentralization. Enacted on 19 July 2010, this Law aims to regulate the autonomous regime by mandate of Article 271 of the SPC and using as a basis the territorial organization of the state established in its Third Part, Articles 269 to 305. This Law has made the creation of diverse and different autonomous levels possible, within the framework of respect for national unity: departmental, municipal, indigenous, and native peoples, and regional autonomies. The first two correspond to the existing territorial entities in the country, while the third would be a new type of entity created through the framework of indigenous territories and the fourth constitutes a new type of autonomous where two or more provinces unite to build a new autonomous region or by associations of municipalities (as long as they do not exceed the departmental limits). All autonomous levels have competencies and attributions related to state management at different levels; they have legislative entities and executive bodies as stated in the law. The departments quickly constituted their autonomous legislative assemblies and their executive bodies, pending the drafting of their autonomous status or adapting to the new constitution through the drafts and proposals of statutes they already have. Municipal Governments have a long tradition of organizational methods, which they will adapt to how they take on and process the new competencies.

Law No. 777. State Integrated Planning System. The Constitution asserts that national planning is an exclusive competence of the central level of the state (Art. 298) and that the planning of autonomous territorial entities is exclusive to the autonomous departmental governments (Art. 300), the autonomous municipal governments (Art. 302) and the rural native indigenous autonomies (Art. 304). Furthermore, the SPC states that planning autonomous territorial entities must be in accordance with the national plans. Law No. 777 State Integrated Planning System (SIPS) approved in 2016 aims to establish the Plurinational State of Bolivia integrated management system for planning integrated development within the framework of Living Well. The SIPS aims to construct Living Well through integrated development, promoting the life systems of Mother Earth to achieve simultaneous and complementarity sustainable farming systems, the eradication of extreme poverty and the conservation of environmental functions in different territorial and jurisdictional areas. The objective of this legal framework is for long, medium and short-term planning to be done using an integrated and harmonious approach, and also by coordinating different levels of national and sub-national governments, which would coordinate with the social sectors to carry out comprehensive monitoring and evaluation of these plans based on specific goals, results and actions. The long-term plan (10 years) includes the General Plan for Economic and Social Development (GPESD), the Bicentennial Patriotic Agenda for 2025, which has a five-year medium-term plan, and the Economic and Social Development Plan (ESDP). The Integrated Development Sectoral Plans (IDSP) are linked with the GPESD over a period of 10 years, and the ESDP five-year plan.

The GPESD defines the pillars and targets, while the ESDP establishes the results of the targets and pillars. The IDSP incorporates the specific actions of the sector in relation to the indicated pillars, targets and results of the GPESD and ESDP. Within this framework, the sector headed by MMAyA prepared its Integrated Development Sectoral Plan (IDSP), with input from MDP. The IDSP incorporates the watersheds and water resources, water and sanitation, irrigation, solid residues, forests, biodiversity and protected areas subsectors, has cross-cutting components for the quality management of the environment and climate change, and intersectional actions with other sectors overseen by various ministries of the Executive Branch of the Plurinational State.

Law No. 144. Agricultural Community Productive Revolution. Law 144 was enacted in 2011 and establishes a state policy – within the framework of sustainable integrated rural development and food security and sovereignty – to promote and strengthen production (Art. 13). This Law recognizes indigenous organizations as economic organizations subject to assistance and loans, and also as central actors in the process of development in rural areas. The Law develops, in detail, the mechanisms of food sovereignty by attributing state control over commercialization, importation as well as exportation of products while coordinating such processes with the producers.

Law No. 2878. Promotion and Support to the Irrigation Sector for Farming and Animal Husbandry. Law 2878 enacted in 2004 creates a water rights regime for different agricultural irrigation actors as a way to legally protect the water sources of native communities and indigenous producers, while also establishing a normative framework for conflict management and resolution, as well as an institutional framework to regulate, support and promote irrigation. The Law establishes two types of rights in relation to water use for irrigation by irrigators' organizations, for native and indigenous producers in general and for other non-community agricultural and forestry users (for example agri-business). The Law establishes the right to use water resources for irrigation (Art. 21). When the Water Resources Authority was set up, it established the National Irrigation System (SENARI) to grant and revoke water use authorizations for irrigation. The Law also establishes the creation of Local Watershed Committees, as an option available to the users. Regulatory decrees establish respect for local irrigation authorities following local tradition.

Law No. 1715. National Agrarian Reform Service (INRA) and Law No. 3545. Community-based Agrarian Reform Renewal. Law No. 1715, on the National Agrarian Reform Service (INRA) or INRA Law, was enacted in 1996 to guarantee the right to land ownership, title lands and plan, organize and consolidate agrarian reform in the country. Law No. 3545 was enacted in 2006, and incorporates the provisions for the INRA Law, making them compatible with Law No. 3351 of the Executive Authority Organization. Among the most important aspects of Law No. 345 are the paragraphs on Social Economic Function, means of verification and the parameters for the areas that must be considered. It also provides the option to extend tax payments for the farming sector, small properties owned by indigenous and native peoples and communities, and for those with appropriate accreditation rights. This Law includes the Ministry of Rural Development and Agriculture and the Environment in the structure of the National Agrarian Reform Service instead of the Ministry of Sustainable Development and the Environment. It confers on the President of the Plurinational State, the attribution of granting legal status to Indigenous and Native Peoples, indigenous and farming communities, and their respective national, departmental and regional organizations, at the request of a party. Finally, it modifies the composition of the National Agrarian Commission, and adds the attribution: "Promote and present plans or policies for the expropriation of land due to established public utility," as presented in Law INRA.

Law No. 337. Support to Food Production and Forest Restoration. Enacted in 2013 this Law aims to encourage – through the use of areas that would have otherwise been cleared without authorization – the production of food to guarantee the fundamental right to sovereignty and food security, as well as the restitution of affected forest areas. This can be found within the envisaged framework paragraph II of Article 16 of the State Political Constitution and Law No. 300 of October 2012: Law of Mother Earth and Integral Development for Living Well. Through this Law the Programme for Food Production and Restitution of Forests was created, which aims to encourage food production and the reforestation of affected areas under the supervision of MDRyT. This ministry is also in charge of the Food Production Support Enterprise (EMAP) and the Authority of Fiscalisation and Social Control of Forest and Land (ABT).

Law No. 071. Rights of Mother Earth. Its objective is to recognize the rights of Mother Earth, as well as the obligations and duties of the Plurinational State and society to guarantee respect for these rights. Enacted in 2010, it established six principles of mandatory compliance (Art. 2) which are: 1. Harmony; 2. The Collective Good; 3. Guarantee the regeneration of Mother Earth; 4. Respect and Defend the Rights of Mother Earth; 5. The NON-commercialization of life systems, nor of the processes that support such, or anyone's private heritage; and 6. Interculturality.

Law No. 1333. Environment Law and Regulations. Enacted in 1992, it aims to protect and conserve the environment and its natural resources, by regulating the actions of human beings in relation to nature and by promoting sustainable development in order to improve the quality of life of the population. This Law establishes five main regulations: General Regulation of Environmental Management, Regulation of Water Pollution, Regulations for Activities with Hazardous Substances, Solid Waste Management Regulation, and Environmental Prevention and Control Regulations.

Law No. 755. Integrated Waste Management. Enacted in 2015, this Law establishes the general policy and legal regime for Integrated Waste Management in the Plurinational State of Bolivia. This law prioritizes prevention to reduce waste production, use it efficiently and dispose of it safely. This relates to the Rights of Mother Earth framework, as well as the right to health and to live in a healthy and balanced environment.

Law No. 1700. Forestry Law. This Law regulates the sustainable use and protection of forests and forest land for the benefit of current and future generations, while harmonizing the social, economic and ecological interests of the country. Enacted in 1996 through S.D. No. 24453, it also declared the Regulation of the new Forestry Law.

Law No. 745. Decade of Irrigation. Enacted on 5 October 2015, the purpose of this law is to declare the period 2015-2025 – The Decade of Irrigation “Towards a Million Hectares”– within the framework of the Bicentennial Patriotic Agenda. This aims to promote agricultural production through investments from the central level of the state and the Autonomous Territorial Entities, oriented to develop irrigation in the country.
General Regulations for Protected Areas. Enacted through S.D. No. 24781 in 1997, it aims to regulate the management of protected areas and to establish its institutional framework based on the provisions of Law No. 1333 of the Environment and the Convention on Biological Diversity ratified through Law No. 1580 of 1994.

Law No. 1576. Approval and ratification of UNFCCC. Bolivia signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, and ratified it in 1994 through Executive Decree No. 1576 approved by the National Congress and the Executive.
Law No. 835. Ratification of the Paris Agreement. Bolivia ratified the “Paris Agreement” adopted on 12 December 2015, during UNFCCC twenty-first Conference of the Parties (COP 21). The agreement was signed by the president of the Plurinational State of Bolivia on 22 April 2016, and became law on 17 September 2016.

10. Institutional framework

Ministry of the Environment and Water (MMAyA). The ministry promotes equitable, reciprocal and harmonious development with Mother Earth through the integrated management of water resources, access to potable and safe water sources, irrigation for food security, as well as the integrated management of the environment and life systems to Live Well.

Ministry of Rural Development and Land (MDRyT). The institution is in charge of defining and implementing policies to promote, facilitate, regulate and articulate the integrated rural development of agriculture, forestry, aquaculture and coca, in a sustainable way that promotes a new structure of tenure and access to land and forests in the country. This will generate decent employment for producers, communities, farmer and indigenous economic organizations and the business sector, under the principles of quality, equality, inclusion, transparency, reciprocity and cultural identity for food safety and sovereignty to Live Well.

Plurinational Authority of Mother Earth (APMT): A strategic and autonomous entity that plans, manages, monitors and evaluates climate change actions, in addition to managing and implementing climate change policies, strategies, plans and programmes.

The Authority of Fiscalization and Social Control of Forest and Land (ABT): Responsible for exercising governance of forests and land: protecting, regulating, supervising and controlling human activities, while promoting the development and integrated sustainable management of forests and land for the benefit of the Bolivian people.

National Fund for Forest Development (FONAFOREST): An independent institution under the Ministry of Environment and Water (MMAyA) that channels financial resources to the integrated management of forests and forest lands. FONAFOREST manages different programmes linked to the application of Law

No. 300 of Mother Earth and Integrated Development to Live Well, as well as the afforestation and reforestation decrees. It is undoubtedly one of the institutions that has been the most receptive and useful to ensuring the application of Law No. 300 and its mandates, particularly for implementing the National Determined Contribution (NDC).

National Irrigation System (SENARI): Law No. 2878 created SERANI at a national level and SEDERI at a departmental level, as entities that regulate and grant registration and authorizations to use water for irrigation.

The Water and Environmental Executing Entity (EMAGUA): The drinking water and sanitation sector receives substantial amounts to be invested in the sector, particularly those managed by the Ministry of Environment and Water. However, the MMAyA cannot make public investment in this sector due to legal limitations; therefore, the state has various executing entities, one of which is EMAGUA created as an executing entity specialized in the environment and water management. EMAGUA is a decentralized entity with an autonomous administration.

11. Consultative platforms

The consultative platforms are spaces in which representatives of public and private entities, producers' associations and others participate in order to reflect on or establish critical routes on various interests, one of them being, for example, integrated watershed management, among others.

The platforms could become a space for the management of information for its dissemination and verification on the situational status of damages and losses, early warnings, among other extreme phenomena that affect small farmers, also related to risk management, climate change, rural development and diversification of production, etc. Although the platforms have begun to function, they still need to be strengthened in terms of climate change mitigation and adaptation criteria and indicators, as well as the application of technologies that will enable them to develop prevention rather than control actions.

Law No. 300 of October 15, 2012, Framework of Mother Earth and Integral Development for Living Well, establishes the vision and foundations of integral development in harmony and balance with Mother Earth for Living Well, guaranteeing the continuity of the regenerative capacity of the components and life systems of Mother Earth, recovering and strengthening local knowledge and ancestral knowledge, within the framework of complementarity of rights, obligations and duties; as well as the objectives of integral development as a means to achieve Living Well, the bases for planning, public management and investments and the strategic institutional framework for its implementation.

Paragraph I of Article 53 of Law No. 300 Framework of Mother Earth and Integral Development for Living Well provides for the constitution of the Plurinational Authority of Mother Earth (APMT) as a strategic and autarchic entity of public law with administrative, technical and economic management autonomy, under the Ministry of Environment and Water (MMAyA).

Paragraph IV of Article 53 of Law No. 300 defines that the APMT operates technically through the following mechanisms: Joint Mitigation and Adaptation Mechanism for the Integral and Sustainable Management of Forests and Mother Earth; Mitigation Mechanism for Living Well; and Adaptation Mechanism for Living Well.

Supreme Decree 1696 regulating Law No. 300 Framework of Mother Earth and Integral Development for Living Well has established five areas of intervention within the framework of the mechanisms for adaptation, mitigation and integrated and sustainable management of forests, according to the following detail:

- Scope of governance of forests and life systems of Mother Earth.
- Scope of participatory processes of territorial management in the framework of the management of life systems, with a focus on mitigation and adaptation to climate change.
- Scope for the coordination of local territorial agreements regarding objectives and/or goals for the development of sustainable productive systems with a focus on mitigation and adaptation to climate change.
- Scope of integral support to sustainable productive systems and to the integral and sustainable management of forests and life systems of Mother Earth, promoting environmental, food, energy, technological and productive sovereignty with diversification.
- Scope of information and integral monitoring of the components, environmental functions and life systems of Mother Earth.

It is worth mentioning that in the area of concertation and local agreements, local, regional and national organizational systems are recognized, as well as the strengthening of Territorial Consultative Platforms with the participation of all public, community and private actors, civil society organizations, international cooperation, among others.

Likewise, Article 9 of Supreme Decree 1696 establishes as mandatory that for the implementation of the aforementioned mechanisms, territorial, sectoral or program-based consultative platforms should be established or strengthened, as appropriate, with the participation of representative bodies at the national or sub-national level where actions to address climate change are being developed.

Under these normative considerations, the establishment of a Territorial Consultative Sectoral Platform for Agriculture and Climate Change, based on spaces for dialogue and reflection on the climate crisis and its impacts on agriculture, could also contribute to compliance with the aforementioned national regulations, as well as to the establishment of strategic guidelines for action.

Inter-institutional platforms related to climate change in Bolivia

The PDES and Sustainable Development Goals Monitoring Committee (CIMPDS) was created by Multiministerial Resolution 001 dated October 30, 2017, is a permanent Committee created as a technical instance responsible for the follow-up and monitoring for the achievement of the results and goals of the Economic and Social Development Plan (PDES) related to the Sustainable Development Goals (SDGs), consistent with the policies of each sector involved. as a technical instance responsible for the follow-up and monitoring of the achievement of the results and goals of the PDES related to the Development Goals.

Pursuant to the provisions of Multiministerial Resolution Nº001 of October 30, 2017, the Committee is made up of technical staff from the following ministries:
- Ministry of Development Planning
- Ministry of Economy and Public Finance
- Ministry of Health
- Ministry of Education
- Ministry of Justice and Institutional Transparency
- Ministry of Environment and Water
- Ministry of Rural Development and Land

The Committee will be under the direction, supervision and general coordination of the Ministry of Development Planning, through the Vice-Ministry of Planning and Coordination. The Committee is also under the technical coordination of the Social and Economic Policy Analysis Unit - UDAPE and the National Institute of Statistics-INE.

On February 27, the first ordinary meeting of the present administration was held, reaching the following final considerations:

- Articulation PDES - NDC. The normative and conceptual framework of the NDCs has been socialized, and the articulation of the NDCs with the PDES and the generation of indicators for the national report has been established.
- Registry of Monitoring and Evaluation Indicators (RIME). The RIME has been used as a computer platform to record the indicators collected in CIMPDS.

Article 8 of Law 602 establishes the structure of the National System for Risk Reduction and Disaster and/or Emergency Response. SISRADE: a) The National Council for Risk Reduction and Disaster and/or Emergency Response CONARADE chaired by the President of the Plurinational State of Bolivia and formed by the ministers of defense, development planning, public works, services and housing, health and rural development; b) The Departmental Committee for Risk Reduction and Disaster Response - CODERADE; and c) The Municipal Committee for Risk Reduction and Disaster Response - COMURADE.

Current Territorial Platforms.

According to APMT information, there are 11 territorial consultative platforms in place, among which are the following:

- Regional Platform of the Department of Pando.
- Working Group of the Municipality of Ixiamas.
- Charazani Territorial Consultative Platform
- Apolo Territorial Consultative Platform
- Concepción Territorial Consultative Platform
- San Ignacio de Velasco Territorial Consultative Platform.

There are also platforms generated by civil society initiatives, such as the Bolivian Platform against Climate Change, which is a national network of social organizations and civil society that contributes to the defense of Mother Earth and the realization of human, economic, social, cultural, environmental and indigenous peoples' rights, contributing from a vision of Climate Justice and gender equity to promote a social process to face the challenge of global climate change and reduce the vulnerability of local communities. The Bolivian Platform Against Climate Change works under the legal protection and support of the NGO COMUNIDAD EN ACCIÓN.

Need to strengthen territorial platforms for agriculture and climate change.
Given the current alarming climate context, where environmental, social and economic losses are becoming more prominent day by day, actions must be taken to combat the existing structural problems in climate governance, such as the lack of coordination between local and national, public and private actors, the lack of support for local development agendas and contradictory public management policies. The basis on which inter-institutional platforms have been created is to achieve local and territorial climate governance, with a focus on productive and development management that goes beyond thematic and sectoral initiatives, with the aim of achieving local climate governance, which implies clarifying the functional relationships and rules between the government at different levels (national, departmental and municipal) with civil society, producer associations and private enterprise, in order to establish mechanisms for citizen participation in management and decision making.
Likewise, the platforms that will be implemented and/or strengthened within the framework of the RECEM Valles Project will be aimed at territorializing public policies in the agricultural sector and their efficiency in dealing with climate change, exchanging experiences of good management practices and local management systems, promoting productive relations, to provide feedback to decision makers with continuous information and to generate the interaction of local communities for the development of their own or shared solutions with the different levels based on dialogue and exchange of local and academic knowledge, as well as to disseminate information on the prevention and control of risks and agricultural disasters resulting from temperature and precipitation variability.
According to Supreme Decree No. 1696, the strengthening of territorial, sectoral or program-based consultative platforms are technical bodies for articulation, planning and climate management, made up of institutions and organizations representing the sector that have field experience in the integrated and sustainable management of water, soil, forests and biodiversity, as well as innovative solutions to advance climate change mitigation and adaptation, generating inputs for operational decision-making to help achieve the objectives, strategies and policies for integrated rural development established.

12. Programmes and Projects

“**Our Forests” Programme:** Approved through S.D. No. 2914 of 2016, this programme aims to establish regulatory mechanisms for agricultural production on forest lands, control and eradicate illegal deforestation, strengthen local institutional capacities, reduce the effects of illegal deforestation, and promote strategies and actions for the recovery of forests in degraded areas. The main authority responsible for this programme is MMAyA, along with other entities that depend on it, especially ABT. The Autonomous Territorial Entities play a special role as they are the programme implementers at the local level − at the municipal and departmental levels with their corresponding governments. MMAyA and MDRyT, through a biministerial resolution, identify annual targets and areas of agricultural frontier expansion for the production of food within the Social and Economic Development Plan framework. This process is carried out by identifying how the land is being used and the environmental functions of the forests in the area in question. MMAyA´s Forestry Information and Monitoring System monitors the achievement of targets.

National Afforestation and Reforestation Plan (NARF): Approved by S.D. No. 2913 of 2016 as a strategic and national priority. This programme relates to the National Determined Contribution that Bolivia presented to the United Nations. There are six institutions that implement the NARF; the MMAyA coordinates the NARF National Implementation Strategy 2016-2030 and runs the projects. Local authorities have specific afforestation and reforestation mandates in their territorial area of competence, and coordinate mainly with the MMAyA. On the other hand, social organizations are invited to participate in afforestation and reforestation processes. The framework promotes the general participation of communities, neighbourhood meetings, associations and other local organizations. Furthermore, the “My Tree” campaign was implemented to disseminate the NARF actions. To monitor progress, the autonomous governments must send all information related to compliance with the NARF targets in their jurisdiction to the MMAyA Forestry Information and Monitoring System. The National Fund for Forest Development (FONABOSQUE) is responsible for financing the NARF. There are also specific mandates for governors and municipal governments to contribute to the financing of targets established through the programme.

13. Investments from the Central Government

National investments in water and sanitation

Among the priorities of the 2006 -2017 government period has been to provide solutions to the problems of scarcity of water sources for consumption, low coverage of drinking water and sanitation, and service providers' institutional weakness.

Considerable financial resources investments have been made and comprehensive policies developed to address several challenges. These challenges include:

- Conclude the water regulatory framework already configured in its specific mandates in Law 2066.
- Design the new institutional framework and implement it by executing the following actions: regulation, technical assistance, institutional strengthening of the Entities for the Provision of Water and Sanitation Services (EPSAs), community development, management of investment processes.
- Strengthening the EPSAs, improving their efficiency and their capacity for administration and investment in the provision of services, as well as planning instruments and implementation of their plans.
- Planning of investment in the sector and construction of information on the progress in service provision goals and improvement of access to sources of water and sanitation.
- Develop significant investments in the sector in a planned manner.
- Make significant progress in meeting goals in water and sanitation and comprehensive watershed management and irrigation management.

It has not been possible to complete the sectoral legal framework by developing the Water Framework Law that would allow the regulation of all water uses, mainly those destined for industrial and extractive services and the rule of the discharge of wastewater from that sector.

Creation of institutions for the provision of water and sanitation

Various institutions were created, including: 1) the Drinking Water and Sanitation Control and Supervision Authority (AAPS), 2) the National Service for the Sustainability of Basic Sanitation Services (SENASBA) and 3) the Environment and Water Executing Entity (EMAGUA). The first is to oversee social control of the Entities of Provision of Water and Sanitation Services; the second is institutionally strengthening the EPSAs in administrative and management issues, in access to technology, and participation in social control through community development projects (DESCOM). The third was created in a context of overload of projects and investments in the executing entities in particular in the National Fund for Productive and Social Investment (FPS), which required the establishment of an executing entity specialized in water, sanitation and environment projects, thus facilitating the administration of financial resources and speeding up the execution of projects in a context of prioritizing the water agenda.

Investments in drinking water and sanitation

Regarding investments in water and sanitation, the following is noted:

- Between 2006 and 2016, in a period of 11 years, investment in drinking water and basic sanitation was 9,295 million bolivianos.
- Between 2011 and 2015 alone, in the Mi Agua I, II and III programs, 2,645 million Bolivians were invested in irrigation and drinking water for a total of 2,845 projects.

As for the coverage goals in water and sanitation, the following should be highlighted:

- The national coverage of drinking water services increased from 71.7% in 2005 to 84.9% in 2015.
- In urban areas, drinking water coverage rose to 92.78% and in rural areas to 67.77% for 2015.
- The population benefited by drinking water projects in the period 2006 - 2014 was 2,131,866 inhabitants.
- 394,672 drinking water connections were made between 2006 and 2014.
- The national coverage of basic sanitation increased from 43.5% in 2005 to 57.4% in 2015.
- In the urban area, sanitation coverage in 2015 reached 64.21% and in the rural area 42.92%
- The population benefited from sanitary sewerage projects between 2006 and 2004 was 1,313,950 inhabitants.

National Investments in Irrigation

Investment in irrigation projects has a significant boost in the country, with an increase of more than 535% in the last 12 years; however, there are substantial challenges that must be faced, which are contemplated in the actions of the State, in the Patriotic Agenda 2025, the Economic and Social Development Plan (PDES) and the sectoral plans at the national and subnational level.

A series of programmes and projects focused on Irrigation have been implemented, mainly to comply with the Patriotic Agenda's provisions of moving throughout the country from agricultural production systems to dry land and flood irrigation to irrigation systems that optimize the use of drip and spray water.

MIAGUA and MI RIEGO Programmes

Since 2011, the MIAGUA I, MIAGUA II and MIAGUA III programs have been implemented with significant impacts on expanding water and irrigation coverage throughout the country. The expansion of irrigation has accelerated in recent years, with a public investment of the order of 80 Million Dollars per year in the last five years, expanding the coverage by 16,000 hectares under irrigation on average per year. This increase is mainly due to the More Investment for Water programme: (MIAGUA), a government undertaking to build infrastructure to provide drinking water to small cities and rural communities, and productive infrastructure to increase access to irrigation water to establish resilient agriculture systems to the risks of climate change.

The MI RIEGO Program has been implemented since 2015 by the MMAyA with external financing from organizations such as the Inter-American Development Bank (IDB) and the Andean Development Corporation (CAF). Additionally, the execution of the Irrigation projects is carried out with the Ministry of Planning and Development (MPD), with financing from “The Opec Fund for International Development - OFID” (Fund for International Development of the Organization of Petroleum Exporting Countries). The objective of the MI RIEGO Program is to increase economic income through agriculture in benefiting rural households by increasing the agricultural area under irrigation, and an improvement in the efficiency in the use and distribution of water for agricultural purposes.

The history and characteristics of the MIAGUA programs can be summarized in the following terms:

- The program is financed by CAF and seeks to facilitate the adequate and timely construction of minor works of irrigation systems that allow increasing agricultural production and the generation of employment; as well as, strengthen the organizational and management capacity of users for the operation and maintenance of irrigation systems.
- Those responsible for the MIAGUA I Program as Co-Executors are: the Ministry of the Environment and Water (MMAyA) and the National Fund for Productive and Social Investment (FPS).
- Regarding the budget, it consists of the Financing Agency's investment - Andean Development Corporation (CAF) and the Counterpart of the Municipality (Local Contribution); 82% and 18%, respectively.
- MIAGUA I: Through Supreme Decree No. 0871 of May 11, 2011, the signing of the Financing Agreement between CAF and the Plurinational State of Bolivia was authorized, for an amount of up to US $. 75,000,000, for the financing of the MIAGUA Programme. Contract approved by Law No. 124 of May 26, 2011.
- MIAGUA I (Phase 2): Through Supreme Decree No. 1274 of June 29, 2012, the signing of the Financing Agreement between CAF and the Plurinational State of Bolivia was authorized, for an amount of up to US $. 18,450,000, for the financing of the MIAGUA I Program (phase 2). Contract approved by Law No. 296 of October 5, 2012.
- MIAGUA II: By means of Supreme Decree No. 1341 of September 05, 2012, the signing of the Financing Agreement between CAF and the Plurinational State of Bolivia, for an amount of up to $ 115,000,000, was authorized to finance the MIAGUA II Program. Contract approved by Law No. 308 of November 13, 2012.
- MIAGUA III: Covered with TGN's own resources, for an amount of US $ 106,000,000, destined for Municipalities and Governments.
- MIAGUA IV: Through Supreme Decree No. 2725 of April 11, 2016, the signing of the Financing Agreement between CAF and the Plurinational State of Bolivia was authorized, for an amount of

up to US $. 70,000,000, for the partial financing of the MIAGUA Phase IV Program. Contract approved by Law No. 806 of May 17, 2012

Investment in Irrigation

As mentioned above, investment in irrigation in the country has been quite significant. In the period 1987 to 2005 Bs. 843 million were executed. In contrast, in the period 2006 - 2015, Bs 5,354 million were executed with a growth of 816%.

In 2015, the budgeted investment in irrigation projects was Bs 1,481 MM, reaching an execution of more than 1,306 million bolivianos, maintaining significant investments in dams, modernized irrigation, intake works, cutwaters, cuttings and channels between new projects; improvement and expansion that allowed to incorporate the 2015 management and incremental area of irrigation coverage approximately 32,736 ha, for agricultural production. This progress has involved an effort by different levels of government (national and sub-national).

A total of 144,327 families benefited from investments in irrigation between 1987 and 2015, of which more than 100,000 benefited from irrigation projects between 2006 and 2015.

Until 2016, the investment projects of the different Programs dependent on the Vice Ministry of Water Resources and Irrigation reached a total of 1,289 investment projects in the country. The intervening executing entities were investing 2,377 million Bolivianos for 2017 with different programs such as Koika, MIAGUA III, PROAR, SIRIC, MIRIEGO and PARC.

For the period 2011-2017, the water and irrigation sector intervention was significant through the intervention of different institutions. The PRONAREC Program invested 197,691,629 Bs executed in 54 projects and the MIAGUA I program executed 310,956,676 Bs with approximately 378 projects completed, reaching the irrigation sector to be covered with financing to 7 departments at the Bolivian level.

Investments by state institutions linked to projects with a climate change approach at the national level.

Investments in water and irrigation described on the previous pages consolidate the State's total investments in Bolivian. However, it is essential to specify some of them and others related to forestry and the environment, account for projects of small and medium-size programmes but are relevant for the analysis because they tell us about strengths and potentials, as well as weaknesses and opportunities to be addressed within the framework of state policies and public institutional actions.

National Forest Development Fund (FONABOSQUE)

FONABOSQUE is an entity dependent on the Ministry of Environment and Water (MMAyA) and functions to channel financial resources for the integral management of forests and forest lands. FONABOSQUE manages different programs linked to the application of Law 300 of Mother Earth and Integral Development for Living Well and the afforestation and reforestation decrees. It is undoubtedly one of the entities that have been permeable and functional to the application of Law 300 and its mandates, particularly to the implementation of the Nationally Determined Contribution (CND).

Between 2012 and 2015, FONABOSQUE arranged and executed a budget of 138 million bolivianos for different projects within the My Tree Program framework. Likewise, as part of the Program for implementing the Framework Law of Mother Earth and its mandates related to the conservation and strengthening of environmental functions, FONABOSQUE executed financing for an amount of 27.9 million dollars for reforestation.

Adaptation of Small-Scale Agriculture in the Chuquisaca, Potosí and Tarija Valleys (ACCESOS - ASAP)

The ACCESOS - ASAP Program corresponds to the Ministry of Rural Development and Lands (MDRyT). This programme aims to finance agricultural projects at the local level in various regions of the country, including the area corresponding to the project.

The program has two components: Capacity Building for Community Adaptation and Climate Risk Management (Investment in Climate Risk Reduction).

The ACCESOS-ASAP program had an accumulated execution as of July 2016 of Bs. 19.7 million out of a total of Bs. 75.6 million budgeted. Some achievements of the project worth mentioning[88]:

- 500 hectares of land recovered for agricultural production through inter-family tenders.
- Increase in the average income of families participating in Productive Economic Enterprises up to 20%.
- The operation of 230 mobile and fixed day care centers in Productive Economic Enterprises and activities programmed in the management POA that benefit women who participate in the program with children under 5 years of age have been developing.
- 20,950,999 Bs were transferred to the Ventures Economic Productive, benefiting 464 producer organizations.

Projects of the Plurinational Authority of Mother Earth (APMT)

The APMT is an authority created by Law 300 of Mother Earth and Integral Development to Live Well. The projects executed by the APMT focused on the following types of projects:

- Adaptation and mitigation in life systems.
- Restoration of the life system in degraded areas.
- Restoration of the environmental functions of the protection forest riparian areas.
- Implementation of production systems as adaptation and mitigation actions.
- Strengthening of institutions for sustainable forest management.

The APMT implemented a little more than 70 projects. Since its creation and operation, it has implemented few advocacy projects at the national level because it is a relatively young institution.

[88] Source: MDRyT, Management Report 2016

However, it has excellent institutional potential that makes it an important actor as an executor or co-executor of projects because it has a comprehensive vision of environmental and climate change issues.

Social Project Financing within the framework of the Economic and Social Development Plan (PDES)

Under the PDES, significant investments have been planned, particularly concentrated in water, sanitation, watershed management, and irrigation. A package of water projects was planned for US$ 674 MM to start in 2017 and US$ 1,523 million to be executed as of 2018. This project package represents a central part of the investments in water planned to advance in the goals established in the PDES and the patriotic agenda. For this purpose, the Ministry of Development Planning (MPD) managed to accumulate grant and loan resources of US$ 588 million for 2017 and US$ 1,523 million for 2018.

Among the projects and programs that received financing, we highlight the following:

- PRONAREC III National Irrigation Programme for Communities for an amount of US $ 196 million.
- Lake Titicaca Sanitation Programme for an amount of US$ 86 MM.
- Programme for Regulation and Storage Capacity / Dams (OFID co-financing- US $ 61 million. Total: US $ 141.5 million) for an amount of US $ 81 million.
- More Investment Programme for Irrigation (MI RIEGO) II for an amount of US $ 81 million.
- Investment Program in Disaster Risk Management for an amount of US $ 40 million.
- Additional PAR II Financing with Technified Irrigation for an amount of US$$ 100 million.
- Urban Sanitation Project (Treatment Plants) for an amount of US$ 250 MM.
- More Investment Programme for Irrigation (MI RIEGO) III for an amount of US$ 100 MM.
- Urban Sanitation Project (Treatment Plants) for an amount of US$ 250 MM.
- More Investment Program for Water - (MIAGUA) V for an amount of US $ 100 million.

Several sources of financing have been utilized for these programs and projects, including the World Bank (WB), the Inter-American Development Bank (IDB), the CAF, the French Development Agency (AFD), among others.

Investments in Water, Sanitation, Irrigation and Integrated Watershed Management in the Project Area for the Period 2010-2016

Regarding the MIAGUA Program, in the 2010-2016 period, a total of 610,882,663 Bs were invested, particularly in small and medium-scale projects where most of the investments are concentrated (See Figure 55)

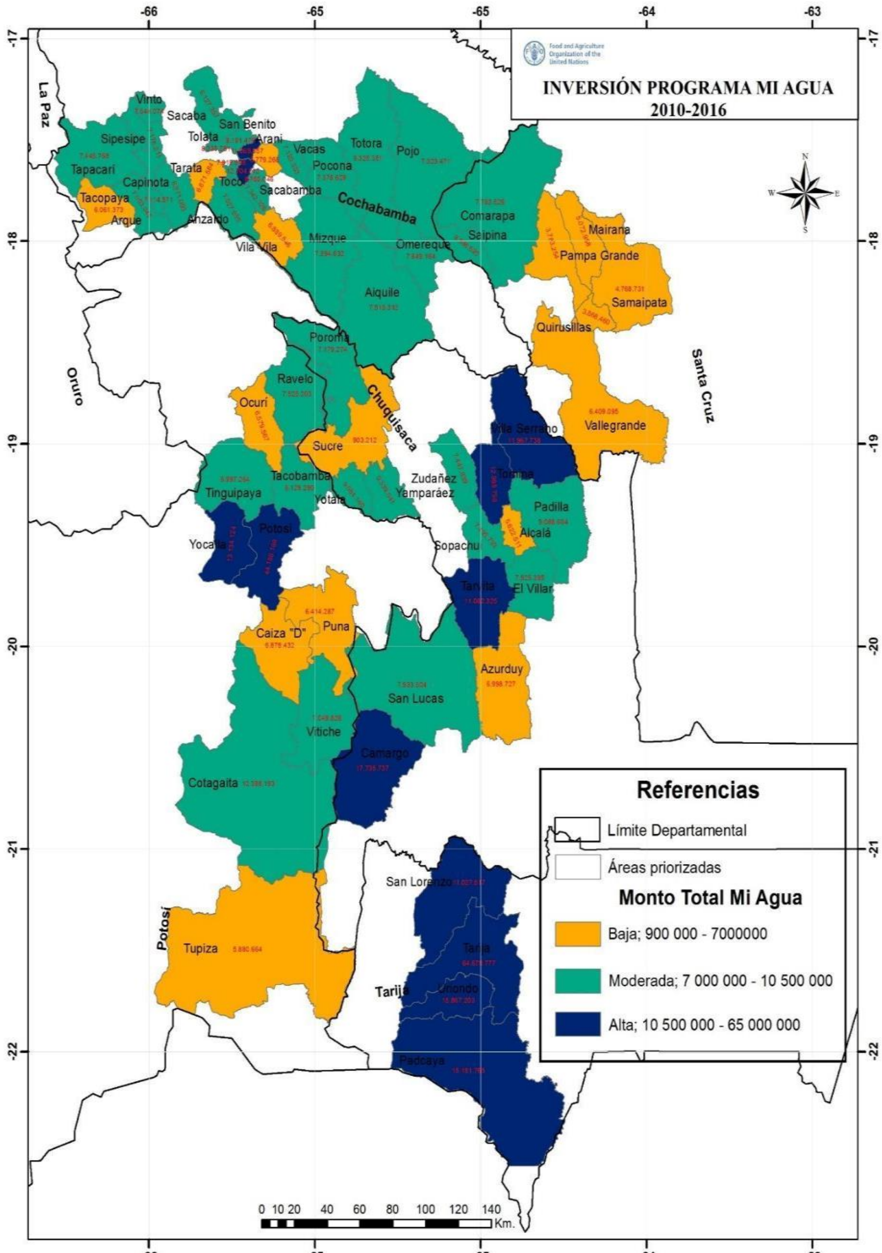


Figure 55 Investments of MIAGUA 2010 – 2016 Project Area

Regarding investments in irrigation, it is observed that 832,385,372 Bs were invested in a total of 55 municipalities in the referred period. It is notable that, in the case of irrigation, most of the investments are concentrated in large-scale projects, particularly in the departments of Potosí, Santa Cruz, Tarija and Chuquisaca (See Figure 56).

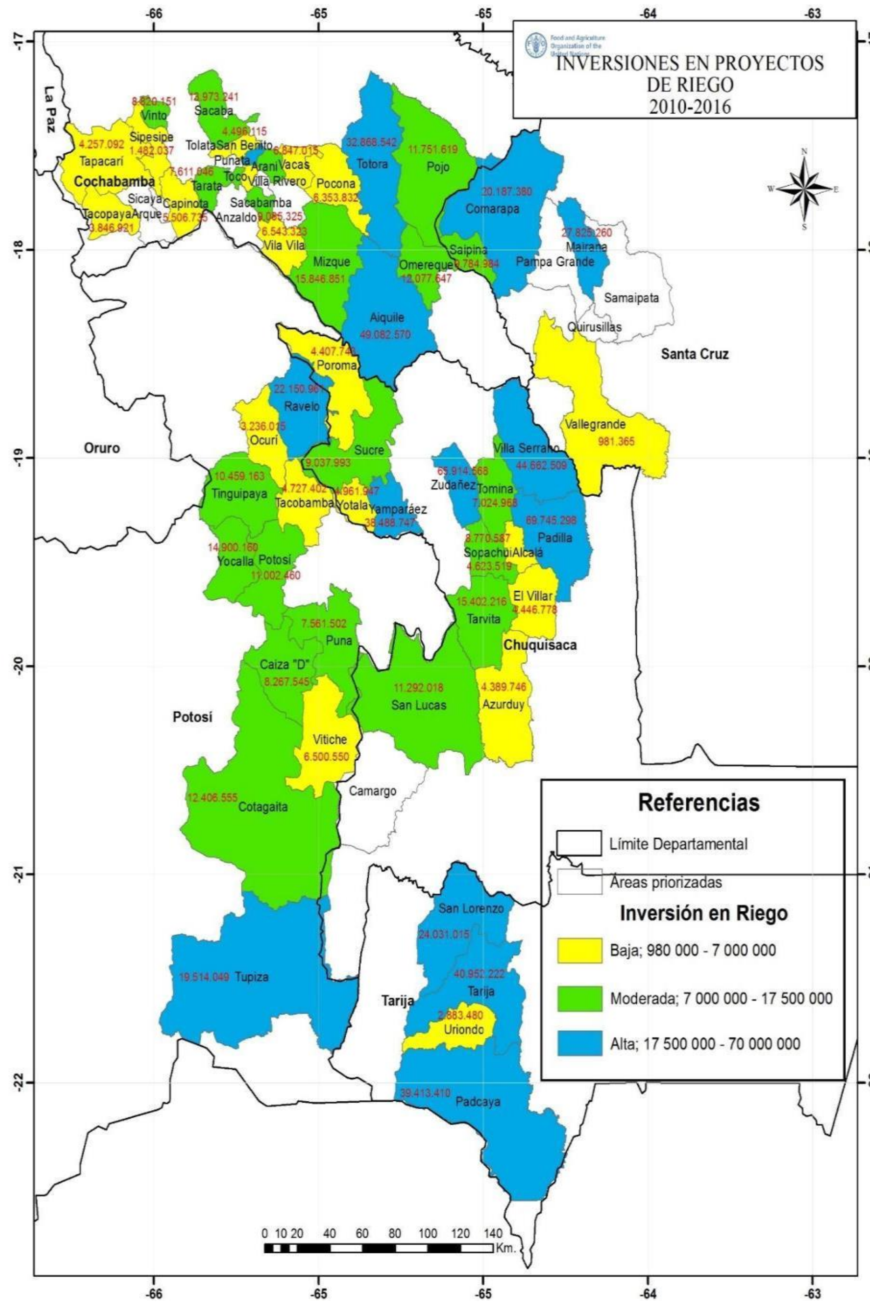


Figure 56 Investment on Irrigation Projects 2010 – 2016 Project Area

Regarding investments in Integrated Watershed Management, for the period 2010-2016, a total of Bs. 626,688,359 was invested, in a total of 59 municipalities (See Figure 57).

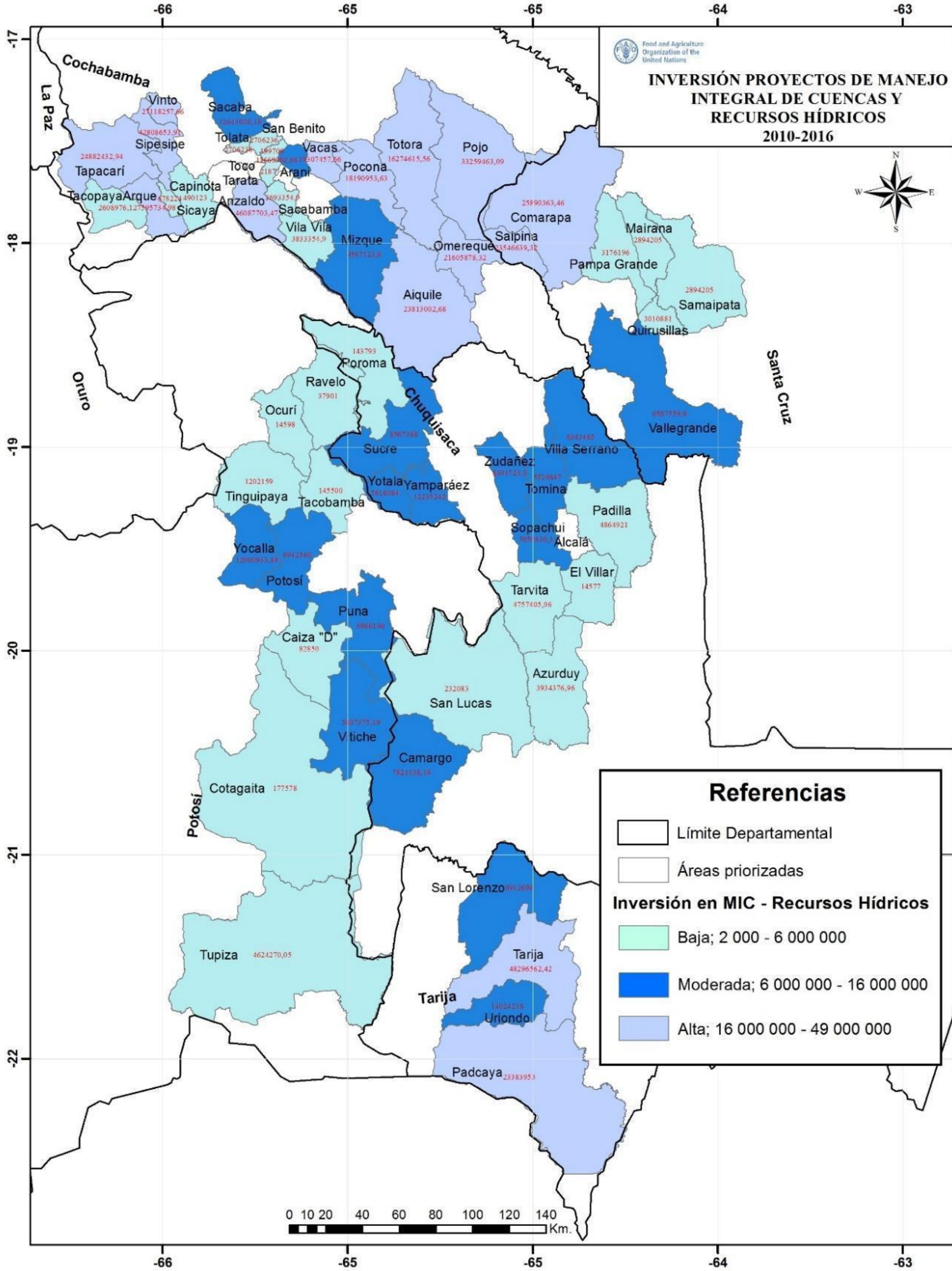


Figure 57 Investment on Integrated Watershed Management 2010 – 2016 Project Area

Finally, regarding Total investments (in Drinking Water, Irrigation, Comprehensive Watershed Management and Basic Sanitation), it is observed that in the 2010-2016 period, 2,666,278,819 Bs were invested in a total of 63 municipalities (See Figure 58).

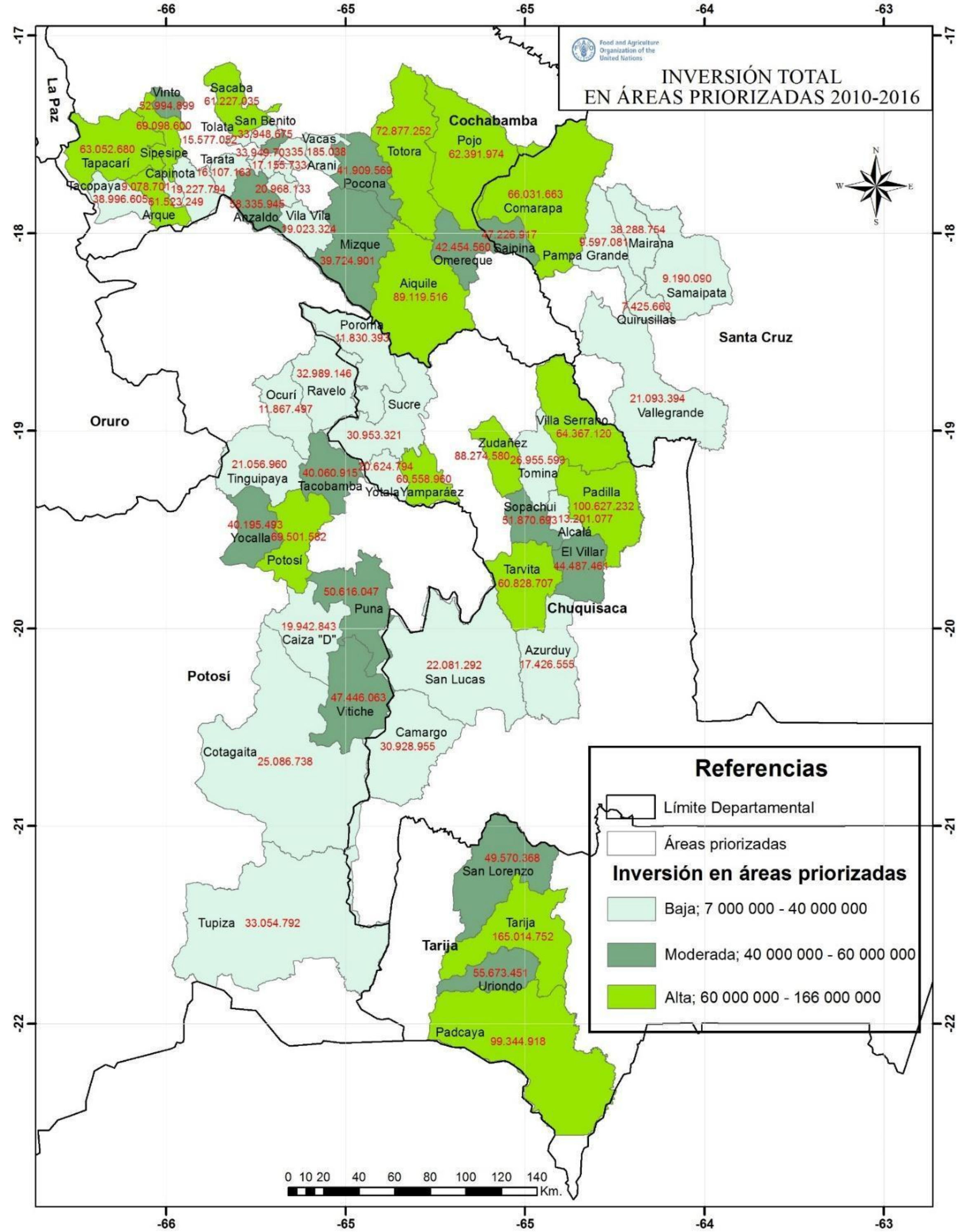


Figure 58 Total investment in prioritized areas 2010 – 2016 Project Area

In both irrigation and drinking water and watershed management, a concentration of large-scale projects is observed in southern municipalities, particularly Tarija, southern Chuquisaca, and in the northern part of the project area, especially the impoverished municipalities of Cochabamba. These regions are priorities in poverty eradication projects, including the poor municipalities of Potosí.

In Cochabamba and Tarija's valleys, there are significant productive potentials that would be increased with substantial investments in irrigation. The areas of less investment are mainly concentrated in Potosí and the poor municipalities of Chuquisaca. This region's geographic conditions and the small scale of production characterized by small landowners and highly degraded community lands require intervention with technified irrigation appropriate for the scale of small producers. These are areas populated by poor communities and ecosystems highly vulnerable to drought.

14. Lessons learned from previous projects

RECEM Valles project is designed on the basis of the lessons learned and good practices demonstrated by the project investments presented above. In particular:

The IADB confirmed in its CPE evaluation report (BID (2016-2020), Country Program Evaluation, La Paz, Bolivia) that many of the irrigation investments have not yielded the expected and generated a series of lessons learned and corrective actions that should be implemented in future projects. Some lessons learned included:

- Not considering a watershed approach in new irrigation investments, can reduce water availability.
- Investments on irrigation did not reach on-farm irrigation systems.
- The investments in irrigation must be done in places where there is a willingness to organize around the irrigation systems.

The results of another IDB impact evaluation[89] suggest that community irrigation systems can generate effects at the agricultural, economic and governance levels. The impacts caused by irrigation systems generate a snowball effect that enhances technology adoption.

The same evaluation indicates that beneficiaries who are more likely to have irrigation on their farms (24%), also have increased their investments dedicated to irrigating their plots, especially in equipment and maintenance (160%). In addition, they are more likely to use improved or certified seeds (80-90%), and agricultural machinery (7-19%), including tractors (11-20%). Overall, we see that technological change at the community level, driven by investments in public irrigation infrastructure, has triggered private technological change among producers. The project´s intervention (IDB investment in irrigation) had a significant impact on the value of agricultural production, increasing it by US$1,250 to US$1,550, representing an increase of 60-70%. In addition, there was a positive effect on total household income (35-45%), derived mainly from agricultural sales.

Adaptation barrier analysis

The project is specifically tailored to address and overcome institutional and local barriers that inhibit resilience-building by vulnerable populations with respect to climate change. At the local level, these barriers are largely socio-economic in nature rather than technical, reflecting issues related to farmers'

[89] Lopez, C. A, Salazar, L. 2017. Descifrando los misterios de los sistemas descentralizados de riego comunitario en Bolivia. (Documento de trabajo del BID ; 858)

agricultural practices, available financial resources, and coordination. Table 28 outlines the identified barriers and the project's approach to address them.

- **Technical Barriers**

Smallholder farmers have limited technical support to apply the appropriate technological know-how and innovation to adapt traditional agroecosystems management to increased climate variability.

Smallholder farmers have developed agricultural practices and cropping systems over millennia that have been finely tuned to historical constraints and opportunities. However, such practices are not enough to cope with current and projected climate change in the Valles Macro-region. Besides, the agricultural assistance to farmers is centralized and is based on the conventional model for extension services, which often provides inadequate support. On the one hand, the extension services cannot reach farmers due to a limited number of technical staff. Moreover, the provided assistance is centered around conventional agricultural practices due to limited knowledge and lack of skills to plan and implement climate-resilient farming practices.

Smallholder farmers lack appropriate and efficient on-farm water management practices and infrastructure to adapt to climate change.

Smallholder farmers in the Valleys Macro-region experience water shortages due to droughts and lack of adequate on-farm irrigation systems. Around 41% of Bolivia's territory has a water deficit, where the combination of insufficient irrigation coverage and the inadequate water use technologies, result in the low agricultural productivity.

- **Economic Barriers**

Limited access of smallholder farmers to financing to build resilience.

Smallholders tend to have little or no access to formal credit, which limits their capacity to invest in the technologies and inputs they need to increase their yields and incomes and reduce hunger and poverty, both their own and that of others. Financial institutions interested in serving this market face myriad risks and challenges associated with agricultural production and lending, including seasonality and the associated irregular cash flows; higher transaction costs; and systemic risks, such as floods, droughts, and plant diseases. Financial service providers (i.e., banks, microfinance institutions, and insurance companies) are discouraged from lending to farmers. As a result, smallholder rain-fed farmers have very limited access to finance and improved opportunities to enhance their production. This has prevented investments in land preparation, the ability to have climate-resilient production practices (e.g., rainwater harvesting) and has kept many families (especially single female-headed households) in continuous cycles of poverty and food insecurity. Consequently, farmers have had trouble entering markets, have poor access to agricultural technologies, and lack critical agricultural/livestock advisory and extension services. Additionally, smallholder farmers do not protect their investments in productive activities through either conventional index-based agricultural insurance or innovative index-based insurance products due to the lack of an adequate insurance product meeting their needs.

In Bolivia most smallholder farmers do not protect their investments in productive activities through either conventional indemnity-based agricultural insurance or innovative index-based insurance products due to the lack of an adequate insurance product meeting their needs. The project will put efforts to also identify mechanisms that enable public/private financial contributions (such as fee reductions) to reduce premium costs.

A normative mandate (Law No. 1488) and the constitution of funds in trust by the central State for the administration of the BDP (Productive Development Bank). The state has made regulatory changes to adapt the financial system, which were formalized with the enactment of the Financial Services Law and pose a set of challenges for financial institutions and regulators, stipulating that financial institutions made up of private capital must allocate at least 6% of their profits to reimbursable financial promotion with non-conventional guarantees to strengthen agri-food production systems.

Although this regulatory mandate exists, to date it has not been fully complied with, given that there are still a number of gaps in reimbursable and non-reimbursable financial support, areas that the RECEM Valles Project has identified and proposes to contribute to ensure food production in a context of mitigation and adaptation to climate change, to advance food security and poverty reduction.

Real guarantees are the traditional means used to guarantee loans, for example, for a loan for the purchase of a house the guarantee will be the mortgage of the same house or a loan for the purchase of an automobile the guarantee will be the same vehicle. Non-conventional guarantees are aimed at facilitating the obtaining of loans from the productive sector, so the client may present as collateral the ownership papers of a piece of land in the rural area, the products made by the client, a literary or artistic work, an invention, among others. Non-conventional guarantees will go through a process of evaluation, appraisal and corresponding registration.

There is a lack of comprehensive technical assistance. Project cash flows are a determining factor in the approval or rejection of an agricultural loan. In the case of agro-environmental models, there is no strong local knowledge about appropriate agroforestry and silvopastoral arrangements that guarantee cash flows within the terms established in the credits.

Lessons from previous initiatives on establishing financing mechanisms for smallholder farmers in Bolivia include: (1) One of the mechanisms for transferring risks from the producer and financier to third parties is insurance. However, although in Bolivia and the countries of the Andean region some state initiatives have been implemented for subsidized agricultural insurance to cover catastrophic weather risks, the scope is still limited and confined to the poorest strata, mainly subsistence farmers, thus leaving out an important segment of producers whose activities are more linked to commercial purposes. The development of a private supply of agricultural insurance is still incipient and has been hampered by a number of factors, among which the following stand out: (i) Moral risk on the part of the insured, (ii) scarce information on data yields, temperatures, rainfall and incidence and frequency of climatic phenomena, as well as the high cost of obtaining and processing the information, (iii) lack of knowledge and understanding on the part of the farmers regarding how insurance works, (iv) high cost of verification in the event of the occurrence of a risk event, (v) high frequency of occurrence of climatic events and covariance of agricultural risks. (2) Within the framework of this innovation process in agricultural insurance, the recommendations refer to the development of the following: (i) Indexed agricultural insurance, based on information from weather stations on rainfall and air temperature, which will make it possible to foresee the potential occurrence of catastrophes and eliminate the need for field verification with adjusters, in addition to paying indemnity directly to the region's producers. As verified by the project financed by the World Bank through FIDES. (ii) Agricultural insurance based on indexes using atmospheric circulation data provided by satellites, for which data studies are being conducted and indexes are being analyzed to determine indemnity parameters.

Smallholder farmers lack support for marketing and selling opportunities for their agricultural produce.

*S*mallholders' access to markets is a crucial challenge, which contributes to poverty and food insecurity. The lack of timely market information on pricing, demand, market trends, and limited management skills hinders smallholder farmers from equitably access and benefit from local, departmental, and national markets. Despite government efforts to improve the agricultural marketing systems, this remains a challenge for smallholder farmers.

- **Institutional Barriers**

Interinstitutional coordination takes place at regional level, without addressing the needs of smallholder farmers and producer associations.

MiRiego Programme is a national programme implemented by the central government which has a wide coverage of irrigation infrastructure; however, there are two limitations: (i) irrigation programs have focused on a centralized administrative approach in providing physical infrastructure and equipment; and (ii) a gap for reaching on-farm due to normative constraints that bans State infrastructure interventions to (i.e. transfer of service like on-farm irrigation) to private actors, including smallholders. Accordingly, in terms of small-size infrastructure, there is a gap between the infrastructure built by the central government and the one needed by the smallholder to transport water to their farms along the last phase of distribution of water for irrigation.

The MiRiego program focuses almost exclusively on the construction of irrigation infrastructure (gray infrastructure) and builds this infrastructure without considering climate change projections for rainfall variability and extreme events. Construction also occurs without considering the climate effects on the hydrological cycle in watersheds feeding irrigation systems. Irrigation infrastructure may be susceptible to siltation, flooding or damage as a result.

Irrigation system management support at the farm and community level will be supplied by the relevant institutions whose capacities will be strengthened in terms of watershed planning, governance, and management, as well as in regard to the use of water-efficient irrigation technologies. In particular, organizational strengthening will be carried out to ensure equitable water sharing and allocations, irrigation scheduling, and cost recovery for O&M expenditures, among other aspects.

This endeavor will be carried out using the information provided by Component 4, specifically on climate change analysis, participatory land use planning, local water and weather monitoring, and the provision of technical support. Accordingly, irrigation allocation and scheduling, and local capacities strengthening will be planned based and backed-up upon robust information.

To reduce the vulnerability of local communities and small producers to the effects of climate change in the "Valleys Macro-region" landscape, government institutions must implement a support program that integrates social, economic and ecological priorities. This articulation of actions requires a shared strategy that incorporates the preservation and restoration of environmental functions from implementing sustainable management practices of grasslands, vegetation cover and forest lands.

Likewise, the lack of coordination between institutions makes it difficult to develop and implement effective mechanisms that allow small farmers and producers in general, to sustainably manage their natural resources and agroecosystems to optimize productivity, with less impact on processes of hydrological regulation, climatic and of other existing environmental functions in the water sources or their parcel. Undoubtedly, one of the causes of the lack of inter-institutional coordination is that most institutions focus on their sectoral priorities, making it impossible to develop synergies with other sectors, thus reducing the opportunities to generate articulated impacts at the landscape level of the "Valleys Macro-region".

In this sense, inter-institutional coordination is a preponderant factor for implementing actions with an integrated landscape approach and required to successfully adopt climate-resilient technologies and/or practices. To date, irrigation programs have focused on a centralized administrative process to provide physical infrastructure and equipment; However, to achieve the development of climate resilience, it is also necessary to restore the vegetation cover and implement measures for the conservation of soil and water sources, as well as the responsible use of water, to develop the most efficient operating capacity in systems irrigation.

In this context, institutions must generate capacities to provide adequate support to small farmers and local authorities, based on the implementation of a participatory approach to watershed management and the administration of efficient irrigation systems, considering the aptitude of the land, water availability and demand, as well as food production within the framework of productive diversification and resilience to climate variability.

Local institutions lack strong governance mechanisms for climate change and natural resources due to limited technical capacities.

Local institutions have significant limitations to implement public policies and adequately integrate gender equality or youth inclusion in relevant programs for climate adaptation and watershed management. An important driver of this limited approach in public policy implementation is the weak knowledge of the internal communal norms, and accordingly limited locally-adapted means to spur leadership and active social roles of women and youth. At the same time, an additional weakness is the lack of community-driven and multi-stakeholder climate change adaptation processes, among others. In addition, institutions focus primarily on their sectoral priorities, often to the detriment of synergies with other sectors, as result, opportunities for broader landscape level impacts are diminished or lost. The limited coordination, due to different factors, across institutions hinders the development and implementation of an effective approach that resolves institutional challenges, addresses direct and underlying causes of vulnerability, and empowers smallholders and other actors to sustainably manage their natural resources and agroecosystems so as to optimize productivity as well as impacts on hydrological and climate regulation and other ecosystem functions and services at watershed scale. Inter-institutional coordination is critical for the integrated landscape approach required for successful adoption of climate resilient agriculture and integral watershed management strategies at scale.

Lack of integral and participatory micro-watershed management plans to guide climate resilient watershed restoration and conservation practices.

In general, there is a lack of planning instruments at micro-watershed level to guide local decision-makers in integral watershed management adopting a climate resilient approach. This often results in unsustainable land and water use in the watersheds. In a context of decreasing water availability due to climate change in the prioritised areas of the project, the lack of water and land-use management plans will exacerbate water scarcity problems and agricultural impacts.

Table 28 Identified barriers to adaptation and the project's approach to address them

	Adaptation barriers	Project's approach to address the barrier
Technical barriers	Smallholder farmers have limited technical support to apply the appropriate technological know-how and innovation to adapt traditional agroecosystems management to increased climate variability.	**The project will provide tailored technical advisory support and capacity building to help farmers and extension services identify and implement appropriate, gender-sensitive and climate-resilient restoration activities locally.** In order to address the capacity gap, technical advisory support will be provided under Output 1.1 and output 3.1 to support producers in the implementation, operationalization and maintenance of the selected climate resilient practices and technologies. Farmers will specifically be trained through the Farmer Field School (FFS) system to learn about climate resilient agricultural techniques and understand the exposure to climate hazards that subsistence agricultural systems pose in the face of climate impacts. The FFS will be implemented in the following stages in the project: (i) design based on the local context, smallholders' needs, partners, and contributors; (ii) framing of the FFS's objective and scope according to smallholders' needs and strategies for scaling up the capacities and knowledge; (iii) development of local capacities for FFS; (iv) definition of the FFS content; and (v) monitoring, evaluation, and continuous learning. All of this will be done in a participatory manner and over the course of at least two years in each FFS cycle, to secure an adequate level of continuity. Participants will be smallholders (both men and women of various ages), with the assistance of the project's technical team, technicians from sub-national public institutions, NGOs, academia, and others supporting stakeholders.[90] The FFS will allow for rapid dissemination of the adaptation to and adoption of climate-resilient agriculture technologies and practices and management, and it will contribute to the decentralisation of extension services. The PROINPA Foundation's experience with the conservation, reproduction, and agroecological management of native potato and horticultural crop varieties in Bolivia's valleys and highlands is an important example of the benefits and possibilities provided by FFS.[91] Additionally, capacity building sessions for farm producers will be conducted under Output 4.3 to enhance their knowledge on climate risks, climate information and how to plan for adaptation.

[90] FAO (2016). Farmer field school. Guidance document. Planning for quality programmes. Rome: FAO.

[91] Vallejos J.; Gandarillas E. (2003). Análisis de impacto de las escuelas de campo en el cultivo de locoto (*Capsicum pubescens*). Estudio de caso de las Escuelas de Miguelito y Chulumani en el Municipio de Colomi. Cochabamba: PROINPA.

		The project ensures that all activities will consider the collection of local traditional knowledge and integrate that with science-derived information to provide culturally relevant adaptation solutions and information for the local context. Grounded processes, such as the FFS and the coordination and consultative territorial and agro climatic platforms, will enable the practical integration of these two types of knowledge. Agroecological management (from planning to capacity building and implementation) will also promote the dialogue between traditional and scientific-technical knowledge, with the former serving as a critical foundation for agroecological management.[92] The capacity and technical advisory services integrate gender sensitivity as part of the project's transformative approach by adopting participatory strategies to ensure equitable and active participation of women and their improved access to knowledge and technology. This will enhance their economic situation via the use of climate-resilient technologies in agriculture, participation in the market opportunities to be fostered, and spaces of participatory governance. This approach is transformative for facilitating women's empowerment towards gender equality.
	Smallholder farmers lack appropriate and efficient on-farm water management practices and infrastructure to adapt to climate change.	**Technical training of farmers in sustainable water management practices and the climate-proofing of irrigation systems will enhance the efficient use of water and thus increase yield production during drought periods.** Project interventions under Output 2.1 on revitalising irrigation systems and making them resilient to climate change by implementing modern systems will ensure efficient water use. On average, 90% of the irrigation systems in the Bolivian Valles Macro-region is based on gravity-fed irrigation or flood irrigation, which entails excessive water use. Technification will enhance the efficient use of water. For those regions where there is already a high deficit of water, the project will propose interventions of irrigation systems that use only rainfall water (instead of surface water from the rivers) that will be collected to be used in the dry months. This will be done in combination with other measures under Output 1.1 that promote climate resilient agriculture and measures under Output 3.1. Under output 3.1, there will be a focus on: (a) changing the planting time to ensure that sowing starts in the rainy season and therefore there is no need for irrigation during the sowing season; (b) changing the existing crops to crops with lower water requirements; (c) ensuring irrigation is based on rainwater harvesting, which can be used in the dry months; Low yields and poor (direct) access to local markets have made it difficult if not impossible for smallholders to generate sufficient income or access affordable credit to invest in technological innovations for climate proofing their irrigation systems. To address this limitation, the project will use two complementary approaches. The first approach is supporting and implementing income-generating activities (e.g., organization of fairs, facilitating access to markets, and setting up

[92] Altieri, M. A. (2021). La agricultura tradicional como legado agroecológico para la humanidad. *Revista PH*, *104*, 180–197.

		community and associative productive enterprises, as described in Output 1.2). A total of 4,448 ha of agricultural land will be more resilient to rainfall variability and other climate events as a result of climate-proofing irrigation systems. This will result in increased and more stable harvests for local markets, e.g., in the local communities, closest municipalities, and, when feasible, large cities within the project area. The second approach is contributing to and promoting the creation of financial mechanisms adapted to and accessible for smallholder farmers in Output 4.3. Additionally, the project activities under Output 2.2 will train smallholder farmers via FFS on adequate water use and management and invest in their implementation on the farms, which includes aspects of crop management for enhancing soil moisture retention.
Institutional barriers	Interinstitutional coordination takes place at regional level, without addressing the needs of smallholder farmers and producer associations. Local institutions lack strong governance mechanisms for climate change and natural resources due to limited technical capacities	**The project adopts a multi-level approach to empower both local and national institutions to effectively integrate climate adaptation interventions across agricultural systems and integral watershed management.** Project interventions include training and increased investment in concrete adaptation actions as a result of improved access to financial resources at local and national scale under Output 4.3. Project activities will strengthen producers and local governance structures on matters related to participatory climate adaptation and early warning systems. Under output 4.1, training and workshops targeting local stakeholders (including smallholders, public officers, local CSOs, relevant academia, and the private sector) are planned to increase their knowledge base on climate resilient agriculture, climate-proofed irrigation, and watershed management for climate adaptation and resilience. These entities include municipality authorities and staff, as well as selected staff from provincial and departmental administrations, who will participate on multi-stakeholder platforms for watershed management. The project will build the capacities of public services staff (central and sub-national government technical and extension officers) to help them understand climate change dynamics regionally, nationally and sub-nationally and, in particular, the effects on the hydrological cycle and temperature. The sub-national governments are the project's co-implementing entities and will participate in its steering committee, where all project decisions will be taken. Investments in data generation and management (analysis and modelling) will contribute to strengthening local and participatory planning, decision making and early warning systems for agricultural risks; therefore, it will be useful for risk information-based governance. The agencies that will generate such data are the National Meteorological and Hydrological Service (SENAMHI) of the Ministry of Environment and Water and the Rural Contingency Unit - Early Warning System for Agricultural Risks, of the Ministry of Rural Development and Land, who will also participate in the training programme under Output 4.3.
	Lack of systematic and solid monitoring	The project has envisioned an integrated monitoring and evaluation process to document evidence and learning to improve processes for

	and evaluation processes and data	climate data generation, long-term monitoring systems, and methodologies (Output 3.2 and 4.3)
	Lack of integral and participatory micro-watershed management plans to guide climate-resilient ecosystem restoration and conservation practices.	**The project will promote highly participatory processes to strengthen micro-watershed governance.** Project interventions under Output 3.1 and 3.2 will support watershed communities to develop governance mechanisms for water management by strengthening the local participatory planning processes. These interventions will establish multi-stakeholder dialogues. Activities under Output 3.1 will implement and develop integral and sustainable water source management practices to ensure availability in permissible quantity and quality. To this end, both the inventory of water sources in municipalities and water balances in water basins in the target area will provide valuable information for the generation and strengthening of climate-responsive planning processes at local level, focused on conservation, access and use of water resources. Additionally, under this output, the project will support the development of common water use plans that will allow local producers to engage in responsible water use from source to consumption. This will strengthen diversified agricultural production systems and thus support the resilience of agroecosystems. For the implementation of the water use plans, affected rural landowners, both men and women, will receive technical assistance regarding water use in productive systems. **The project will build capacities on integral and participatory watershed planning and management to foster conservation and restoration of ecosystem functions and services, primarily hydrologic cycling.** Under Component 3, the project will restore 17,510 ha, of land, which is linked to the restoration of other watershed components (e.g., soil). This, together with the sustainable watershed management, will enhance and gradually secure the water cycle and groundwater replenishment. This approach will make a crucial contribution to securing water sources for implementing climate resilient agriculture (Component 1) and climate proofing irrigation (Component 2). It will also contribute to the implementation of the JMAM, since the ecosystem-based approach for restoration of ecosystem functions is in line with the national regulation adaptation to climate change and the Management Plan for Watershed Resources and Integrated Watershed Management.
Financial barriers	Limited access of smallholder farmers to financing to build resilience.	**The project will strengthen the capacity of farmer organisations and develop tools and guidelines to facilitate farmers to overcome financial constraints.** Output 4.2 aims to partner with existing domestic funders and financial institutions to develop innovative financial instruments that enable the implementation of climate-proofed irrigation and ecosystems restoration investments. The project will further strengthen the capacities of communities, smallholders and associations on financial management and access to innovative financial instruments relevant for climate resilient agriculture.

	Smallholder farmers lack support for marketing and selling opportunities for their agricultural produce.	**The project will catalyze financing and foster inclusive markets.** Project interventions under Output 1.2 will aim to establish market fairs and mobilize public resources for investment in climate-resilient interventions. To address this barrier, the project interventions under Output 1.2 aim to conduct training to improve producers' access to markets for climate-resilient products. Smallholder organizations will receive training in business development to ensure adequate planning and management of production and marketing operations, as well as potential value-addition activities. As part of business development, farmers will learn how to apply for and manage production credit, including accounting, repayment schedules, and other aspects. This will enhance the adaptive capacity of the smallholder producers by generating additional and sustained income, which will be invested in the adoption and implementation of climate resilient agroecological management. **The project will provide technical assistance and guiding tools to key financial institutions to facilitate the creation of suitable financial products and services that respond to the needs of smallholder farmers.** Project interventions under Output 4.3 will (1) develop a Financial Strengthening Plan for FONABOSQUE to leverage new climate-related funds and scale up and increase the number of beneficiaries and (2) provide specialized Technical Assistance to INSA to develop and implement innovative insurance mechanisms and to analyze the possibility to expand this activity to other private financial institutions.

The linkages between climate change impacts and proposed interventions are highlighted in the following Table 29:

Table 29 Linkages between climate risks and adaptation interventions and benefits

Syste	Climate risk	Evidence of impacts	Adaptation interventions	Adaptation benefits
Agriculture production	Increasing temperatures and decreasing precipitation reduce crop production mainly in the central part of the study area.[93]	• Rising temperatures will alter the suitability of areas for specific crops and cropping systems (FAN, 2017) and decrease crop yields, e.g. maize (Tito et al, 2018). • Beyond a certain point, higher air temperatures adversely affect plant growth, pollination, and reproductive processes	• Livelihood diversification (ensuring that farmers are not only dependent upon production of agricultural crops for their livelihood).[95] • Production and multiplication of heat tolerant crops (e.g.	Avoid losses of livelihoods for farmers by diversification of their income generation (also focusing on the value chain of honey) can lead to overall increase in income.[99] Farmers have adapted climate change adaptation measures to

[93] Fundación Amigos de la Naturaleza (FAN). 2017. Producto 1. Efecto del cambio climático en el área de influencia del proyecto. FAO.
[95] Alvar-Beltrán, J., Elbaroudi, I., Gialletti, A., Heureux, A., Neretin, L. Soldan, R. 2021. Climate Resilient Practices: typology and guiding material for climate risk screening. Rome, FAO.
[99] Sardar, Asif & Kiani, Adiqa & Kuslu, Yasemin & Bilgic, Abdulbaki. (2020). Examining the Role of Livelihood Diversification as a Part of Climate-Smart Agriculture (CSA) Strategy (İklim-Akıllı Tarım stratejisinin bir parçası olarak geçim çeşitliliğinin rolünün incelenmesi). 79-87. 10.17097/ataunizfd.604937.

		(Klein et al., 2007; Sacks and Kucharik, 2011)[94]	sesame, millet, sorghum, quinoa) [96] • Agroforestry – Canopy cover reduces evaporation from direct sunlight and by decreasing air and soil surface temperature[97] • Agroecology practices, that include conservation agriculture such as[98]: • Optimizing crop calendars • Short cycle variations	guarantee agricultural production under changing climatic conditions. Therefore, leading to improved food security.
		Rising temperatures result in soil degradation: the availability of nutrients decreases, resulting in a loss of soil biodiversity[100]. Changes in runoff would cause different effects in the region. Uncovered or sparsely vegetated slopes would be more prone to erosion due to increased runoff[101]	• Soil management with the aim to increase soil fertility. This includes the application of: contour cropping practices for erosion control / crop rotation / grass strips / use of bio-fertilizers • Agroforestry: Reforestation and revegetation of erosion prone areas that improve soil health [102]	Increase the agricultural production by improving the soils biodiversity and availability of nutrients Avoiding further losses of soil degradation and leading to less erosion. Therefore restoring the soils not only for biodiversity purposes (restoring ecosystems) but also for the purpose of agricultural use.

[94] Hatfield, J.L., Prueger, J.H. 2015. Temperature extremes: Effect on plant growth and development. https://reader.elsevier.com/reader/sd/pii/S2212094715300116?token=0E5FBC34B3AC9F32390CF72D23171FC21B02BB992A9168D52A82770F0C4262FEB754 0832B1A83ACCF58D962296FBB978&originRegion=us-east-1&originCreation=20220216183036
[96] Idem
[97] Idem
[98] Idem
[100] FAO. 2016. Estado Mundial del Recurso Suelo. Resumen Técnico
[101] Idem as 85
[102] Alvar Beltran, et al. Idem Footnote 69

			• Conservation agriculture – implementation of practices that reduce soil erosion, increase macronutrient deposition and infiltration by reducing surface runoff: Half-moons, zaï pit systems[103] • Protection and natural regeneration on <u>degraded slopes and slopes</u> and in the headwaters of watersheds by applying <u>*agroforestry practices*</u> that stabilize the ground, sustain soil moisture and reduce soil erosion[104]	
		As a result of the reduced precipitation and increased temperatures, the project area suffers from deficit of surface water, some areas more than others, particularly for irrigation, this information will inform the 2 different adaptation measures as described in the next column.[105] The number of droughts has been increasing over the last few decades. One drought alone, from 2016, cost Bolivia 450 million USD and affected 665,000 people living in the	<u>Adaptation measures for regions with sufficient availability of surface water for irrigation:</u> Climate-proof existing irrigation systems to improve efficiency (drip and sprinkler irrigation technologies, lining of irrigation canals, etc., page 147, FS). These systems are intended to increase water-use efficiency by providing	Increased water efficiency by the farmers for irrigation and thus ensuring the agricultural production Farmers are able to continue the production of crops, even without sufficient surface water. Efficient water use reduced pesticide use and improved soil health can lead to an average increase in crop yields of 79%[112].

[103] Idem as 93
[104] Idem as 95
[105] Villazon, M. 2021. Línea Base de Balance Hidrológico. FAO
en el área de influencia
[112] FAO. 2016. Estado Mundial del Recurso Suelo. Resumen Técnico

		country[106]. A drought in 2019 damaged more than a third of the land cultivated in soybeans (350,000 of 1.02 million hectares of land sown with soybeans), resulting in losses over 168 million USD[107].	sufficient water according to the crop[108] Adaptation measures for regions with insufficient availability of surface water for irrigation: (a) Optimizing crop calendars[109] (b) changing the existing crops to crops with lower water requirements e.g. quinoa y sorghum[110] (c) ensuring irrigation is based on rainwater harvesting (d) application of hydrogel to maintain soil moisture (provision and implementation)[111]	
		Corn and potato production decreased by more than 87%, mainly as a result of new pest attacks. (Tito et al, 2018). Warmer and drier conditions favour disturbances by insects, whereas warmer and wetter conditions favour disturbances from pathogens, with increasing pest risk[113].	Establishment of agroecological management at the family and community level for integrated pest management. To reduce the impact of agricultural pests, examples of modified cropping practices and adaptive management strategies include: (I) planting different crop varieties; (II) planting at different times of the year to minimize exposure to pest outbreaks; and (III) increasing biodiversity at field margins to increase the number of natural enemies[114]	Reduced impacts of pests will lead to increased agricultural production and increased resilience of the farmers to the outbreak of pests.

106 https://reliefweb.int/sites/reliefweb.int/files/resources/adsr_2016.pdf
107 https://www.efe.com/efe/english/business/bolivian-farmers-crushed-by-drought-and-debt/50000265-3929408
108 Alvar-Beltrán, J., Elbaroudi, I., Gialletti, A., Heureux, A., Neretin, L. Soldan, R. 2021. Climate Resilient Practices: typology and guiding material for climate risk screening. Rome, FAO
109 Idem as 97
110 Idem as 97
111 Cortés, B., Ramírez, B., Xiomara, I., Eslava., B, Francisco., Gerard, R.N. 2007. Evaluación de hidrogeles para aplicaciones agroforestales. Ingeniería e Investigación, vol. 27, núm. 3, pp 35-44. Universidad Nacional de Colombia Bogotá, Colombia.
113 IPPC Secretariat. 2021. Scientific review of the impact of climate change on plant pests – A global challenge to prevent and mitigate plant pest risks in agriculture, forestry and ecosystems. Rome. FAO on behalf of the IPPC Secretariat.
114 Skendžić, S.; Zovko, M.; Živković, I.P.; Lešić, V.; Lemić, D. The Impact of Climate Change on Agricultural Insect Pests. Insects 2021, 12, 440. https://doi.org/10.3390/insects12050440

	More frequent and intense hailstorms: According to the perception of rural producers, hailstorms have become frequent in the last ten years in the puna area (UNDP, 2011).	Evidence from the Central Valley of Tarija, demonstrated that in the last four agricultural seasons, frost and hail resulted in a reduction of between 12% and 39% of total production.[115] The records shows that 2,012 events in the period between 2010 - 2021, of this total, 89%, represent four types of extreme events: floods (34%), hailstorms (25%), frosts (15%) and droughts (14 %). The summer agriculture season (October 2020 to April 2021) and winter (May to September 2021) extreme events have affected 122,939 families. In the 2020-2021 agriculture season, frosts occurred with the highest incidence, followed by floods, hailstorms, and droughts[116].	Provision and implementation of anti-hail nets[117]	Increased resilience of the farmers to hailstorms, and therefore securing continued crop production and the food security of the country.
	More frequent and unpredictable frost events.	According to reports from rural producers themselves, frosts can create losses of 50% of production or losses of up to 100% of crops. Although frosts are a recurring phenomenon, the changes observed in climate variability in the last decade mean that they are occurring unexpectedly and in areas where they have not occurred usually.[118]	Provision and implementation of thermal blankets[119]	Increased resilience of the farmers to frosts, and therefore securing continued crop production and the food security of the country.

15. Project location and beneficiaries

Criteria for the prioritization of the project area and beneficiaries

The project target area consists of 65 municipalities in Valles Macro-region one of the most vulnerable regions to hydrological drought in Bolivia covering 8,338,000 ha and with a population of approximately 2,328,741 people, mostly (80%) dedicated to small-scale (partially subsistence) farming. The Valles

[115] Estudio de Identificación, Mapeo y Análisis Competitivo del Cluster de Uvas, Vinos y Singanis en Bolivia; CAF Alejandro Paniagua, 2012.
[116] Government of Bolivia, 2020. Third National Communication on Climate Change to UNFCCC. Available online: https://unfccc.int/sites/default/files/resource/NC3%20Bolivia.pdf
[117] Figuerola, 2015. Project for the exploitation of apple trees in high altitude areas for the production of maximum quality fruits, in Burgo de Osma (SÓRIA). Higher Technical School of Agricultural Engineering. University of Valladolid. 494p.
[118] https://www.portalfruticola.com/noticias/2017/08/30/heladas-tipos-medidas-prevencion-manejos-posteriores-al-dano/
[119] https://www.portalfruticola.com/noticias/2017/08/30/heladas-tipos-medidas-prevencion-manejos-posteriores-al-dano/

Macro-region covers the watershed Río Grande, Guadalquivir, Azero, Rocha, Mizque, Cachimayo, and Arque-Tapacarí. In the Valles macro-region, there are 111 identified areas titled as Original Community Lands (TCOs) and Indigenous Territories (TIOCs) in the Macro-region, which cover around 7.7% of the territory of the region.

Selection of the project target area

A multi-criteria analysis was used to identify and prioritize the project intervention area among the different regions in the country (see also Table 30):

* High vulnerability to climate change: Areas highly vulnerable to drought, frost and hailstorms (Indicator: Level of vulnerability).

* Contribution to the basic family food basket of the main cities: Areas where agriculture is a key livelihood activity (Indicator: Production of more than 60% of the basic family food basket).

* Water recharge areas: Areas with high water recharge, where climate change is likely to impact the aquifer conditions (Indicator: >640 mm/year)

* Priority areas for conservation of biodiversity: Conservation areas in good condition generate ecosystem services in particular hydrological ecosystem services (Indicator: Level of biodiversity).

Table 30 Summary of the criteria and prioritization process for the project target area and beneficiaries.

Criteria	Level	Weighting	Reasoning	Source of information
Step 1: Selection of the Macro-region for the Project implementation				
High vulnerability to climate change (hailstorms, frosts and droughts)	Macro-region	High = 3 Medium = 2 Low = 1	Areas with baseline high exposure to drought, frost, hailstorms, etc., are at highest risk of complete livelihood collapse under CC	Fundación Amigos de la Naturaleza (FAN) (2018). Estudio de la Línea Base Ambiental de la Macro-región Valles. Santa Cruz: FAN. FAN (2018). Cambio climático en el área de influencia del Proyecto FAO para el Fondo Verde del Clima. Producto 5. Análisis de vulnerabilidad climática. Santa Cruz de la Sierra: FAN. Tercera Comunicación Nacional del Estado Plurinacional de Bolivia, ante la Convención Marco de las Naciones Unidas sobre Cambio Climático (2020). APMT, La Paz, Bolivia. pp. 86

Contribution to the basic family food basket of the main cities.	Macro-region	Production of more than 60% of the basic family food basket	The areas of greater food production threatened by climate change should have higher priority in the processes of adaptation to this phenomenon.	Levantamiento de información de consumo de alimentos, estado nutricional y uso de la agrobiodiversidad en la Macroregión Valles (2018). FAO Bolivia, Proyecto de Biodiversidad.
Water recharge areas, measured by SENAMHI	Macro-region	>640 mm/year	Adaptation actions in high recharge areas will have greatest impact on aquifer conditions	Datos Hidrometeorológicos (1997-2008). SENAMHI. La Paz, Bolivia.
Priority areas for conversation on biodiversity	Macro-region	High = 3 Medium = 2 Low = 1	Conservation areas in good condition generate environmental functions and services.	GAP análisis de Bolivia (2011). Conservación Internacional y TNC. La Paz, Bolivia. 36 p.
Criteria	**Level**	**Weighting**	**Reasoning**	**Source of information**
Step 2: Identification of priority municipalities in the Valles Macroregion – As described in section 8 regarding vulnerability analysis.				
Criteria	**Level**	**Weighting**	**Reasoning**	**Source of information**
Step 4: Definition of project beneficiaries within target areas				
Small-holder farmers who met all of the following criteria: • Residence within the project Municipalities. • High dependence on agriculture and/or natural resources. • Small-scale family farmers. • Those whose primary source of income depends on agriculture. • Vulnerability due to exposure to environmental and climate change risk. • Household with 5 or more members. • Agrarian property titled by INRA. • Manifest willingness to implement project management practices. •			Reliance on family labour implies limited access to financial resources to buffer against the impacts of climate change on livelihoods under conditions of non-adaptation	Informe del estado de la agricultura familiar en Bolivia (2013). FAO, La Paz, Bolivia. 36 p. Censo Agropecuario Nacional (2012). INEC, La Paz, Bolivia. Plan de Desarrollo Económico y Social (2016). Ministerio de Planificación para el Desarrollo, La Paz, Bolivia.

This analysis allowed to identify the Valles Macro-region as the priority area for food production at the national level, which is highly vulnerable to the effects of climate change, mainly to the variability of precipitation and temperature.

Once the Valles macro-region was prioritized, the most vulnerable Municipalities to climate change within the macro-region were prioritized based on the results of the vulnerability assessment conducted by FAN in 2018 and described in section 8. Figure 59 shows the prioritized Municipalities (in blue colour) within the Valles macro-region and Original Community Lands (TCOs) and Indigenous Territories (TIOCs) (in red colour). The TCOs and TIOCs include:

- Chuquisaca Poroma Nación Qhara Qhara
- San Lucas Nación Qhara Qhara
- Cochabamba Mizque Nación Chuwis
- Aiquile Nación Chuwis

- Potosí Tupiza Nación Chichas
- Cotagaita Nación Chichas
- Vitichi Nación Chichas
- Caiza D Nación Karangas
- Potosí Nación Karangas
- Tacobamba Nación Qhara Qhara
- Puna Nación Qhara Qhara
- Tinquipaya Nación Charkas

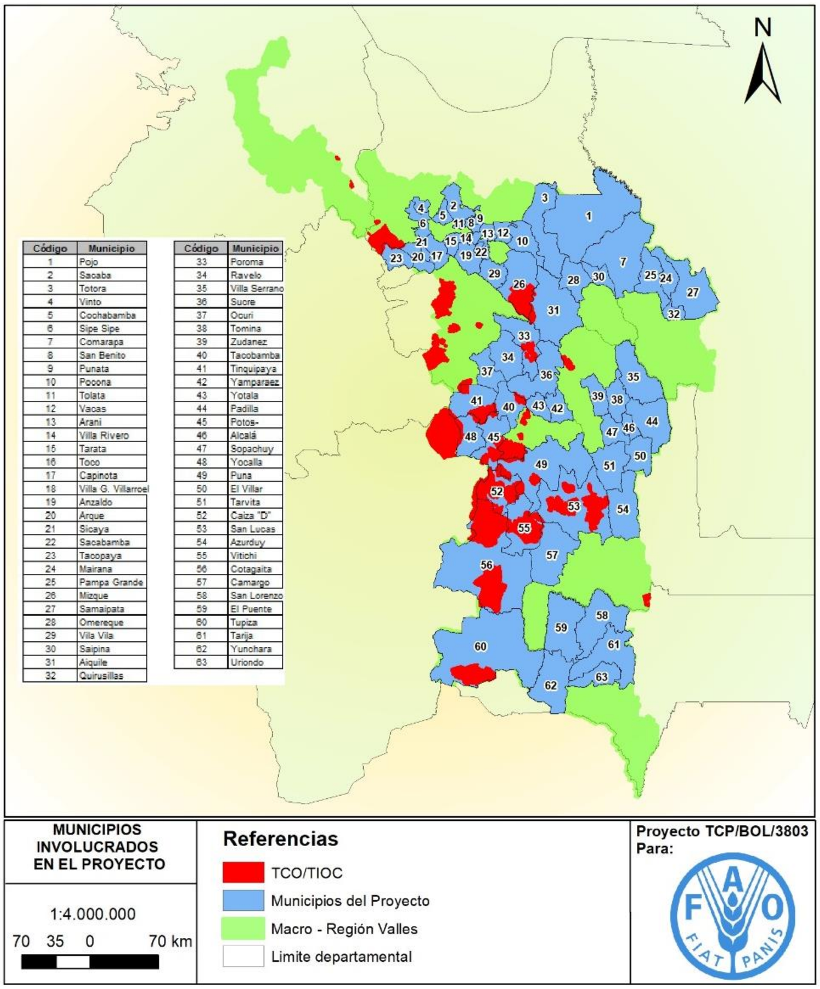


Figure 59 Project intervention area in Valles macro-region: 65 prioritized Municipalities (in blue colour) and the TCOs and TIOCs (in red colour).

For the selection process of the intervention areas of RECEM-Valles and the beneficiaries of the project, environmental, geographical distribution and socioeconomic criteria of the population were applied.

This Macro-region has a high prevalence of poverty (approximately 63% of the population is poor), and it is considered the most vulnerable area within the national territory. The people currently living in poverty are mainly concentrated in rural areas, where 56% of the inhabitants work in agriculture, livestock and fishery, relying on the availability of natural resources (water, soil, biodiversity), the environmental functions of the life zones and favorable weather conditions for their survival. Among the main agricultural crops are wheat, potatoes, corn, peas and broad beans, which cover a total area of 379,134.54 hectares. There are other agricultural products that are becoming increasingly relevant for small producers, such as peach, apple, grapes, vegetables such as garlic and onions. Nonetheless, increasing the production of these products requires specialized technical assistance.

A multi-criteria analysis was applied to identify and prioritize the municipalities within the Macro-region considering the following variables:

- vulnerability to food insecurity,
- traditional food production zone,
- areas with soil degradation and
- poverty levels

The inclusion of socioeconomic variables in the prioritization process reflects the assumed relation that exists between vulnerability to the effects of climate change and poverty: the poorest members of the national population are assumed to have the least ability to invest in diversifying their livelihoods to reduce their exposure to CC impacts, and least access to social and financial safety nets. The greatest concentrations of high-vulnerability municipalities, in accordance with the indicated criteria, were located, resulting in the final selection of a total of 65 target municipalities.

Within these selected highest vulnerability areas of the 65 target municipalities, the project will work with small-holder farmers (defined as small-scale family farmers relying on family labour, and therefore with limited access to the human, physical and financial resources required for adaptation), and who are at greatest risk of being pushed into conditions of extreme food insecurity due to climate change (all of those in conditions of poverty or extreme poverty fall into this group). The project will target the same small-holder farmers with approximately 0.5 ha of land, who principally produce maize, vegetables, potatoes, wheat, etc.

Selection of project beneficiaries

The methodology used for the selection of project beneficiaries began with the i) identification and sociocultural characterization of agricultural producers; ii) territorial diagnosis (hydrological, environmental, legal, legal and institutional of agriculture), iii) description of the impacts of climate change and proposal of adaptation measures in the forest, water, soil and biodiversity; iv) food insecurity analysis, and; v) priority areas for biodiversity conservation and water recharge.

Table 31 Definition of project beneficiaries

Definition of project beneficiaries within target areas		
Small-holder farmers who met all of the following criteria: • Residence within the project Municipalities. • High dependence on agriculture and/or natural resources. • Small-scale family farmers. • Those whose primary source of income depends on agriculture.	Reliance on family labour implies limited access to financial resources to buffer against the impacts of climate change on livelihoods under conditions of non-adaptation	Informe del estado de la agricultura familiar en Bolivia (2013). FAO, La Paz, Bolivia. 36 p. Censo Agropecuario Nacional (2012). INEC, La Paz, Bolivia. Plan de Desarrollo Económico y Social (2016). Ministerio de Planificación

• Vulnerability due to exposure to environmental and climate change risk. • Household with 5 or more members. • Agrarian property titled by INRA. • Manifest willingness to implement project management practices.		para el Desarrollo, La Paz, Bolivia.

The most vulnerable will be included because of their high level of vulnerability to climate change and extreme events. Under this over-arching criterion, analyses will be made with base maps of the project's area of influence, superimposing the maps of family agricultural and livestock production units, vulnerability to hail, drought, and other extreme phenomena related to climate, versus the INE poverty map in its different categories. This includes identifying indigenous peoples and ensuring project resources are targeted to support their increased resilience. In this way, the poorest and most vulnerable people to whom this project is directed will be identified.

Based on the above, in areas prioritized by the RECEM VALLES project there are approximately 2,328,741 persons. Due to the fact that it is impossible to reach the entire population prioritized by MMAyA, and considering project key stakeholders working capacity; after several meetings of the project formulation team (which included implementing partner technicians), it was decided that 0.5% of the total population of the country and 3% of the population of the Valleys Macro-region could be supported, that represent 81,551 direct beneficiaries or heads of households (of which 39,144 women and 42,407 men) with an average of 2 ha of land. Of the total number of direct beneficiaries, 2,800 will be indigenous people. On the other hand, 1,251,769 indirect beneficiaries (of which 48% are women and 52% men) will benefit from the project implementation, which represents the entire family of the direct beneficiaries. The indirect beneficiaries represent 10.7% of the total population of the country and 53.7% of the population of the Valleys Macro-region. See Table 32 for the estimation of the direct beneficiaries per activity. See Appendix 4 for more details on the calculation of the direct and indirect beneficiaries.

Female headed households will be prioritized. Selection criteria will assign a weight to women's participation in access to technical assistance, level of participation in local organized structures, and access to incentives. Women represent 48% of the total population of the intervention area.

It is important to note also that the project proposes differentiated strategies for both small, poorer and more vulnerable farmers who are already part of associations, and those who are not but can become members, thus fostering inclusion through associativity. The support and technical assistance to both groups has clear and differentiated activities to achieve climate resilience benefits at both the farm, community and agro-ecosystem level. Strengthening producers' associations and helping farmers join will help improve market access, facilitate certifications of designation of origin and directly strengthen agrifood systems carried out by small farmers at the individual or family plot level.

In the table below, the number of beneficiaries are distinguished as per the financing component, either GCF or for the co-financing contribution, either MMAyA or FAM. Where there is no distinction made, the funding is only from GCF contribution.

Table 32 Expected distribution of beneficiaries according to the different project components.

	Total number of direct beneficiaries	Number of beneficiaries males	Number of beneficiaries females
Component 1: Strengthened food and income security in changing climate through climate resilient agricultural systems			
Output 1.1 Climate resilient agriculture implemented and managed by smallholders for increasing the productivity and sustainability of their agroecosystems	23,551	12,247	11,304
Activity 1.1.1 Provision of climate technologies to address vulnerability and increase resilience in the Valles Macro-region	4,680	2,434	2,246
Activity 1.1.2 Capacity building on climate resilient agricultural practices to contribute to increased resilience and productivity of agricultural systems.	23,551	12,247	11,304
Output 1.2 Increased market access of climate resilient agricultural products	4,947	2,572	2,375
Activity 1.2.1 Development and implementation of community and associative productive enterprises	4,000	2,080	1,920
Activity 1.2.2 Technical support and implementation of collection and marketing centers for agroecological products.	4,000	2,080	1,920
Activity 1.2.3 Promoting climate resilient value chain for livelihood diversification according to the prioritized region	947	492	455
Component 2: Smallholder water resources secured to reduce the risks from droughts and low rainfall			
Output 2.1 Enhanced and modernized on-farm climate-proofed irrigation systems implemented and managed	GCF: 24,896 MMAyA: 33,104 TOTAL 58,000	GCF: 12,946 MMAyA: 17,214 TOTAL 30,160	GCF: 11,950 MMAyA: 15,890 TOTAL 27,840
Activity 2.1.1 Improve and expand the water reservoirs network to optimize water harvesting activities linked to on-farm climate-proofed irrigation systems	GCF: 12,000 MMAyA: 33,104	GCF: 6,240 MMAyA: 17,214	GCF; 5,760 MMAyA: 15,890

	TOTAL 45,104	TOTAL 23,454	TOTAL 21,650
Activity 2.1.2. Update the inventory of irrigation systems implemented, to enable the implementation and revitalization of climate-proofed on-farm irrigation systems	8,896	4,626	4,270
Activity 2.1.3. Implement, revitalize and technify on-farm climate-proofed irrigation systems.	4,000	2,080	1,920
Output 2.2 Strengthened capacities for the management of on-farm climate-proofed irrigation	GCF: 8,896 MMAyA: 52,396 FAM: 8,896 TOTAL 70,188	GCF: 4,626 MMAyA: 27,246 FAM: 4,626 TOTAL 36,498	GCF: 4,270 MMAyA: 25,150 FAM: 4,270 TOTAL 33,690
Activity 2.2.1 Strengthen capacities of irrigation associations, farmers and community promoters to enable locally-owned technological innovation processes related to on-farm climate-proofed irrigation systems	8,896	4,626	4,270
Activity 2.2.2: Replicate technological innovation processes related to on-farm climate-proofed irrigation systems to up-scale the knowledge to other communities through the strengthening of capacities of key actors, technicians and professionals in national and subnational levels. *This activity will be solely implemented with co-financing support from MMAyA (Ministry of Environment and Water), USD 1 M.*	MMAyA: 52,396	MMAyA: 27,246	MMAyA: 25,150
Activity 2.2.3: Design an O&M Plan for the irrigation systems including the legal agreements between MiRiego, Municipalities and the Irrigation Committees	8,896	4,626	4,720
Activity 2.2.4: Promoting the signature of the legal agreements and the O&M Plans for the irrigation systems between MiRiego, Municipalities and the Irrigation Committees. *This activity to be implemented solely with co-financing from FAM, USD 0.2 M.*	FAM: 8,896	FAM: 4,626	FAM: 4,270
Component 3: Restored and conserved micro-watersheds and ecosystem functions and services.			
Output 3.1 Restored and conserved ecosystem management for enhanced climate resilient watersheds	GCF: 46,531	GCF: 24,196	GCF: 22,335

	MMAyA: 35,020 TOTAL: 81,551	MMAyA: 18,210 TOTAL 42,406	MMAyA: 16,810 TOTAL 39,145
Activity 3.1.1: Development and implementation of integral micro-watershed management and water use plans to enhance climate change adaptation	46,531	24,196	22,335
Activity 3.1.2: Implement restoration processes in micro-watersheds, to increase resilience and climate adaptation by enhancing ecosystem functions and services.	GCF: 22,980 MMAyA: 35,020 TOTAL: 58,000	GCF: 30,160 MMAyA: 18,210 TOTAL 30,160	GCF: 27,840 MMAyA: 16,810 TOTAL 27,840
Output 3.2. Information and long-term monitoring system for water sources at place	58,000	30,160	27,840
Activity 3.2.1: Develop and implement an online tool[120] for monitoring, consolidation and dissemination of information relevant for informed climate-sensitive planning and decision-making processes related to sustainable water use ((based on climate, weather conditions, foot print of food production, water availability)	58,000	30,160	27,840
Component 4: Enabling conditions created to implement and upscale climate-resilient agroecological management, climate-informed integral micro-watershed management, and access to financial mechanims			
Output 4.1 Strengthening capacities for national and sub-national government entities to implement policies and norms for the climate-resilient food production under irrigation systems, integral watershed management and monitoring of ecosystem functions and services	400	208	192
Activity 4.1.1 Implement national and sub-national policies and plans (including PTDIs) that contribute to climate change adaptation and mitigation processes, contributing to the JAMA and to the Bolivia´s NDCs.	400	208	192
Output 4.2 Improved financial mechanisms that support climate-resilient agricultural production and irrigation systems to mobilise increased finance for farmers	22,904	11,910	10,994
Activity 4.2.1 Establish partnerships with existing domestic funders and financial institutions to develop innovative financial mechanisms and instruments that enable the implementation of climate-proofed irrigation, climate-	2,224	1,156	1,068

[120] The online tool will be used by all municipalities through the FAM and agreements signed with SENANMHI.

resilient agriculture and investments in ecosystems restoration.			
Activity 4.2.2: Strengthen the capacities of communities, smallholders and associations on financial literacy, management and access to innovative financial instruments relevant for climate resilient agriculture, ecosystems conservation schemes, climate-proofed irrigation systems.	20,680	10,754	9,926
Output 4.3 Strengthening local governance in participatory climate adaptation, early warning systems and long-term monitoring systems	FAM: 400 GCF: 81,551 Total: 81,551	FAM: 208 GCF: 42,407 Total: 42,615	FAM: 192 GCF: 39,144 Total: 39,336
Activity 4.3.1 Capacity strengthening for local stakeholders (including smallholders, public officers, local CSOs and relevant academia) on the integration of climate change risks for decision making to increase the resilience of smallholders and communities,	800	416	384
Activity 4.3.2. Establish coordination and consultative territorial platforms (to facilitate climate change adaptation mainstreaming into the participatory implementation of policies and strategies) in accordance with the Comprehensive Management Plan for Watershed Resources and Integrated Watershed Management.	800	416	384
Activity 4.3.3. Enhance capacity of municipalities to strengthen the monitoring and reporting base for the macro region related to climate change impacts *This activity to be implemented solely with co-financing from FAM, USD 0.3 M.*	FAM: 400	FAM: 208	FAM:192
Activity 4.3.4: Impact evaluation and developing knowledge management products	81,551	42,407	39,144

The implementation phase of the project is grant funded, and the qualifying criteria were designed primarily to improve the likelihood that farming households adopt the transformational interventions in a sustainable manner. These activities may help to crowd-in (or de-risk) financial intermediaries, but the main objective is to build on lessons learned from past projects to ensure the sustainability of the project interventions (see examples on section III regarding maintenance of irrigation systems). The primary criterion for inclusion in project activities is vulnerability to climate change, which is assessed along multiple axes including conditions of extreme poverty. This is reflected specifically in Activities 1.1.1, 1.1.2, 1.2.1, 1.2.2 and 2.1.1.

For the detailed selection of beneficiaries once implementation has commenced, it is proposed that the Coordination and Consultation Territorial Platform, under the facilitation of PMU/FAO, will prepare a list of the beneficiaries to be selected to participate in the project´s implementation. To this end, a user selection guide based on the RECEM-Valles criteria will be elaborated by FAO during the inception phase of the project and training workshops will be developed with the counterparts and stakeholders at the local level, for its correct application. In this way, the selection process will have the support of both: institutions and community representatives and will be based on the governance mechanisms promoted by the project. The process will be fully documented for the Project Management Unit and supervised for the Technical Committee.

The most vulnerable farmers will be included because of their high level of vulnerability to climate change and extreme events. Under this over-arching criterion, analyses will be made with base maps of the project's area of influence, superimposing the maps of family agricultural and livestock production units, vulnerability to hail, drought, and other extreme phenomena related to climate, versus the INE poverty map in its different categories. This includes identifying indigenous peoples and ensuring project resources are targeted to support their increased resilience. In this way, the most vulnerable people to whom this project is directed will be identified.

The vision of the project is to ensure a highly participatory process, where stakeholders are considered agents of change. Similarly, the project will make use of different technical assistance and lessons exchanges, including Farmer Field School, Farmer-to-farmer methodologies and the concept used by FAO of "Soil Doctors", which refers to people from the communities with existing knowledge that contribute to transmitting knowledge and innovation to farmers from a practical perspective.

Project location

Table 33 Summary of socioeconomic and environmental context of the intervention area of the project

Area	8,338,000 ha
Administrative geographical scope	5 departments, 65 municipalities
Region	Bolivian Valleys Macro region
Municipal organization	12 associations of municipalities
Population in 65 municipalities of the Macro region	2,328,741 inhabitants Male 1,210,946 (52%) Female 1,117,795 (48%)
Poverty	63% of the population considered poor
Drinking water coverage	76% of the population with access to drinking water

Basic Sanitation Coverage	42.4% of the population with access to basic sanitation
Direct beneficiary population	81,551 heads of households of which 48% are women (39,144) and 52 % are men (42,407) 0.7% of direct beneficiaries vis-à-vis total population, and 5,5 % vis-à-vis total population of the Valleys Macro Region.
Indirect beneficiaries	1,251,769 of which 48% women (600,849) and 52% are men (650,920) 10.7 % of indirect beneficiaries vis-à-vis total population and 53.7% vis-à-vis total population of the Valleys Macro Region.
Municipalities with high and very high risk of hail	16 municipalities
Municipalities with high and very high risk of frost	49 municipalities
Municipalities with high and very high risk of drought	36 municipalities
Watersheds	3 watersheds level 1
Hydrographic sub-basins	23 sub-basins level 3
Ecoregions	9 ecoregions
Forests	1,219,444 ha
High Andean wetlands	7,725 ha
Protected Areas	1,393,417 ha of protected areas 25 PA national (895,517 ha) 3 PA departamental (39921 ha) 16 PA municipal (105,979 ha)
Agrarian property rights:	

Community Land of Origin[121]	4,307,145 ha
Small farmers community	1,104,911 ha
Agricultural Business	20,005 ha
Medium Property	18,496 ha
Small Property	2,263,150 ha

16. Objective and duration of the project

The project will be executed over a five-year period and its central objective is to "enhance the resilience to climate change of communities and small farmers in the Bolivian Macro-region of the Valleys, through capacity building and the development of best agricultural practices to increase the productivity and sustainability of their agroecosystems, aimed at adapting to the increasing variability of temperatures and rainfall."

To this effect, the communities and small-scale farmers will apply climate-resilient agricultural practices (sustainable water, soil, agroecological and agroforestry management activities) and technologies (solar tents, thermal blankets, antihail nets, hydrogels), complementing the revitalization and expansion of coverage of efficient irrigation systems, and promoting ecosystem restoration actions with the objective of optimizing water recharge and supply cycles, reducing erosion and risks, and minimizing agricultural climate change related disasters.

To enable adaptive capacities, the project will support smallholder farmers to diversify their production, and will work hand in hand with producers to enhance access to markets to enhance the capacity of smallholders (particularly women and youth) to produce market value-added agricultural products and improving therefore their income and capacity to invest in adaptation measures. Additionally, the project will include activities to strengthen the decision-making capacities of local institutions, and early warning systems and supporting participatory and dialogue platforms at local level to improve the dissemination of information on climate and weather forecasting.

17. Rationale of the investment

[121] Community lands of origin (TCOs) are lands owned collectively, by communities or commonwealths to which the rules and customs of the community apply. Legal possessions by de facto occupations on fiscal lands that in practice are subdivided for transmission to descendants.

The project “Upscaling Ecosystem Based Resilience of Vulnerable Rural Communities in the Valles Macro-region of the Plurinational State of Bolivia” (RECEM-Valles) represents an adaptation investment aiming to enhance the resilience of the livelihoods of the most vulnerable producers, of the ecosystems and environmental functions, of the infrastructure and technologies developed, and of food security in the Valles Macro-region of Bolivia, in order to face the threats of climate change. The project structure and proposed activities in this sense reflect on the close relationship between ecosystem functions and services (primarily hydrological regulation) on one hand and climate and social-ecological resilience on the other, and aim to tackle the climate vulnerability experienced in the Valles Macro-Region through an integral and systemic perspective.

Objective of the project

The objective of this project is to increase the resilience to climate change of smallholder farmers in the Valles Macro-region of Bolivia by implementing integral and participatory micro-watershed management that includes the improvement of small-scale farmers’ capacities to manage their agroecosystems sustainably, on-farm climate-proofed irrigation systems, and strengthening the corresponding institutional capacities to support climate risk management by smallholder farmers and communities. To do so, farmers will collectively enhance the ecosystem functions at agroecosystems and watershed levels, which will manifest in water regulation and supply, reduction of erosion and disaster risk (e.g., flooding), among others that jeopardize smallholders’ livelihoods and welfare.

The project is, in this regard, tailored to address barriers faced by smallholders in the target area, including a) limited technical support and financial means for technology deployment, know-how and innovation to adapt traditional agroecosystems to increased climate variability; b) lack of stable access to water and appropriate and efficient on-farm water management to adapt to climate change; c) lack of integral and participatory micro-watershed management plans and practices and d) weak or lack of governance mechanisms and technical capacities at institutional level for climate-related information generation and distribution as well as on the ground coordination of relevant programs and policies.
The project also addresses the barriers faced by smallholders in relation to access to markets and financial instruments, by supporting strategic activities leading to diversification and access to upscaled markets through certifications of production and by promoting opportunities for investment in products with added-value. Similarly, the project targets to work with domestic funders and financial institutions to develop different financial instruments that more particularly respond to the needs of smallholders in the target areas, and to facilitate smallholder’s knowledge and information on financial management and access to finance. These activities represent the backbone of the exit and sustainability strategy of the project, which will enable smallholders to sustain climate adaptive investments beyond the project span.

Therefore, the long-term vision of the project is that with an increased and more reliable income stream resulting from more climate-resilient agroecosystems, together with stronger farmers´ organizations and institutional capacities, smallholders in the target areas, with the support of strengthened governance structures and institutions, would be able to increase their possibilities to secure financing and invest in adaptation measures to keep pace with the rate of climate change.

Lessons learned and knowledge management

The RECEM-Valles project is based on the considerable investments implemented by Bolivian Central Government over the period 2006-2017 to provide solutions to the problems of scarcity of water resources, including the MiAgua I, II and III programme. Particularly, the project will establish synergies with the MiRiego Programme by not only filling the gap of on-farm water provision, due to the large-scale characteristics of irrigation systems deployed under MiRiego, but also by climate-proofing irrigation to enable-climate resilient agriculture. Lastly, the RECEM-Valles will scale-up the investments carried out under MiRiego by supporting watershed management in a highly vulnerable macro-region from a climate-resilient approach that enables sustainability in the provision of ecosystems functions and services.

The project will work closely with smallholder organizations to build the climate risk management capacities of their constituents through Farmer Field Schools (FFS), water users associations (WUA) and watershed committees, prioritizing peer-to-peer exchanges to leverage lessons learned and best practices among municipalities and communities. This will include empowering the decision-making capacities of these local institutions, especially of women, and increasing the abilities of women and youth to produce, add value to, and market climate-resilient agricultural products. The project will also organize larger learning-dialogue-coordination platforms[122] organized by agroecological zones or establishments to share lessons in enhancing productivity and resilience, facilitate development of value chain partnerships and achieve economies of scale in regard to input acquisition, marketing, and advocacy for policy implementation and dialogue. Institutional support to producers' organizations and community leaders (through FFS, WUAs, watershed committees) will be strengthened through training of field staff and decision makers in climate-resilient agriculture and watershed management and the FFS action-research approach for learning by doing, and the provision of climate and weather information for more effective and timely decentralized climate risk management.

All project activities – including technical topics, capacity building methodologies, field trials of adaptive technologies - will be monitored and the results evaluated to identify new knowledge, lessons and best practice/best tech. Project field staff will capture this information and feed it to the project's knowledge management specialists who will analyze, systematize, codify and package it for dissemination to producers, local governments, NGOs, and others throughout the Valles Macro-region. The KM team will also produce relevant potential policy inputs for submission to local, provincial and national authorities regarding resilience enhancing agricultural systems, watershed restoration and management and landscape governance.

Relevance for food security

Agriculture in the Bolivia's Valley Macro-region is characterized by smallholder cultivation of an average of 2 hectares, primarily for self-consumption with only small surpluses destined for local or departmental markets.[123] Irrigated plots are even smaller ranging from 0.4 ha per family (considered "micro") to 1.5 ha per family (considered "large" in this Macro-region). These irrigated farms, which are under threat due to climate change, are responsible for 60% of food production in Bolivia. Moreover**,** the population of the Valles Macro-region has a strong dependence on low-yielding agriculture[124] and as a result, a high degree of relative food insecurity.

[122] The Territorial Consultation Platforms integrate smallholders and local authorities through the Federation of Municipal Associations (FAM).

[123] Agua Sustentable (2018). Análisis Socioeconómico de la Macro-región Valles. *Ibid*, footnote 7.

[124] According to the Map of Vulnerability to Food Insecurity, the Macro-region Valles concentrates the most vulnerable territories and populations due to shortage of food and deficient economic Access to food.

There are currently 161,982 hectares in the Macro-region served by irrigation systems and 86,740 hectares without. However, 40% of existing systems reported at national level are unable to access water consistently and efficiently, exacerbating smallholder vulnerability to rainfall variability[125]. In this context, the most vulnerable people in the Valles Macro-region are the subsistence farmers with highly vulnerable to degrading landscapes, declining ecosystem functions, increasing climate change effects, and low yields. These factors contribute to place them into a vicious cycle of asset depletion and extreme poverty. Without the financial resources to invest in adopting resilience-enhancing agricultural management, smallholders have severe limitations to address their increasing vulnerability.

At least 48% of agricultural production systems in Bolivia are managed by women, and they represent approximately 42% of the economically active population in agriculture, nationally. Their main activities are crop production, bee keeping, forestry, animal husbandry, and commercial activities[126] At the same time, 34% of all smallholder farms led by women correspond to families where the woman is the head of the household[127]. This figure tends to increase due to men migration, therefore, the Valley Macro-region also experiences the process of feminization of agriculture. With low yields on small plots, farmers are often forced to migrate seasonally for months to urban and other areas for wage labor. Over time there is a progressive drain of male labor and knowledge from rural to urban areas resulting in a trend towards a greater proportion of women and older inhabitants in rural farm communities, resulting in another rural process: aging of agriculture. Both women's and elders' agricultural activities rely mostly on ecosystem functions and services, particularly the ones resulting from agrobiodiversity since they have limited access to credit and technical assistance, among other services and infrastructure, given that such credits and assistance are mainly addressed to adult and economically active man.

The adverse effects of climate change on agriculture mainly affect the most impoverished rural population including women, youth and elderly populations, since the risk of disasters of hydrometeorological origin results from the occurrence of natural hazards and the vulnerability of human populations as a result of poor socio-economic conditions. The most vulnerable people in the Valles Macro-region are the subsistence farmers with high vulnerability to degrading landscapes, declining ecosystem functions, increasing climate change effects, and low yields. These factors contribute to place them into a vicious cycle of asset depletion and extreme poverty. Without the financial resources to invest in adopting resilience-enhancing agricultural management, smallholders have severe limitations to address their increasing vulnerability.

Stakeholders, indigenous peoples and gender approach

Additionally, Bolivia has a comparatively large fraction of indigenous population, estimated at 42%. In 2012, 4.2 million Bolivians identified themselves as indigenous. (INE, 2012) Indigenous peoples in Bolivia are diverse, with 36 different recognized indigenous groups (nations). The largest indigenous groups are Aymara and Quechua. In this context, 7.72% of the targeted territory of the project belong to indigenous people; therefore, as part of the project preparation activities, stakeholder engagement included a process to seek and obtain the Free, Prior and Informed Consent (FPIC) by indigenous peoples. The FPIC process included seven workshops carried out in 2019[128]. As a result of this participatory

[125] Ministerio de Medio Ambiente y Agua (2017). Programación Plurianual y Marco de Evaluación de Desempeño del Subsector de Riego 2017-2020.
[126] CFS (2019). Producto 2. Plan de Gestión Ambiental y Social. Proyecto: "Preservación y restauración de las funciones ambientales con énfasis en la seguridad hídrica para la adaptación al cambio climático y una mayor resiliencia de los agricultores familiares vulnerables de la Macro-región Valles de Bolivia". La Paz: CFS.
[127] ECLAC (2019). Social Panorama of Latin America 2019. Santiago de Chile: CEPAL.
[128] Detailed information on the conducted FPIC process is included in Annex 7 on Stakeholder engagement for this project.

engagement with relevant stakeholders, a stakeholder engagement and an indigenous people's plan have been designed (See annex 7 Stakeholder Engagement Plan for further details).

The project has been designed through a participatory process that has sought inputs from stakeholders for the identification and prioritization of the needs and opportunities to be addressed, and that invited recommendations on the strategies and actions to be implemented. The participatory process has included actions to secure the buy-in and participation from local authorities and institutions across the 65 participating municipalities. The process has also invited the participation of local civil society organizations (CSOs), non-governmental organizations (NGOs) associations of agricultural producers, women organizations, and academic institutions.

The project will follow a gender-sensitive approach, consider women, youth and elderly population as key agents of change. The project in this sense, will provide highly vulnerable populations with tools, knowledge, technologies and enhanced management practices to empower them to drive a transformation of their livelihoods and ecosystems and reduce dependence on low-yielding agriculture. It is therefore expected that the project will not only tackle climate vulnerability directly through the climate-proofed investments in irrigation, but also will increase population´s adaptive capacities by improving income generation and diversifying agricultural production.

Project implementation will be highly participatory, where the key stakeholders and beneficiaries will be part of the decision-making process. To achieve this, the project's general management structure includes the "Territorial Platforms" whose members are the Associations of Municipalities, Municipalities, local officers of associations, local NGOs, representatives of beneficiaries, etc., who will interact with the beneficiaries and with the Territorial Operating Units[129]. At the start of the project, the Technical Committee of the project comprised by technical staff of Ministry of Environment and Water (MMAyA), Ministry of Rural Development and Lands (MDRyT), Ministry of Development Planning (MDP-GCF NDA) and Federation of associations of Municipalities (FAM) and FAO, will lay the foundations on the importance of the involvement of stakeholders for the Valles project and define the vision, scope and objectives, as well as some general guidelines based on the results of the consultation exercises carried out during the design phase of the project and the GCF provisions on gender, indigenous peoples and social and environmental policy. This will be carried out in one or two specific work meetings, facilitated by FAO specialists on social issues, resulting in the draft RECEM-Valles project stakeholder's engagement strategy to be validated with local representatives of the institutions, farmers, and beneficiaries of the project, to produce the final version of this strategic document.

Paradigm shift

GCF resources in this sense will cover incremental costs of adaptation measures, including deployment of climate-resilient technologies, climate proofed on-farm irrigation systems and ecosystems restoration activities, enabling a holistic response to the challenge of adapting agroecosystems in the Valles Macro-region through a participatory approach involving smallholders (among which indigenous peoples, women and youth are considered a priority). In this sense, GCF incremental finance will deliver direct benefits to vulnerable smallholders in poverty and extreme poverty, in particular women, youth and indigenous peoples; by enabling a paradigm shift based on biodiverse production systems, and a

[129] Four Territorial Operating Units (TOUs) operating at the local level will be established to serve as the key channel of communication between the PMU and local stakeholders and to assist with the implementation of activities on the ground. TOUs will be located in Cochabamba, Potosí, Sucre, and Tarija.

participatory micro-watersheds management approach to enhance water security, revitalization and climate-proofing of existing irrigation systems and building the capacities of smallholders, their communities and local authorities to implement climate risk management through resilience-enhancing practices and use of climate and other information in readily accessible formats and local languages.

This project will enhance the productive and social assets of smallholders and their organizations and communities so that they not only adapt to climate change impacts and vulnerability to rainfall variability and drought, but also build their financial management capacities to invest in sustained maintenance of investments and continued climate-risk management.

Due to the heterogeneity of the Project intervention area in terms of climatic, ecological, social, cultural and economic and productive factors, the interventions have been defined and prioritized based on the following aspects:

- Types of climate hazards and levels of risk of occurrence of climatic events such as drought, frost, hail, resulting from climate change to determine agricultural technologies and production techniques or systems.
- Eco regional characteristics to determine suitable cropping systems.
- Importance of ecosystems for regulatory and production functions to determine preservation and restoration areas

The central objective of the project is to "enhance the resilience to climate change of communities and small farmers in the Bolivian macro-region of the Valleys, through climate-proofing of irrigation infrastructure required to ensure sustainable and climate resilient livelihoods. Similarly, the project will provide support to smallholders and farmers to strengthen their capacities and for the development of best agricultural practices to increase the productivity and sustainability of their agroecosystems, aimed at adapting to the increasing variability of temperatures and rainfall and restoring and conserving ecosystem functions and services." *To do so, farmers will collectively enhance the ecosystem functions at agroecosystems and watershed levels, which will manifest in water regulation and supply, reduction of erosion and disaster risk (e.g., flooding), among others that jeopardize smallholders' livelihoods and welfare.*

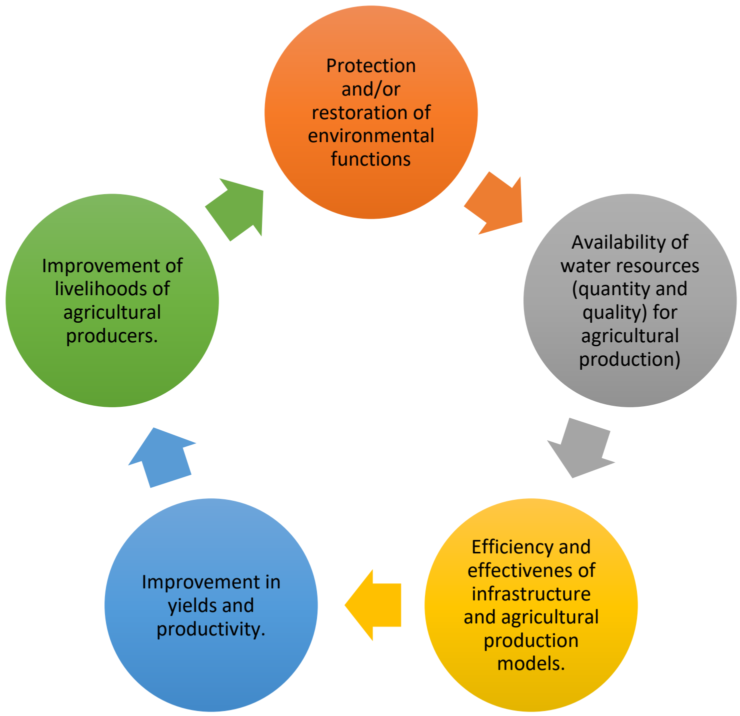


Figure 60 Overview of RECEM-Valles project intervention cycle.

The project will contribute to the GCF Paradigm Shift objective related to Increased climate-resilient sustainable development, by supporting a transformational change in climate-adaptive capacities of vulnerable populations in the Valles Macro-Region, while also enabling sustained ecosystem functions and services related to regulation of the hydrological cycle. By facilitating comprehensive transformation and improvement of water management in the target area, the project is also supporting and enhancing the enabling environments for agricultural diversification, efficiency and competitiveness through access to markets and therefore reducing dependence on low-yielding agriculture and significantly improving food security in the highly impoverished area of the Valles macro-region. Financial barriers will be approached by setting up financial mechanisms (e.g. LFI / MFI, index-based insurance) adapted and affordable to smalholders –participating in the project directly and indirectly– for the climate-resilient production of food, installation and maintenance of on-farm agricultural infrastructure (e.g., climate-proofing irrigation systems). Moreover, technical and financial assistance will be provided to communities in productive enterprises and climate-resilient agricultural management.

Potential for scaling up

By supporting climate-resilient watershed management and climate-proofing of irrigation systems, the project has significant **scalability potential** to other municipalities within the Valles Macro-region or other regions within Bolivia. Furthermore, the holistic approach followed by the RECEM-Valles project, will on one hand ensure that irrigation investments are responsive to the forecasted impacts of climate change and the experienced vulnerability of population in the Valles, influencing the country´s longer-term vision by facilitating sustainable water management practices from an ecosystem perspective enabling continuous provision of ecosystem functions and services and improving water availability and quality; on the other hand this will be complemented by the diversification of agricultural systems and access to markets, significantly contributing to effectively mainstream climate resilience in the agriculture sector in Bolivia.

Scaling out climate-resilient practices, will be the result of different intertwined technical, financial and institutional-governance approaches for fostering climate-resilient agriculture, such as: (i) Providing technical support and inputs combining traditional knowledge of smallholders for building resilience in agricultural sector (e.g solar tents, anti hail nets, drip irrigation, agroecological and agroforestry practices, etc) ((ii) Supporting market access and income diversification as well as facilitating processes of organic certification (iii) Establishing community and associative productive enterprises that encourage the implementation of climate-resilient agriculture (iv) Strengthening the capacities of national and sub-national government entities to foster policies and regulation for climate-resilient agriculture (v) Contributing to set up financial mechanisms accessible to smallholder farmers (vi) Improving (through training and organization) the local governance for climate-resilient agriculture. Therefore, scaling out will be the result of combined technical, financial and institutional-governance approaches for fostering climate-resilient agriculture.

This approach also has potential for replication in other countries- especially in Central and South America with similar economic structure (rural agroecosystems suffering from ecosystems degradation and the impacts of climate change in hydrological cycles).

18. Project structure

Within the framework of the climate change adaptation approach, the project was designed with 4 interrelated Components that seek to achieve climate change resilient productive systems which are compatible with the conservation of ecosystems and environmental functions and which the local population and authorities can manage themselves:

- Component 1. Strengthened food and income security in changing climate through climate resilient agricultural systems
- Component 2: Smallholder water resources secured to reduce the risks from droughts and low rainfall
- Component 3: Restored and conserved micro-watersheds and ecosystem functions and services
- Component 4: Enabling conditions created to implement and upscale climate-resilient agroecological management, climate-informed integral micro-watershed management, and access to financial mechanisms

For each of the Components of the project, results and goals are proposed, as mentioned in Table 34 below:

Table 34 Structure of RECEM Valles project

Component	Expected Component	Final target (Year 5)	Outputs
Component 1 Strengthened food and income security in changing climate through climate resilient agricultural systems	The capacities of small farmers, including women and youth, have been strengthened to increase their agroecosystems' productivity and sustainability as a measure of adaptation to the variability of temperatures, rains, and droughts.	Productivity and sustainability have increased in at least 23,400 hectares of agroecosystems of small farmers, including women and young people vulnerable to climate variability, rains, and droughts due to climate change.	**Output 1.1.** Climate-resilient agriculture implemented and managed by smallholders for increasing the productivity and sustainability of their agroecosystems
			Output 1.2. Increased market access of climate resilient agricultural products
Component 2. Smallholder water resources secured to reduce the risks from droughts and low rainfall	The existing irrigation systems have been revitalized and optimized in efficient water use, reducing the risks of droughts due to the variability of temperatures, prolonged dry periods and scarce rainfall.	Technified and resilient irrigation systems have been revitalized and implemented in at least 4,448 hectares to optimize the efficient use of water, reduce the risks of droughts and low rainfall generated by the effects of climate change.	**Output 2.1** Enhanced and modernized on-farm climate-proofed irrigation systems implemented and managed
			Output 2.2 Strengthened capacities for the management of on-farm climate-proofed irrigation
Component 3: Restored and conserved micro-watersheds and ecosystem functions and services	The water security of communities and small producers is improved to guarantee the sustainability of their climate-resilient livelihoods, based on prioritizing micro-basins and the preservation and restoration of environmental functions using the participatory approach comprehensive watershed management.	Indigenous communities, smallholders, and public-private institutions in the project's area of influence have developed practices to preserve and restore environmental functions with a micro-watershed approach for water security in **17,510** hectares	**Output 3.1.** Restored and conserved ecosystem management for enhanced climate resilient watersheds
			Output 3.2. Information and long-term monitoring system for water sources at place
			Output 4.1. Strengthening capacities for national and

Component 4: Enabling conditions created to implement and upscale climate-resilient agroecological management, climate-informed integral micro-watershed management, and access to financial mechanisms	Public and community institutional capacities to manage climate risk by small farmers and communities have been strengthened.	One governance mechanism implemented for adaptation planning and local financial mobilization.	sub-national government entities to implement policies and norms for the climate-resilient food production under irrigation systems, integral watershed management and monitoring of ecosystem functions and services
			Output 4.2. Improved financial mechanisms that support climate-resilient agricultural production and irrigation systems to mobilise increased finance for farmers
			Output 4.3. Strengthening local governance in participatory climate adaptation, early warning systems and long-term monitoring system

Based on the expected results and the proposed goals, a series of activities were proposed and agreed with stakeholders, that respond to the different needs that small farmers have, to face the adverse effects of climate change on productivity, crop yields, and on environmental functions that provide environmental services to local populations, etc. The proposed activities also consider the region's socio-economic and ecological characteristics and particularly the vulnerability of agricultural production to climate change.

Due to the extension of the Project's intervention area, these activities will be implemented taking into account the social, economic, cultural, ecological and environmental particularities, and the most essential needs of rural producers, so that they have tools that allow them to face to the adverse effects of climate change.

Component 1: Strengthened food and income security in changing climate through climate resilient agricultural systems

Rationale: Component 1 is aimed at developing resilient production systems through the application on one hand of climate-resilient agricultural technologies (thermal blankets, anti-hail nets, hydrogels, etc.), as well as climate-resilient agricultural practices and management systems (e.g. conservation agriculture, agroforestry systems) and organic agriculture practices as a tool for the conservation and soil recovery, with clear mitigation co-benefits, efficient water use and to achieve more productive and sustainable agroecosystems, transforming and reorienting agricultural systems to effectively support development and ensure food security in a changing climate. New local capacities will be generated among rural producers to ensure sustainability beyond the scope of the project, by providing smallholders support on market access and identification of opportunities for productive diversification as an adaptation strategy in itself and as an alternative income generation source that could in the long run ensure sustainability of project investments. In this sense, productive diversification is promoted, reinforcing the concept that productive diversity is a determining factor in mountain ecosystems' sustainability, even more so under a climate change scenario including its indirect effects (Taboada *et al.*, 2014).

Component 1 Objective: To strengthen small farmers' capacities, including women and young people, to increase the productivity and sustainability of their agroecosystems as a measure of adaptation to climate change and the variability of temperatures, rains and droughts.

Component Goal: Increase productivity and sustainability in at least **23,400** hectares of agroecosystems of small farmers vulnerable to climate change in five years.

Component 1 is fully responsive to the limited technical support and appropriate technical know-how and innovation, defined by smallholders and farmers in the Valles Macro-region as a key challenge to adapt their traditional agroecosystems management to increased climate variability. Also, Component 1 will provide support to smallholders to improve their income through enhanced access to markets for their agricultural products, including certified organic and climate-friendly products as a strategy to provide smallholders and farmers with the means for sustained climate-resilient production practices. In this sense, Component 1 is structured in two main outputs or project results:

- Output 1.1. Climate resilient agriculture implemented and managed by smallholders for increasing the productivity and sustainability of their agroecosystems
- Output 1.2. Increased market access of climate resilient agricultural products

Output 1.1 Climate-resilient agriculture implemented and managed by smallholders for increasing the productivity and sustainability of their agroecosystems

Total GCF budget; USD 11.3MM, to be executed by FAO. Total beneficiaries: 23,551 (12,247 males and 11,304 females).

Activities under this output will implement resilient agricultural management, deployment of climate-resilient technologies and strengthening of capacities to improve productivity and management of agroecosystems. Particularly, agricultural technologies and practices in the context of Output 1.1. will be implemented in municipalities with a high and very high vulnerability to climate change, specifically with a **high and very high risk of frost, with a high risk of hail and/or with a very high and high risk of drought, see** Table 35[130]**.**

Table 35 Municipalities under high and very high risk of hail

MUNICIPALITY	RISK LEVEL	MUNICIPALITY	RISK LEVEL
Azurduy	Very High	San Lorenzo	Very High
Camargo	Very High	Tarija	Very High
San Lucas	Very High	El Puente	HIgh
Sucre	Very High	Yuncharà	HIgh
Tarvita	Very High	Zudañez	HIgh
Yamparáez	Very High	Cotagaita	HIgh
Yotala	Very High	Tupiza	HIgh
Puna	Very High		
Vitichi	Very High		

Table 36 Municipalities under high and very high risk of frost

MUNICIPALITY	RISK LEVEL	MUNICIPALITY	RISK LEVEL
Tupiza	Very High	Yamparáez	High
Yuncharà	Very High	Yotala	High
Puna	High	Potosí	High
Vitiche	High	Punata	High
Aiquile	High	Ravelo	High
Anzaldo	High	Sacabamba	High
Arque	High	Saipina	High
Camargo	High	San Benito	High
Cotagaita	High	Sicaya	High
Mizque	High	Sipe Sipe	High
Poroma	High	Sopachuy	High
San Lucas	High	Tarata	High
Sucre	High	Tinquipaya	High
Tacobamba	High	Toko	High
Tacopaya	High	Tolata	High
Tapacarí	High	Tomina	High
Alcalá	High	Vacas	High
Arani	High	Vila Vila	High
Caiza "D"	High	Villa Gualberto Villarroel	High
Capinota	High	Villa Rivero	High
Cochabamba	High	Villa Serrano	High
El Puente	High	Vinto	High
Ocurí	High	Yocalla	High
Omereque	High	Zudañez	High
Pocona	High		

Table 37 Municipalities under high and very high risk of droughts

MUNICIPALITY	RISK LEVEL	MUNICIPALITY	RISK LEVEL
Puna	Very High	Capinota	High

130 Centro de Apoyo a la Gestion Sustentable del Agua y el Medio Ambiente. 2018. Producto 2. Línea de base socioeconómica, ambiental y cultural del área de influencia del proyecto en relación con los sistemas de vida y usos de los recursos naturales. Estudios socioeconómicos relacionados a la elaboración del Proyecto FAO para el Fondo Verde del Clima

Vitiche	Very High	Cochabamba	High
Aiquile	Very High	El Puente	High
Anzaldo	Very High	Ocurí	High
Arque	Very High	Omereque	High
Cotagaita	Very High	Pocona	High
Mizque	Very High	Pojo	High
Poroma	Very High	Potosí	High
Tacobamba	Very High	Ravelo	High
Tacopaya	Very High	Sicaya	High
Tapacarí	Very High	Sipe Sipe	High
San Lucas	High	Tinquipaya	High
Sucre	High	Tomina	High
Tupiza	High	Totora	High
Yamparáez	High	Vila Vila	High
Yotala	High	Villa Rivero	High
Yunchará	High	Villa Serrano	High
Alcalá	High	Yocalla	High

This output includes the following activities:

- **Activity 1.1.1.** Provision of climate technologies and implementation of climate resilient agricultural practices to address vulnerability and increase resilience in the Valles Macro-region. Total of 4,680 direct beneficiaries, 2,434 males and 2,246 females.
- **Activity 1.1.2.** Capacity building on climate resilient agricultural practices to contribute to increased resilience and productivity of agricultural systems. Total of 23,551 direct beneficiaries, 12,247 males and 11,304 females.

Activity 1.1.1 Provision of climate technologies and implementation of climate resilient agricultural practices to address vulnerability and increase resilience in the Valles Macro-region.

This activity aims to provide technical assistance for the adoption of the integral packages of climate technologies for agricultural adaptation.

Sub-activities:

- Incorporation of solar tents or greenhouses is proposed as an intervention, to protect crops and avoid losses due to frost.
- Provision of anti-hail nets is proposed as an intervention to protect crops and avoid losses due to hail.
- Provision of thermal blankets is proposed to protect crops and avoid losses due to frost.
- Provision of hydrogel in crop plant to avoid losses due to droughts.

Deliverables:

- 1,200 family and communal solar tents have been implemented
- 600 anti-hail nets have been installed
- 1,000 frost blankets implemented

- 5,200 small-scale producers (30% women and 10% youth) have incorporated hydrogel

The project will provide, as a grant, the above mentioned technologies to the direct beneficiaries: solar tents, anti-hail nets, frost blankets, hydrogel, taken into consideration the following criteria. The final selection of beneficiaries will be determined after thorough stakeholder consultations, where it will be possible to also agree on more detailed criteria together with the stakeholders.

Table 38 The following criteria will be used for the selection of direct beneficiaries:

Solar tents	i) Farmers living in areas with very high and high risk of frost (including extreme events) ii) Family farmers producing vegetables iii) Farmers who can provide an in-kind contribution (like labor).
Anti-hail nets	i) Farmers living in areas with very high and high risk of hail (including extreme events) ii) Family farmers producing vegetables and others. iiii) Farmers who can provide an in-kind contribution (like labor).
Frost blankets	i) Farmers living in areas with very high and high risk of frost (including extreme events) ii) Farmers producing grapes and fruit iii) Farmers who can provide an in-kind contribution (like labor).
Hydrogel	i) Farmers living in areas with very high and high risk of drought (including extreme events) ii) Family farmers with agroforestry systems iii) Farmers who can provide an in-kind contribution (like labor).

Description:

After an initial consultation with stakeholders and having conducted a cost-benefit assessment of different technologies, the project proposes the use of the following technologies to respond to specific needs identified in the target area, related to the most urgent climate risks and to increase the productivity and yields of crops and reduce losses

- In municipalities with a greater horticultural vocation and with a high and very high risk of frost (see Table 36), resilient agricultural technologies and practices (solar tents, frost blankets) will be implemented
- In municipalities with a high risk of hail (see Table 35), resilient agricultural technologies and practices (anti-hail nets) will be implemented to increase yields and productivity, and reduce crop losses.
- And in municipalities with a high risk and a very high risk of drought (see Table 37), resilient agricultural technologies to be implemented include solar tents and hydrogels.

During the project preparation phase, a number of different technologies were identified and assessed considering the socio/economic and environmental characteristics of the targeted areas. Table 39 presents a summary of the key technologies identified for anti-frost, anti-hail and drought management hard technologies, while subsequent paragraphs present a detailed description of selected technologies.

Table 39 Identified antifrost, anti-hail and anti-drought technologies

Identified Technology	Climate impact	Key characteristics

Antifrost Candles	Antifrost	Antifrost candles are an innovative technology with a caloric power of 25.5 MJ per hour (40 MJ/KG). The deployment of this might require increased financial resources as it is suggested to place between 250 and 300 candles per hectare for a frost between -3°C and -4°C In addition, it is suggested to position another 150 to 200 candles per hectare, in anticipation of a frost from -4°C to -6°C to be ignited in a second phase if needed. This technology is not easily available in Bolivia.
Antifreeze Tower		Optimal protection area up to 3.5 hectares. It is powered by a tractor and therefore the use of fossil fuels is required.
Solar tents		This technology is already being implemented among horticulturists in Bolivia, mainly for horticulture, floriculture, and fruit growing. And with good results.
Thermal blankets		In Bolivia, there are experiences among horticulturists in the use of thermal blankets, which have been very well accepted.[131] Thermal blankets are used in agriculture, horticulture, fruit growing and nurseries. The thermal blanket for agriculture's main advantage is the higher productivity and quality of the plants, low cost, easy placement and handling, and a uniform climate. After use, if not deteriorated, it can be stored for reinstallation in a new growing season.[132]
Rocket anti-hail technologies	Anti-hail	Delivers ice-nucleation aerosol directly into the area of realization. As this is a highly technified technology it requires additional financial resources for its deployment.
Ground generators		It starts working in occurrence of potentially hail-dangerous situation in a few hours before a prospective beginning of the processes. During that time a surface air becomes saturated with ice-nucleation aerosols and then dragged up with ascending flows.
Anti-hail nets		An increasingly used technology is the anti-hail mesh, which protects the plantation from hail and is mainly used in fruit crops[133].
Subsurface Water Retention Technology (SWRT)	Anti-drought	With the ability to improve the water storage capacity of soils. It consists of membranes installed within the soil profile to prevent the loss of water via deep percolation. These water-saving membranes are an innovation designed to retain water while permitting extended root growth beyond the depths of the membranes. This technology is still unavailable in Bolivia.
Nanoclay		Nanoclay can turn dry sandy soils into fertile land. This product, when applied to soils, acts as a sponge that helps the soil retain water. The use of this technology is still not available in Bolivia.
Hydrogels		Hydrogel is used to increase the retention of water and nutrients in soils; it acts as a reservoir of water that it releases according to the

[131] https://www.elpaisonline.com/index.php/ellas-y-ellos/item/176822-ministerio-dara-mantas-termicas-a-los-horticultores
[132] https://texdelta.com/blog/manta-termica-para-agricultura/
[133] Figuerola I.A. 2015. Project for the exploitation of apple trees in high altitude areas for the production of maximum quality fruits, in Burgo de Osma (SÓRIA). Higher Technical School of Agricultural Engineering. University of Valladolid. 494p.

		plants' needs, which allows improving plant development and production.[134] The cost of the input is 150 Bs (17 USD) per kg, which is applied to 200 holes of forest seedlings.
Solar tents		This technology is already being implemented among horticulturists in Bolivia, mainly for horticulture, floriculture, and fruit growing, and with good results[135].

After careful consideration of all available technologies the following technologies have been selected to be deployed in the context of the project:

Solar tents:

Solar Tents are greenhouse-type infrastructures that allow an environment with a microclimate conducive for the cultivation of agricultural crops whilst maintaining suitable growing temperatures between 17° C to 27° C during the day and no less than 5° C during the night.

The incorporation of solar tents or greenhouses is proposed as an intervention to protect crops and avoid losses due to frost. In different sectors of the intervention area, frosts significantly affect vegetable crops, among which tomatoes are particularly highlighted. Solar tents or greenhouses are among the most widely used agricultural technologies to protect crops against frost, hail and other climatic events. There are experiences among horticulturists of using solar tents in Bolivia, mainly for horticulture, floriculture, and fruit growing. This system will produce vegetables and other crops such as quinoa, fruit trees, bananas, condiments, etc. throughout the year. As the system is under control, then the products obtained are of high quality, (without pesticides), uniform and feasible to be marketed nationally and internationally (Delgadillo, 2015).

The main advantage of using solar tents is to combat intense frosts and water shortages in crops; besides, it is a technology that may be easily handled by women and young people, allowing families to have nutritious food such as vegetables in places where they are hardly produced or are not available in local markets.[136] In the Bolivian Valleys Macro-region, families in communities produce more than ten species of leafy vegetables, fruit and spices in solar tents from 50 m^2. In this way, they ensure their food and surpluses that reach approximately 60% with direct marketing. Women lead the production, and the man helps. They have different types of irrigation, in some cases with a technical drip or sprinkler irrigation; the use of manure in this system is the most common and the production of compost. These techniques have been developed mainly in high areas of the valleys (MDRyT, 2018).

In the Valleys Macro-region of Bolivia, the tomato is among the four vegetables with the largest cultivated area, with approximately 2,259 ha. The departments of Cochabamba and Santa Cruz, being the most important and therefore used for the financial evaluation, and it was carried out at the plot or farm level. Tomato is one of the best-known crops within the greenhouse production field among vegetables. Furthermore, the biological or organic production of tomatoes in solar tents is very feasible due to the

[134] https://www.projar.es / Fernandes, R.D.R., Gallo, F.M. 2016. Absorcón de agua de hidrogel de uso agrícola y su humedicimiento de tres tipos de suelos

[135] https://reliefweb.int/report/bolivia-plurinational-state/solar-tents-improve-nutrition-highlands-villages-bolivia_/ Escobar, Z., Gabirel, A. 2018. Impacto de los sistemas de riego y microriego en tres regiones de Bolivia. Cochabamba, Centro de Investigación y Promoción del Campesinado.

[136] http://www.ipsnoticias.net/2017/05/carpas-solares-mejoran-alimentacion-de-valles-andinos-de-bolivia/

complete control of the plants' environment. Tomatoes are also highly susceptible to damage from chilling temperature and frost, increasingly affecting the Valles Macro-Region.

The following actions are contemplated with regard to the implementation of the solar tents:
- Elaboration of construction materials with local materials.
- Construction of the greenhouse walls.
- Construction of the roof with agrofilm, windows and door of the greenhouse.
- Implementation of drip irrigation system connected to the cistern,
- Substrate preparation (with local fertilizers).
- Preparation of nurseries
- Construction of vegetable transplanting areas.

There are many models with which you get good results. Some models are built on the surfers are semi-underground because they are built by digging the ground. These greenhouses can be family, commercial or industrial. Figure 61 below presents the models that, according to consulted literature, have shown best results: 1. Model of a drop or half water; 2. Two-fall model; 3. Tunnel model.

Greenhouses must have a fall or slope for the runoff of snowfalls and hail that are very common in the highlands of Bolivia. These also facilitate the runoff of water droplets that accumulate on the ceiling. Slope should be between 25 to 30%

Figure 61 Solar tent models

Anti-hail nets:

These meshes are made of high-density polyethylene in monofilament with resistance to ultraviolet rays. The anti-hail mesh is installed according to the conduction system and availability of investment resources; in vineyard it can be partial or total. It is one of the most efficient proven methods for hail control. Anti-hail nets consist of a Gauze or «English twist» fabric, made with monofilament yarn, designed to protect crops against hailstorms. High Density Polyethylene (HDPE), with a pore size of 3.44mm x 2.22mm. It provides a shading of 14% and average cost per hectare covered is around 51,000 bs (7,380 USD) with some accessories, such as plastic wires and connectors, it does not take into account the poles. Figure 30 below presents a diagram with the application of anti-hail nets.

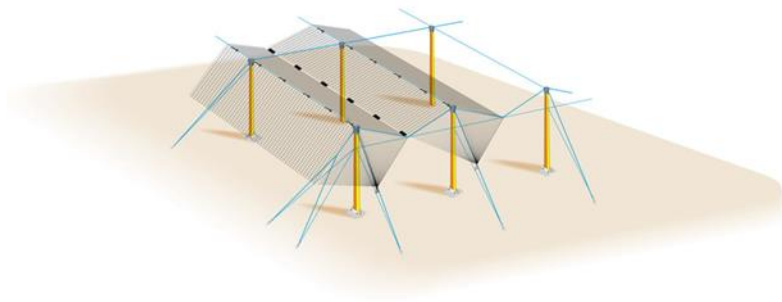


Figure 62 Application diagrame of antihail nets

The provision of anti-hail nets is proposed as an intervention to protect crops and avoid losses due to hail. In the country, technologies have already been tested and evaluated to deal with hail. For example, in several municipalities with crops affected by hail, hail bombs and bomb launchers were delivered, used in coordination with early warning systems and can prevent and reduce the damage caused by this type of event (UDAPE, 2015). However, they are doubtful operation systems and environmentally unsustainable, since they try to alter storms and dissipate hail, being ineffective[137]. An increasingly used technology is the anti-hail mesh, which protects the plantation from hail and is mainly used in fruit crops. The anti-hail mesh system consists of arranging the crop under a structure covered by a plastic mesh, whose weave of threads allows the passage of air, water, and sunlight, but prevents hail passage. This system's great advantage is its efficiency (it is a fixed installation), although its main drawback is the large initial investment[138].

The municipalities or areas in the project intervention area under very high and high risk of hail are prioritized, being the highlands and valleys those with the most significant hail threat. According to the perception of rural producers, hailstorms have become frequent in the last ten years in the puna area. They are unpredictable, hail is more extensive, and affect the development of crops. While hailstorms are more frequent in the valley area and last longer, hailstorms are also larger (UNDP, 2011). These perceptions coincide with the hail reports registered in Bolivia for the period 1970 to 2010, which show a trend line of more remarkable recurrence as of 2007, having reached in 2010, the highest number of events and those affected (DESINVENTAR 2011, in Public Policy Series No. 2, 2014). The areas of most significant recurrence are found in the highlands, inter-Andean valleys, and valley headwaters, subject to convective phenomena, ideal for forming high-altitude humid masses.

The production of valley fruits in Bolivia has experienced in the last 12 years an important evolution in cultivated area, in production volumes and yields per ha, in the five most important fruit species (peach, table grape, apple, cherimoya and avocado). Peach and grape are the most important fruit crops in the Valles Macro-region of Bolivia. The peach cultivation reaches an approximate surface of 4,844 ha. These are crops that are very sensitive to hail, especially in areas with high hail hazards. Although the yields are highly variable for each fruit species, they are subject to the degree of technological innovation and farmers' investment capital. The average peach yield for Bolivia is 5.7 MT / ha.[139] The model proposes

[137] Figuerola I.A. 2015. Project for the exploitation of apple trees in high altitude areas for the production of maximum quality fruits, in Burgo de Osma (SÓRIA). Higher Technical School of Agricultural Engineering. University of Valladolid. 494p.

[138] Figuerola I.A. 2015. Project for the exploitation of apple trees in high altitude areas for the production of maximum quality fruits, in Burgo de Osma (SÓRIA). Higher Technical School of Agricultural Engineering. University of Valladolid. 494p.

[139] www.del.org.bo/info/archivos/RUTA%20DEL%20DURAZNO.doc

the production of peaches using anti-hail nets in established productive crops of four years or more. In this sense, the product used for the financial evaluation is peach cultivation and it was carried out at the parcel or farm level.

A single hailstorm can ruin a crop at best, and a plantation at worst. For this reason, hail can become a clear limiting factor for the establishment of a fruit plantation in a given area[140]. In different sectors of the intervention area, hail significantly affects fruit and vine crops, among which is peach.

Thermal blankets:
Thermal Blanket is a 2.5 oz. white, non-woven, needle-punched polypropylene fabric primarily used as a plant protection fabric. Thermal Blanket is designed to let rain and irrigation through to your nursery stock, while holding in precious heat. Due to the fabric's permeability, there is no need to worry about foliage burn, so Thermal Blanket can remain in use even on sunny days. Thermal Blanket also makes an effective alternative for over-wintering perennials and other ornamentals. This technique can create a microclimate in the immediate vicinity of the plants warmer than air above the blanket inside of the structure. Commonly used materials for thermal blankets include Microfoam (¼" flexible, polypropylene foam), The Winter Blanket (polyethylene foam, laminated with 3-mil UV resistant P/E) and Guilbond (1/4" closed cell polyethylene foam laminated to white UV treated polyethylene film). Figure 62 below shows the application of thermal blankets.

Figure 63 Farmer with thermal blanket in the field

The provision of thermal blankets is proposed to protect crops and avoid losses due to frost. The municipalities or zones in the project intervention area under a very high and high risk of frost are

[140] Idem as 121

prioritized. In different sectors of the intervention area. Frosts are climatic events of great concern in agricultural activity due to the economic losses they generate, significantly affecting the crops of vegetables, corn, potatoes, and others such as alfalfa, which is used as feed for cattle.

According to reports from rural producers themselves, frosts can create losses of 50% of production or losses of up to 100% of crops. The level of damage suffered by the yield will depend on various factors such as the vulnerability of the species or variety to low temperatures, phenological status, the intensity of frost, exposure time, and geographical location. Although frosts are a recurring phenomenon, the changes observed in climate variability in the last decade mean that they are occurring unexpectedly and in areas where they have not occurred usually, which makes it necessary to implement adaptation measures for new climate scenarios.[141]

In Bolivia, there are experiences among horticulturists in the use of thermal blankets, including initiatives supported by the government, which have been very well accepted.[142] Thermal blankets are used in agriculture, horticulture, fruit growing and nurseries. They are used in greenhouses creating a double chamber effect; in outdoor crops (lettuce, watermelons, melons, potatoes, peppers, etc.); for early sowing out of seasons; for growing flowers. The thermal blanket for agriculture's main advantage is the higher productivity and quality of the plants; low cost, easy placement and handling, and a uniform climate. After use, if not deteriorated, it can be stored for reinstallation in a new growing season.[143]

The product used for the financial evaluation is the pea cultivation, and it was carried out at the plot or farm level. Although frosts occur every year, their intensity, periodicity and effects on vegetable crops vary. In different sectors of the project intervention area, frosts significantly affect vegetable crops, including peas. The pea is among the four vegetables with the largest extension cultivated in the Valleys Macro-region of Bolivia. It reaches an approximate area of 8,622 ha.

A conservative estimate of the decrease in pea yield due to frost is presented below:

Table 40 Potential effects of frost on pea crop yields

Effect of frost on pea yields	**Estimated decrease in pea yields**
Annual frosts within the usual time of year	10%
Expected frosts every 3 years within the usual time of year	30%
Frosts outside the usual season of year and with a longer duration	80%

Hydrogel

Among the technologies to mitigate the effects of water stress, the hydrogel stands out, which are hydrophilic, soft, elastic polymers capable of expanding in the presence of water, considerably increasing

[141] https://www.portalfruticola.com/noticias/2017/08/30/heladas-tipos-medidas-prevencion-manejos-posteriores-al-dano/
[142] https://www.elpaisonline.com/index.php/ellas-y-ellos/item/176822-ministerio-dara-mantas-termicas-a-los-horticultores
[143] https://texdelta.com/blog/manta-termica-para-agricultura/

their volume, but maintaining their shape, while in the dehydrated state they are crystalline. The ability of the hydrogel to absorb water arises because hydrophilic functional groups are found in its structure, and its resistance to dissolution is given by the cohesion forces produced by the crosslinking of its molecules. It is important to mention that these cohesion forces are due to different types of interactions such as: electrostatic, hydrophobic, dipole-dipole interactions or hydrogen bonds. Hydrogel synthesis is essentially based on copolymerization reactions, in which one of the monomers is hydrophilic and the other is hydrophobic. Due to the benefits of the hydrogel, its viability as a mechanism to mitigate or eliminate the effects of water stress in different plant species has been studied in the last decades. In this sense, the hydrogel has been used in the conservation campaigns carried out by the Ministry of the Environment and Water in Bolivia, as well as in the program to strengthen the community social economy[144]

The incorporation of hydrogel is proposed in crops to avoid losses due to droughts. The municipalities or zones in the project intervention area under very high and high risk of droughts are prioritized. In different sectors of the intervention area, droughts significantly affect fruit crops, including peaches.

Hydrogel is used to increase the retention of water and nutrients in soils; it acts as a reservoir of water that it releases according to the plants' needs, which allows improving plant development and production.[145] Hydrogel is a Reversible and biodegradable polymer with 4 years of useful life, optimizing fertilization by reducing nutrient percolation by 30%. The cost of the input is 150 Bs (17 USD) per kg, which is applied to 200 holes of forest seedlings. Due to its ability to retain water and nutrients, it reduces the frequency of irrigation by up to 50% and the need for fertilizers; increases available water content and reduces leaching of fertilizers; It does not lose the ability to absorb-release water after drought; After 50 humidity-drought cycles, the rehydration capacity of this retainer is greater than 80%; In new plantations, it improves the survival of the trees after transplanting; it helps to reduce soil compaction, generating an increase in the water infiltration rate. This increase in the infiltration rate causes less water runoff, thus reducing erosion. Hydrogel is environmentally safe and biodegradable.[146]

Peach and grape are the most important fruit crops in the Valleys Macro-region of Bolivia. The peach cultivation reaches an approximate surface of 4,844 ha (Appendix 2). Although the yields are highly variable for each fruit species, they are subject to the degree of technological innovation and farmers' investment capital. The average peach yield for Bolivia is 5.7 MT / ha.[147] In this sense, the model proposes peach production incorporating hydrogel in established productive crops of four years or more. The financial evaluation was carried out at the plot or farm level (1 ha per family). Figure 64 presents the application of hydrogel.

[144] GCP / BOL / 052 / ITA.
[145] https://www.projar.es
[146] https://www.projar.es
[147] www.del.org.bo/info/archivos/RUTA%20DEL%20DURAZNO.doc

Figure 64 Hydrogel Application

The criteria and location of the implementation for Activity 1.1.1 include:

Table 41 Criteria and location of the implementation of activity 1.1.1

Activity	General criteria	Indicator	Specific indicators	N of beneficiaries	Selected municipalities
Activity 1.1.1 Provision of climate technologies to address vulnerability and increase resilience in the Valles Macro-region	Residence within the project Municipalities. High dependence on agriculture and/or natural resources. Small-scale family farmers. Those whose primary source of income depends on agriculture. Vulnerability due to exposure to environmental and climate change risk. Household with 5 or more members. Agrarian property titled by INRA. Manifest willingness to implement project management practices.	1,200 family and communal solar tents have been implemented	Areas in the project intervention area with very high and high risk of frost and that are also vegetable producers.	Beneficiarios: 1200 Mujeres: 576 (48%) Varones: 624 (52%)	Mancomunidad Chuquisaca Centro (Alcalá, Azurduy, El Villar, Padilla, Sopachui, Tarvita, Tomina, Villa Serrano); Mancomunidad Cono Sur (Aiquile, Mizque, Omereque, Pocona, Pojo, Totora, Vacas, Vila Vila); Mancomunidad Valles Cruceños (Comarapa, Mairana, Pampa Grande, Quirusillas, Saipina, Samaipata, Vallegrande).
		600 anti-hail nets have been installed	Zones in the project intervention area with very high and high risk of frost. Prioritized grapevine and fruit products (Implemented to increase yields and productivity and reduce climate-related losses of vine and fruit crops)	Benficiaries: 600 M: 288 V: 313	Municipalities (49): Tupiza, Yunchará, Puna, Vitiche, Aiquile,,Anzaldo,Arque, Camargo, Cotagaita, Mizque, Poroma, San Lucas, Sucre, Tacobamba, Tacopaya, Tapacarí, Alcalá, Arani, Caiza "D", Capinota, Cochabamba, El Puente, Ocurí, Omereque , Pocona, Yamparáez, Yotala,

					Potosí, Punata, Ravelo, Sacabamba, Saipina, San Benito, Sicaya, Sipe Sipe, Sopachuy, Tarata, Tinquipaya, Toko, Tolata, Tomina, Vacas, Vila Vila, Villa Gualberto, Villarroel, Villa Rivero, Villa Serrano, Vinto, Yocalla, Zudañez.
		1,000 frost blankets implemented	Zones with the greatest risk of frost	B: 1000 M: 480 V: 620	Municipios con alto y muy alto riesgo de granizo (16): Chuquisaca (Azurduy, Camargo, San Lucas, Sucre, Tarvita, Yamparáez, Yotala, Zudañez); Potosí (Puna, Vitichi, Cotagaita, Tupiza); Tarija (San Lorenzo, Tarija, El Puente, Yunchará).
		5,200 small-scale producers (30% women and 10% youth) have incorporated hydrogel	Very high and high drought risk areas	B: 5200 M: 2.496 V: 2.704	Municipalities Very high risk of drought (11): Aiquile, Anzaldo, Tacopaya, Arque, Vitiche, Tapacarí, Puna, Poroma, Tacobamba, Mizque, Cotagaita Municipalities High risk of drought (25): Alcalá, Capinota, Cochabamba, El Puente, Ocurí, Omereque, Pocona, Pojo, Potosí, Ravelo, San Lucas, Sicaya, Sipesipe, Sucre, Tinguipaya, Tomina, Totora, Tupiza, Vila Vila, Villa Rivero, Villa Serrano, Yamparáez, Yocalla, Yotala, Yunchará

Activity 1.1.2 Capacity building on climate resilient agricultural practices and support production and delivery of biological agricultural inputs to contribute to increased resilience and productivity of agricultural systems.

This activity aims to conduct training on 1) climate resilient agricultural practices such as agroecological production (crop planting seasons, crops that require less water in drought areas, the proper use of agricultural inputs and the provision of organic inputs such as fertilizers and biological products for pest control) 2) agroforestry practices appropriate to agronomic and environmental needs and 3) the proper use of the technologies as provided under activity 1.1.1 (anti-hail nets, solar tents, hydrogel and thermal blankets)

Sub-activities:

- Provide technical assistance to implement practices of conservation agriculture and agroecological for adaptation
- Conduct trainings and generating greater awareness about the use of agrochemicals.
- Conduct trainings for the adoption of the integral packages of climate technologies (anti-hail nets, solar tents, thermal blankets and hydrogel) for agricultural adaptation

Deliverables:

- At least 23,551 producers (at least 40% women) that have been trained in agroecological production, conservation agriculture and/or agroforestry

Training topics of the technical assistance include:

- Use of the climate resilient agricultural practices implemented under activity 1.1.1. (hail nets, solar tents, hydrogel and thermal blankets)
- Agroecological management (including conservation agriculture, changing planting times and crops to adapt to drought, organic pest management, etc)
- Agroforestry

The criteria for the selection of the direct beneficiaries of activity 1.1.2 are Activity 1.1.1, since 1.1.2 complements Activity 1.1.1:
i) Farmers living in areas with very high and high risk of drought (including extreme events)
ii) Family farmers with agroforestry systems
iii) Farmers who can provide an in-kind contribution (like labor).

Description:

Small-scale agriculture is the most vulnerable sector, both in socioeconomic terms and because of its high exposure to adverse climatic events (VDRA-UCR, 2021). Given this situation, precise guidelines are required to provide differentiated services to families in the communities according to their social and productive typologies in order to improve their productive capacities and integral resilience (CPLI and Indigenous Peoples Plan, RECEM Valles 2020).

For its part, the RECEM Valles Project, within the framework of the activities planned to improve the performance of family agriculture in the Valleys of Bolivia, in order to meet the indicators and milestones established without precedent, will strengthen and generate capacities within the framework of Technical Assistance and Rural Extension, with the aim of training and strengthening the skills of field technicians and producers, who have identified a series of problems and challenges caused by climate change. The capacity building objectives have been identified based on the baseline information and the needs indicated by the farmers during stakeholder engagements, see also Table 13. In this table, the following needs were highlighted:

- More in depth technical training aspects of drought, frost, hailstorms, floods, pests and diseases in order for producers to then manage livestock health in coordination. As a community they also benefit from other collaborations (this is included in activity 1.1.2)
- Permanent presence of professionals who give permanent advice during the production cycle under technified irrigation systems, management and conservation of water sources (this has been incorporated in activity 2.2.1)
- The technical assistance should be accompanied by the management capacity to solve other problems of the producers. For example, access to quality inputs (agrochemicals) to prevent the producer from being subject to deception by counterfeiters in the market, because they sell adulterated products. (this has been incorporated in activity 4.3.2)
- The project also has to support in the market, so that we can market in a better way (this has been incorporated in output 1.2)

The gaps to be overcome by the capacity building in technical aspects under activity 1.1.2

- Producers in many cases do not know about crop rotation cycles and productive diversification.
- Producers have tried to carry out climate change mitigation and adaptation processes without much success. There is no updated or adapted technical training programs for improving agrifood systems that consider the criteria and indicators of resilience and adaptation to climate change.
- Producers do not have sufficient resources to apply innovative and cutting-edge technologies to deal with the extreme phenomena of frost, hailstorms, droughts and floods.

The capacity building under this activity is also complemented with the other capacity building activities under: *Activity 2.2.1* (Strengthen capacities of key stakeholders (including irrigation associations, community promoters, technicians and professionals) to enable locally owned technological innovation processes related to on-farm climate-proofed irrigation systems) and *Activity 4.3.1* (Institutional strengthening of SENAMHI and MDRyT to generate and timely disseminate locally adapted information to smallholders and decision makers on meteorological/weather, hydrological, hotspots and forest fires Capacity strengthening for local stakeholders (including smallholders, public officers, local CSOs, and relevant academia and private sector) on the integration of climate change risks for decision making to increase the resilience of smallholders and communities).

In different sectors of the project intervention area, producers make intensive use of agricultural inputs many times without due control and knowledge of the negative impacts on their health, consumers' health, and the soil, water, and local biodiversity. For this reason, the project proposes capacity building, aimed at the farm level, in:

- The proper use of agricultural inputs and the provision of organic inputs (fertilizers and biological products for pest control) appropriate to agronomic and environmental needs, in addition to generating greater awareness about the use of agrochemicals.
- Agroecological farming practices
- Agroforestry farming practices

Nitrogen-based fertilizers spur greenhouse gas emissions by stimulating microbes in the soil to produce more nitrous oxide. Nitrous oxide is the third most important greenhouse gas, behind carbon dioxide and methane. Agriculture accounts for about 80 percent of human-caused nitrous oxide emissions worldwide, which have increased substantially in recent years due to increased nitrogen fertilizer use. In this regard, the project proposes to complement agricultural practices such as agroecological agriculture and sustainable agroforestry systems by providing training to smallholders and farmers on these practices that will in turn have an important co-benefit in terms of greenhouse gas emissions reductions.

Areas of intervention (only capacity building will take place under this activity, whereas the implementation of the practices will take place under activity 3.1.2): Municipalities in need of improving soil fertility conditions and the state of conservation of agricultural soils (23): Chuquisaca Centro Community (Alcalá, Azurduy, El Villar, Padilla, Sopachui, Tarvita, Tomina, Villa Serrano); Southern Cone Commonwealth (Aiquile, Mizque, Omereque, Pocona, Pojo, Totora, Vacas, Vila Vila); Valles Cruceños Association (Comarapa, Mairana, Pampa Grande, Quirusillas, Saipina, Samaipata, Vallegrande).

A total of 23,551 farmers will be trained under this activity. The key selection criteria to define training participants include:

- Farmers most threatened by the impacts of climate change, especially those whose agricultural lands are most affected by droughts, frost and hail.
- Farmers participating in different cooperative production modalities which will allow them a greater capacity to adapt or assimilate the changes in production that the project will bring about, and are readier to work in groups and more inclined to share knowledge with others.
- Farmers with different extensions of agricultural land and with different uses of land from the production of grains and vegetables to larger extensions.
- Farmers willing to assimilate new knowledge, with leadership capacity and willing to apply science and technology on their farms and production areas

The macro-region of the Valleys suffers from soil deterioration, especially in the regions with traditional production, which is the result of different pressures and degradation processes with convergent effects, including unsustainable agriculture practices which can lead to reductions of the soil organic matter pools as second order process; also, the reduction of organic matter pools is also a first order process triggered by the effects of rising temperatures (Crowther et al., 2016) as well as other climate changes such as precipitation shifts (Viscarra Rossel el al., 2014) (IPCC, 2019). Climate-resilient practices of agroecological practices and management of agroforestry systems will be implemented, in the context of this project, under activity 3.1.2. Under this activity, the project actions will focus on capacity building on these two topics, described below, and also in more detail under activity 3.1.2

Agroforestry and agroecological management practices aim at building resilient food systems in the Valles Macro-region through farm diversification and building soil fertility with organic matter, achieving equal or even higher yields, as compared to the current conventional practices, which translate into potentially important option for food security and sustainable livelihoods for the rural poor in times of climate change.

The proposal focuses on the transformation of conventional agricultural production into a more sustainable one, that is, to move from the extractive production of the forest, extensive and/or monoculture, towards production with sustainable management of resources: semi-intensive, diversified in species and planned from annual and perennial crops. Sustainable Agroforestry practices (SAFs) contribute to the political, economic and cultural strengthening of small farmers and indigenous peoples. In this perspective, SAFs are seen as an alternative to the current agricultural production system because, apart from improving income from the sale of products, they represented more significant potential to improve food security and the social situation of farming and indigenous families. (Soliz & Aguilar, 2005 in CIPCA, 2015). SAFs are an interesting economic alternative: they require a low initial investment, and are compatible with other productive activities such as semi-intensive livestock, to generate higher income and improve food security.

Agroecological practices

Agroecological practices include land management practice that supports the recovery of productivity from degraded soils. Degraded and eroded soils represent a critical environmental hazard, due to the threat to agricultural production sustainability and due to the multiple local and regional externalities (Cotler et al., 2011). Studies carried out in Mexico estimated that the cost of soil loss caused by erosion is in the range of US $. 16.2 to US $ 32.4 / ha while the replacement cost of lost nutrients amounts to US $ 22.1 / ha (Cotler et al., 2011).

In the Valleys Macro-region of Bolivia, ecological production has various techniques, including Andean agroforestry systems, such as in Tapacarí, Sipe Sipe and Pojo. The basis is the improvement of soils and their fertilization with different practices of organic fertilizers, rotation and association of crops as well as the construction of terraces of slow formation. Family irrigation is applied in small plots to diversify production, both for self-consumption and to have marketing alternatives (MDRyT, 2018).

Output 1.2 Increased market access of climate resilient agricultural products

Total GCF budget; USD 4.3 M, to be executed by FAO. Total of 4,947 direct beneficiaries, 2,572 males and 2,375 females.

The project proposes an approach to food production that can improve productivity, increase resilience to climate change through a number options for climate resilient management of agricultural systems. In this sense, this output will aim at generating capacities among rural small producers and strengthening community and associative productive enterprises by supporting access to markets to ensure sustainability beyond the scope of the project, and identifying opportunities for productive diversification as an adaptation strategy and as an alternative income generation source to ensure sustainability of project investments.

Lastly, under Activity 1.2.3. the project promotes economic diversification by identifying high-value products that have the potential to provide producers with new alternatives that complement their economic income. In this regard, beekeeping is defined as the targeted value chain that can complement smallholder’s income, to support the investment in climate technologies under this Component and the climate proofing of irrigation systems in other Components of the project, serving as enablers for the sustainability of adaptation measures implemented under the project.

Besides training, specific activities will be carried out in a participatory manner, to support market access and development, and to set up community and associative productive enterprises that encourage implementation of climate-resilient agriculture. Together, these activities will include obtaining market opening instruments, such as supporting farmers (technical assistance) to promote the certification to agroecological and/or organic products through the national seal, or others provided by third party certification entities; organization of, participation in and promotion of local and national fairs for agroecological and/or organic products; opening markets for food production from agroecological climate-resilient management; development and implementation of an incubation methodology for community and associative productive enterprises; and, as mentioned previously, technical and financial assistance productive enterprises and climate-resilient agricultural management.

- **Activity 1.2.1.** Development and implementation of community and associative productive enterprises. Direct beneficiaries 4,000 of which 2,080 males and 1,920 females.
- **Activity 1.2.2.** Technical support and implementation of collection and marketing centers for agroecological products. Direct beneficiaries 4,000 of which 2,080 males and 1,920 females.
- **Activity 1.2.3**. Promoting climate resilient value chain for livelihood diversification according to the prioritized region. Direct beneficiaries 947 of which 492 males and 455 females.

Activity 1.2.1. Development and implementation of community and associative productive enterprises

This activity will provide capacities and know-how of communities and associative productive enterprises by putting in place enabling environments and required information to allow vulnerable populations to improve access to markets.

Sub-activities:

- Facilitate the process and provide technical assistance in organic certification and/or agroecological certification of agricultural, beekeeping, and other products
- Improve the supply of agricultural products by facilitating market access for agroecological products by organizing fairs and constructing new markets for the marketing and retail of agricultural products

Deliverables:

- At least 120 producer associations (at least 40 led by women) that have received training and technical assistance for the organic certification process
- Organize at least 5 local and 4 national fairs to promote and market products, ensuring the participation of women and young people
- At least 3 markets (national and local) for marketing agroecological products have been identified and opened.

Description:

Ecological production offers a system that can reduce environmental impacts compared to conventional production. Increased conversion to organic agriculture can contribute increasing resilience by enhancing ecosystems functions and services, also bringing important co-benefits, such as conserving stored soil carbon, maintaining or improving biodiversity on farmland, conserving soil fertility, reducing eutrophication and water pollution, and improving food security and farmers' sovereignty (IFOAM EU, 2017). One way to add value to agricultural products and introduce them into increasingly demanding markets is to offer products with organic certification and/or ecological certification. In this regard, the project will promote the certifications of agricultural products as a means to increase market value and gain access to organic markets. Participation in national fairs is indispensable for the promotion and marketing of products. Certified organic products cater for higher income options for farmers and, therefore serve as promoters for climate-friendly farming practices (Scialabba & Müler-Lindenlauf, 2010).

- Organization of 5 local and 4 national fairs to promote and market the organic production, ensuring the presence of women and young people. Fairs are an essential space to promote products and get customers as currently there are scarce spaces to showcase and market agricultural products of organic production, but they have shown effectiveness in their results.

Smallholder farmers will receive training through the producers´organizations to improve their access to markets for climate-resilient products and matters related to financial management of their farms to reduce economic and climatic vulnerabilities of smallholders. The training will focus on the following topics:
- Quality improvement and presentation
- Organizing volume aggregation and timing of marketing.
- The use of digital technologies to organize and overcome logistical challenges regarding storage and transport of produce, as well as to use market information to determine timing of market entry.
- Basic business development to ensure adequate planning and management of production and marketing operations, as well as potential value-addition activities. As part of business development, farmers will learn how to apply for and manage production credit, including accounting, repayment schedules, and other aspects.

Smallholder farmers have technical limitations for designing pre-investment projects and for managing funds for implementation. It is important to both support the preparation of business plans as a non-financial incentive and finance ventures that demonstrate environmental, financial and social viability. At least 30% of the beneficiaries are women and 10% are young people. Women and youth are included as beneficiaries in productive ventures because they are highly vulnerable population segments to cope with climate change.

Beneficiaries:
At least 120 producer associations (at least 40 led by women) that have received training and technical assistance for the organic certification process. A total of 4,000 farmers from productive smallholder organizations will be trained in the context of this activity, in this regard, the selection of farmers and smallholder organizations to benefit from trainings under this activity will be conducted according to the following criteria:

Table 42 Selection criteria for beneficiaries under activity 1.2.1.

Type of Beneficiary	Selection Criteria

Farmers	✓ Farmers most threatened by the impacts of climate change ✓ ✓ Farmers with different extensions of agricultural land and with different uses of land from the production of grains and vegetables to larger extensions. ✓ Farmers living in communities most affected by poverty. ✓ Farmers willing to assimilate new knowledge, with leadership capacity and willing to apply science and technology on their farms and production areas. ✓ Farmers who have interest in/have implemented agroecological and sustainable production practices in the past and are ready to scale up these transformative practices in their plots ✓ Farmers who can provide an in-kind contribution (like labor).
Producers Organizations	✓ Organizations have at least 4 years of active existence at the start of the project and whose members will benefit from the activities in output 1.1 ✓ Organizations must be assessed as possessing the potential capacity to sustain the implementation of the new productive modules as a viable enterprise beyond the duration of the project. ✓ Taken into account the singularities of the economics conditions in Bolivia Organizations must have financial independence to manage their financial resources including bank accounts to deposit their incomes. ✓ Identified organizations will be invited to nominate staff to participate in the activities based on the alignment between the contents of the proposed activity (e.g. technical focus of the training) and the respective beneficiaries' responsibilities and expertise within their organization. ✓ Gender balance prioritizing women and young people (over 18 years old according to Bolivian regulations)

Activity 1.2.2. Technical support and implementation of collection and marketing centers for agroecological products.

This activity aims to strengthen community-based and associative productive ventures related to resilient agroecological management within the framework of the consolidation or implementation of centers for the collection, processing and marketing of agroecological products.

Sub-activities:

- Construction of four collection and marketing centers
- Implement entrepreneurship incubator for community-based and associative productive ventures.
- Technical assistance and implementation of centers for the collection, processing and marketing of agroecological products

Areas of intervention: Municipalities of Tarija and Chuquisaca. Municipalities with the potential to collect fruit / vegetables and better feasibility to obtain a better price, facilitate their transportation and marketing.

Municipalities with the greatest potential for vegetable production: Chuquisaca (Alcalá, Azurduy, El Villar, Padilla, Sopachui, Tarvita, Tomina, Villa Serrano); Cochabamba (Aiquile, Mizque, Omereque, Pocona, Pojo, Totora, Vacas, Vila Vila); Santa Cruz (Comarapa, Mairana, Pampa Grande, Quirusillas, Saipina, Samaipata, Vallegrande).

Deliverables:

- 4 collection and marketing centers built for agroecological products
- One (1) incubation methodology implemented and 120 community-based productive ventures, at least 40 of which led by women and 20 led by young people, designed for implementation.
- At least 24 community-based and associative productive ventures, involving women and young people, receive technical and financial assistance.

The final selection of beneficiaries for the deliverables are based on the following criteria:

i) Areas close to urban and/or peri-urban centers with high potential for the consolidation and/or development of local markets for family farmers.

ii) Areas with high demand for products for basic food supply

iii) Areas where local governments and/or producer associations show plans for technical and/or financial counterpart (PTDI, private investment, etc.)

Description:

Within the intervention framework of the program "Strengthening the Community Social Economy through Integrated and Sustainable Management of the Amazon Forest", whose main objective is to strengthen and diversify the family economy through the use of forest resources by providing added value in a progressive manner in the transformation processes and finally direct these products to significant markets in the value chain.

To this end, PGISBA, through FAO, applies the Community Productive Business Incubation approach based on the MA&D methodology, with the aim of empowering the direct actors of the community social economy in processes of design, planning and development of enterprises linked to the integrated and sustainable management of the forest, biodiversity and family agriculture.

The GISBA Program has developed this Guide for the Incubation of Community Productive Ventures with the purpose of providing a series of tools to facilitate the process of building the Community Social Economy (SE) Venture plan with the active participation of the stakeholders related to the territorial productive complexes for the Bolivian Amazon, as well as the concurrence of the institutional allies to be identified.

Under this methodology, the RECEM Valles Project plans to strengthen the capacity of producers through the implementation or strengthening of community-based productive enterprises that contribute to food security and poverty reduction.

1. The construction of four collection and marketing centers.

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Among the benefits of the collection centres are that they generate information on the products offered and establish price ranges for the basic family basket's different products. Also, they offer the producer a commercialization space for their products, promote new relationships and commercial articulation networks. Complementary to the current systems in operation, promote a diversified and standardized offer of food to benefit the citizens and allow the application of regulations and public standards of quality and safety. There are also environmental benefits because they extend the lifetime of some foods, reduce the carbon footprint and the emission of greenhouse gases linked to the transport of food, and enable innovations for the use of spoiled food and organic waste (Municipal Committee of Food Safety of La Paz, 2016).

The approach consists of the construction of centers, where the direct marketing of products is carried out. In this case, as a requirement of operation, the Manager of the Collection Center commercializes directly with local and regional producers. Inside the sheds, it occupies a preferential space. Likewise, wholesale marketing is also possible, which occurs in secondary areas, where merchants carry out transactions similar to traditional markets. The Collection Center Administrator determines the spaces where merchants can operate, dividing their locations according to the type of product sold and not according to its origin. In many cases, traders are also producers (Municipal Committee for Food Safety of La Paz, 2016).
The Collection and Marketing Centers have the following purposes:
- establishing a community space where small producers and producers from peasant and indigenous communities can sell their products directly "from the producer to the consumer" at a fair price.
- must meet the minimum conditions to be able to provide a freezing and refrigeration service, in order to maintain and prolong the shelf life of perishable products, which are often marketed for lack of this space at prices that do not allow the generation of surpluses and reinvestment for the new production cycle.

The Collection and Marketing Centers will be built in agreement with the municipalities in which their establishment will be prioritized. In this sense, their management must establish the collection of fees, which will be supervised and managed at the municipality level. Community productive enterprises are groups of associated natural persons who, within the framework of the legal personality of the community or a specific legal personality.

The GISBA Program (Gestion Central y Sostentable del Bosque, or the Central and sustainable management center for the forest) has developed a guide for the Incubation of Community Productive Ventures with the purpose of providing a series of tools to facilitate the process of building the Community Social Economy Venture plan with the active participation of the stakeholders. Under this methodology, the RECEM Valles Project plans to strengthen the capacity of producers through the implementation or strengthening of community-based productive enterprises that contribute to food security and poverty reduction.

In Bolivia, around 30% of production is lost due to poor transportation, storage and handling systems. Storage centres with refrigeration and good production management could help farmers in the conservation of these perishable and seasonal products, which would also achieve a constant supply and stable prices, for both producers and consumers.[148] The project has assessed the feasibility of such investment considering tomato production at the plot or farm level. There are organic tomato production initiatives in the country; such is the case of the municipality of Omereque (Department of Cochabamba),

[148] http://www.opinion.com.bo/opinion/articulos/2012/0219/noticias.php?id=44588

considered the "factory" of tomatoes.[149] In Omereque, like other areas of the central valleys of Cochabamba, tomato cultivation is the primary source of economic income for local producers. In Santa Cruz's valleys, the cultivation of organic vegetables is also increasingly promoted to reduce the use of agrochemicals.[150] In the Valleys Macro-region of Bolivia, the tomato is among the four vegetables with the largest cultivated area, with approximately 2,259. Being the departments of Cochabamba and Santa Cruz, the most important.

2. Implement entrepreneurship incubator for community-based and associative productive ventures
3. Technical assistance and implementation of centers for the collection, processing and marketing of agroecological products.

These 2 actions will be implemented in the framework of the program "Strengthening the Community Social Economy through Integrated and Sustainable Management of the Amazon Forest", whose main objective is to strengthen and diversify the family economy through the use of forest resources by providing added value in a progressive manner in the transformation processes and finally direct these products to significant markets in the value chain.

To this end, PGISBA, through the Food and Agriculture Organization of the United Nations, applies the Community Productive Business Incubation approach based on the AyDM methodology, with the aim of empowering the direct actors of the community social economy in processes of design, planning and development of enterprises linked to the integrated and sustainable management of the forest, biodiversity and family agriculture.

The GISBA Program has developed this Guide for the Incubation of Community Productive Ventures with the purpose of providing a series of tools to facilitate the process of building the Community Social Economy (SE) Venture plan with the active participation of the stakeholders related to the territorial productive complexes for the Bolivian Amazon, as well as the concurrence of the institutional allies to be identified. Under this methodology, the RECEM Valles Project plans to strengthen the capacity of producers through the implementation or strengthening of community-based productive enterprises that contribute to food security and poverty reduction.

Background

In 2006, a new productive model was born in Bolivia based on industrialization and the strengthening of small community-based producers, with the purpose of promoting production, transformation and commercialization processes of the Bolivian natural heritage, from the family unit, the community and producer associations, in strategic alliance with autonomous territorial entities and the national government within the framework of current programs and projects.

Against this background, in 2016, within the framework of the Social Economic Development Plan 2016 - 2020, priority is given to the implementation of actions that give greater force to the consolidation of the new Productive Community Social Economic Model, in order to ensure that in the future this model will sustain the economy of the country and its population. In this sense, priority is given to re-launching the

[149] http://www.opinion.com.bo/opinion/articulos/2014/1116/noticias.php?id=145191
[150] https://www.eldia.com.bo/index.php?cat=357&pla=3&id_articulo=185568

vision of productive sovereignty with diversification, which includes: i) the strengthening of productive diversification within the framework of the plural economy with a clear orientation towards the incorporation of greater value added; ii) the promotion of knowledge, creative and sustainable economies beyond the use and transformation of natural resources; and iii) the incorporation of products made in Bolivia in the domestic market, replacing imports and in the international market, with high quality national products.

In this understanding and in order to provide an impulse to the the country's economy, the National Government of the Plurinational State of Bolivia instituted the implementation of productive complexes, with the objective to advance in a process of integration of productive and transformation initiatives, within the framework of macro-regional articulation processes through the implementation of Strategic Industrial and Territorial productive complexes.

The Strategic Production Complexes are conceptualized as those production processes focused on strategic natural resources (hydrocarbons, mining, energy), articulated with their respective displacements related to industries derived from lithium, petrochemicals, metallurgy; While in the case of the Territorial Productive Complexes, it is established that these are the generators of income and jobs from the strengthening of production processes, transformation and commercialization of agricultural products, forestry, tourism, manufacturing industry and handicrafts, among others. In accordance with these policy guidelines and goals of the PDES, the Program to Strengthen the Community Social Economy of the Ministry of Environment and Water, in collaboration with FAO and the Italian Cooperation, have prioritized as goals of its objective 2, the strengthening of community productive enterprises through the application of an incubation methodology, This will make it possible to contribute to the goals and results in integrated forest and biodiversity management, as well as to initiate transformation and commercialization processes that will make it possible to improve family income and develop management models linked to transformation and commercialization processes in fair and inclusive markets.

Legal basis

The legal framework on which the Guide for the Incubation of Community Productive Enterprises and the development of strengthening actions in production, transformation, commercialization and consumption processes is based is the following:

- The Political Constitution of the State in its articles 9 numeral 6, 30 paragraph II numeral 17, 47 paragraph I, 52, 55, 342, 342, 346, 348, 349, 386, 388, 391, 392, 406, 407 and 408.
- Law 144 of the Community Agricultural and Livestock Production Revolution in its articles 8, 9, 17, 18, 19, 49 and 56.
- Law 338 on Peasant and Indigenous Indigenous Economic Organizations - OECAs and Community Economic Organizations - OECOM for the Integration of Sustainable Family Agriculture and Food Sovereignty in its articles 2, 3, 5, 10, 11, 13, 14, 15, 19, 21, 25, 32, 33 and 37.
- Law No. 300 Framework of Mother Earth and Integral Development for Living Well in its article 54 and following.

Purpose of the process and incubation

Contribute to the strengthening of the organizational, technical and economic capacities of associations of producers and/or indigenous native peasant communities of the community social economy, with the purpose of improving their productive practices in the field, complemented by processes of technical and financial assistance in transformation and commercialization, as well as the promotion of consumption at local, regional and national level of products with high nutritional value coming from family agriculture.

Description of the methodology

The purpose of the methodology for incubating community productive initiatives is to characterize and identify the indigenous and rural communities and/or associations of producers of the community social economy that will be beneficiaries of technical, financial, social, cultural and environmental capacity building processes aimed at improving the processes of production, transformation, marketing and consumption of forest products, biodiversity and family agriculture.

In this sense, one of the first actions to be developed in the process of identifying productive family and community-based enterprises refers to the description of the legal situation of the entrepreneurial group related to their agrarian property rights, rights of integrated management of forests and other biodiversity products. Additionally, the existence of a first or second degree association will be verified.

In a second stage, the productive potential of the community and/or association of producers will be identified, which due to the biophysical characteristics of the valleys, will be closely linked to family subsistence agriculture, the conservation of water sources and the implementation of irrigation systems, thermal blankets, anti-hail nets, among other technologies that can mitigate the impacts of extreme climatic phenomena. This space will be used to establish production volumes and future visions related to the progressive increase of added value and/or the strengthening of ongoing processing systems to guarantee a high quality product.

Third, market niches will be established and marketing strategies developed to ensure the constant sale of products at fair prices in inclusive local, departmental, national and international markets.
Fourth, the incubated Community Productive Venture Plan document will be shared with the members of the community and/or producers' association so that it can be approved and validated in its analysis of strengths, opportunities, weaknesses and threats, as well as the implementation of production, transformation and marketing strategies.

Activity 1.2.3. Promoting climate resilient value chain for livelihood diversification according to the prioritized region

This ahis activity will promote the economic diversification in the context of increasing resilience to climate change. In this regard, an alternative value chain is proposed, which is beekeeping.

Sub-activities:

- Implement the actions for the strengthening of the beekeeping

- Technical assistance to promote beekeeping not only for honey production, but also for the promotion of pollinators.

Potential areas of intervention: Municipalities with a larger area of forests that provide more favorable conditions for beekeeping (23): Chuquisaca Centro Mancomunidad (Alcalá, Azurduy, El Villar, Padilla, Sopachui, Tarvita, Tomina, Villa Serrano); Southern Cone Commonwealth (Aiquile, Mizque, Omereque, Pocona, Pojo, Totora, Vacas, Vila Vila); Valles Cruceños Association (Comarapa, Mairana, Pampa Grande, Quirusillas, Saipina, Samaipata, Vallegrande).

Deliverables:

- 20 associations of honey producers, both men and women, at the local level
- 3 regional associations have been strengthened in production, marketing processes and pollinator conservation

Description:

Beekeeping in Bolivia is considered an important basis for food production and forest renewal. The importance of bees in the world's ecosystems, as one of the fundamental pollinators for the conservation of biodiversity and life in general, is recognized in several countries that even protect them by law and promote their conservation and breeding, in addition to providing us with an important food of exceptional properties "honey". The main problems reported by beekeepers in the Valles Macroregion were the lack of specialized professional technical assistance, lack of credit to increase the number of hives, lack of stable markets to monetize artisanal production.

In this sense, it is proposed to promote honey production in the municipalities or zones in the project's intervention area that are most important for their environmental functions, such as municipalities with forests.

Justification of the intervention with beekeeping: Beekeeping is an activity that is gradually growing in the country, especially in the departments of interest for the Project. The Department of Cochabamba is the largest honey producer in the country and in the Valleys Macroregion of Bolivia. In 2015, it was estimated that there were 61,466 hives in the hands of 10,484 producers, with between 6 and 15 hives managed by each beekeeper.

It is particularly relevant to highlight, that the production of honey is compatible with the conservation of forests. Some interesting information about beekeeping is that 2,500 bees are needed to gather a kilo of honey. Each worker will make between 10 and 15 daily flights, flying between 40 and 100 kilometers per day, at a maximum speed of 25 km / h, for at least 21 days.[151] The social and environmental impact is positive with beekeeping because it generates economic income and improves social conditions and raises beekeepers' self-esteem, especially when it comes to women, managing to develop their skills and abilities (Miranda, 2013). Unlike traditional crops, Beekeeping production does not require intensive care, so the beneficiaries will appropriate this activity to include it in their Andean subsistence logic (Miranda, 2013).

[151] https://ecocolmena.com/tag/cuanto-vuela-una-abeja/

It is crucial to promote beekeeping hand in hand with technical training. That is why the project seeks to achieve both aspects. The training process of the technical career of beekeepers (2 years), which is proposed would be developed taking into account technical feasibility conditions, such as: beekeeping, climate, water availability, commitment to participate by the individual in the training process and make counterpart investments for the implementation of the productive unit. The implemented productive unit is expected to include at least 30 populated hives and in production. The training will be parallel to the implementation of the honey production units.

According to the result of the financial evaluation for honey, in ten years (the timeline considered for the assessment) the producer will have a higher income than costs with the intervention.

A total of 947 farmers (464 male and 483 female) will benefit from this activity and will receive training. The selection of these smallholder farmers will be conducted according to the following criteria:

i) Associations of producers located in areas with very high and high vulnerability to extreme phenomena (frosts, hailstorms, droughts).
ii) Associations of producerslocated in areas with a high incidence of degradation and/or desertification in adjacent areas
iii) Associations of producers with possibilities of counterpart in-kind and/or financial resources.
iv) Gender balance prioritizing women and young people (over 18 years old according to Bolivian regulations)

Component 2: Smallholder water resources secured to reduce the risks from droughts and low rainfall

Component 2 aims to develop and implement resilient irrigation technologies for efficient use of water and counteract the water deficit as a consequence of the effects of climate change. Activities under this Component will result in revitalized and modernized irrigation systems that are resilient to climate variability to reduce the risks of droughts and low rainfall. To produce the best results to increase resilience, this Component complements Component 1, since in Component 1 there is the inclusion of the provision of technologies such as solar tents, anti-hail nets, whilst in Component 3, agroforestry and agroecological practices will be implemented. Performed together, these Components will increase resilience of farmers to cope with climate change impacts.

Goal: In five years, it is planned to revitalize and implement technified and resilient irrigation systems on at least **4,448 hectares**, in order to optimize the efficient use of water, reduce the risks of droughts and low rainfall generated by the effects of climate change.

Two main outputs are proposed under this Component:

- **Output 2.1** Enhanced and modernized on-farm climate-proofed irrigation systems

1. **Output 2.2** Strengthened capacities for the management of on-farm climate-proofed irrigation

Output 2.1 Enhanced and modernized on-farm climate-proofed irrigation systems

Total GCF budget; USD 5.1 M, to be executed by FAO.
Total co-financing budget from MMAyA: 20.5 M, to be executed by MMAyA (only applicable to activity 2.1.1).
Total number of direct beneficiaries 58,000 of which 30,160 males and 27,840 females. The direct beneficiaries with GCF financing is 24,896 of which 12,946 males and 11,950 females whilst the direct beneficiaries with MMAyA contribution are 33,104 in total of which 17,214 males and 15,890 females.

Output 2.1 aims to implement small-scale irrigation infrastructure and technologies such as community reservoirs and family water tanks in municipalities with a high and very high risk of drought, water will be available during periods of drought and production losses will be avoided. As has been mentioned, there is an institutional and normative limitation to MiRiego to provide on-farm irrigation. Law 1178 on Government Control and Administration forbids public transfers of technologies, inputs and services to private entities or people. To address this limitation and gap resulting from the scope of work of MiRiego, the project will fund small scale and climate-proofing on-farm irrigation

“Small scale technologies for water use efficiency” refers to drip and sprinkler irrigation technologies, lining of irrigation canals and improved storage to reduce seepage and other losses. These technologies are easy and cheap to adopt and operate and maintain at both individual and organizational levels. Costs associated with communal systems will be equitably apportioned to the water users. Co-financing for the dissemination of these technologies will be confirmed during project development. Where feasible i.e. where social, ecological and economic conditions permit, private sector investors may invest in equipping smallholder partners with these technologies. Credit will also be considered in this light.

Only applicable to activity 2.1.1: Complementarily, revitalization of existing irrigation systems (until the hydrant) will be co-financed with Bolivian public resources from MMAyA, while GCF financing will support small-scale technologies for water use efficiency, that are intended to connect individual water users to the irrigation network. Such small-scale technologies (e.g. drip and sprinkler irrigation technologies, lining of irrigation canals, and improved storage to reduce seepage and other losses) have multiples advantages: easily accessible due to their availability and costs (including O&M costs), adapt to different productions systems, and do not require or depend on specialized technical knowledge. These characteristics facilitate adoption and even ownership of small-scale technologies at individual and organizational levels.

Furthermore, an inventory of irrigation systems from 2012 is currently available for the country. It is important to update the inventory, taking into account the major investments made by the Central Government to date and those scheduled to be carried out as set out in the PDES. This will be a baseline for decision-making on new investments in irrigation and the revitalization of existing systems.

Revitalizing irrigation systems and making them resilient to climate change by implementing modern systems will ensure efficient water use. On average, 90% of the irrigation systems in the Bolivian macro-region of the Valleys is based on gravity-fed irrigation or flood irrigation, i.e. entailing excessive water use. Technification will enhance the efficient use of water. Low yields and poor market access have made it difficult if not impossible for smallholders to generate sufficient income or access affordable credits to invest in technological innovations for climate-proofing of their irrigation systems. To address this limitation, the project with contribute with two complementary approaches. On one hand, by supporting and implementing income-generation activities (e.g., organization of fairs, facilitating access to markets, and setting up Community and associative productive enterprises, as described in Output 1). On the other, by contributing and lobbying to set up financial mechanisms adapted and accessible to smallholder farmers (Output 4).

The MiRiego program focuses almost exclusively on the construction of irrigation infrastructure (gray infrastructure) and builds this infrastructure without considering climate change projections for rainfall variability and extreme events. Construction also occurs without considering the climate effects on the hydrological cycle in watersheds feeding irrigation systems. Irrigation infrastructure may be susceptible to siltation, flooding or damage as a result. Revitalizing irrigation systems and climate proofing them by implementing new systems that already consider climate risks will reduce the smallholders' losses due to climate change effects such as longer periods of drought and scarce rainfall. The loss of production, which is the pillar of the household economy, will be avoided, earning income and ensuring the families' food sovereignty.

A total of 4,448 ha will possess greater resilience to rainfall variability as a result of climate-proofing irrigation systems.

<u>Areas of intervention:</u> Municipalities under very high and high risk of drought: Aiquile, Anzaldo, Tacopaya, Arque, Vitiche, Tapacarí, Puna, Poroma, Tacobamba, Mizque, Cotagaita, Alcalá, Capinota, Cochabamba, El Puente, Ocurí, Omereque, Pocona, Pojo, Potosí, Ravelo, San Lucas, Sicaya, Sipesipe, Sucre, Tinguipaya, Tomina, Totora, Tupiza, Vila Vila, Villa Rivero, Villa Serrano, Yamparáez, Yocalla, Yotala, Yunchará.

*W*hile the hectares with revitalized on-farm irrigation systems, through the project activities, is proportionally limited in comparison to the full area that has no access to water, the impact of it will be also in terms of lessons learnt from a climate-proofing irrigation model in the Valleys Macroregion.

These on-farm irrigation systems will facilitate the generation and implementation of climate-resilient agriculture, good water management practices, and lessons learned that will allow the scaling up of this model with other funds and programs and the local governments. Larger areas with on-farm rehabilitated irrigation systems will not be possible to establish due to budgetary limitations within the project. Despite climate-proofing irrigation systems being proposed are comparatively cheaper than other systems, the level of investment required on irrigation systems to improve on-farm water security, represents an important cost per hectare (USD 3,500/ha).

This output includes the following activities:

- **Activity 2.1.1.** Improve and expand the water reservoirs network to optimize water harvesting activities linked to on-farm climate-proofed irrigation systems. Total number of direct beneficiaries are 12,000 of which 6,420 males and 5,760 females (for GCF contribution). For MMAyA contribution (in-kind, co-financing), the direct beneficiaries are 33,104 of which 17,214 males and 15,890 females.
- **Activity 2.1.2.** Update the inventory of irrigation systems implemented, to enable the implementation and revitalization of climate-proofed on-farm irrigation systems. Total number of direct beneficiaries 8,896 of which 4,626 males and 4,270 females.
- **Activity 2.1.3.** Implement, revitalize and technify on-farm climate-proofed irrigation systems. Total number of direct beneficiaries 4,000 of which 2,080 males and 1,920 females.

Activity 2.1.1 Improve and expand the water reservoirs networks to optimize water harvesting activities linked to on-farm climate-proofed irrigation systems

This activity aims to implement water reservoirs to optimize water storage activities linked to resilient irrigation systems is proposed as an intervention. The municipalities in the project intervention area with a very high and high risk of continued drought are prioritized (with water deficit, where water irrigation with surface water is not possible or very limited in dry season).

Sub-activities GCF contribution:
2.1.1. A. Strengthen and implement community and family water reservoirs with geomembrane and/or water tanks to optimize (rain) water harvesting activities linked to resilient irrigation systems. These systems are directly related to connecting individual water users to the irrigation system, whereas MMAyAs contribution is until the hydrant.

Sub-activities MMAyA contribution:
2.1.1.B Improve and strengthen small water reservoirs (Structures with less than half a million cubic meters of reservoir, with a length of less than one kilometer and a crown height of less than 10 meters are considered small) to optimize water storage and water availability. MMAyA will also implement water systems only until the hydrant.
Areas of intervention: Municipalities under very high risk to drought: Aiquile, Anzaldo, Tacopaya, Arque, Vitiche, Tapacarí, Puna, Poroma, Tacobamba, Mizque, Cotagaita Municipalities High Risk to drought (25): Alcalá, Capinota, Cochabamba, El Puente, Ocurí, Omereque, Pocona, Pojo, Potosí, Ravelo, San Lucas, Sicaya, Sipesipe, Sucre, Tinguipaya, Tomina, Totora, Tupiza, Vila Vila, Villa Rivero, Villa Serrano, Yamparáez, Yocalla, Yotala, Yunchará.

Deliverables GCF contribution:
1,000 community reservoirs and 5,000 family water tanks have been implemented in municipalities with a high and very high risk of drought.

The project will provide, as a grant, the above mentioned community reservoirs and family water tanks to the direct beneficiaries, taken into consideration the criteria as mentioned below in Table 43 . The final selection of beneficiaries will be determined after thorough stakeholder consultations, where it will be possible to also agree on more detailed criteria together with the stakeholders.

Description:

Community reservoirs

The construction of water storage systems is proposed, with catchment and adduction through pipes for the catchment, taking advantage of some existing tributaries such as springs and streams. These systems will be implemented according to the needs and conditions of the area, the storage space or area that the beneficiaries have, the amount of rainfall-runoff that can be captured, as well as the amount of water that can be stored, according to the contribution/flow of each water source. Some water storage systems that work and have already been analyzed in a region of Tarija, which is part of the Valleys Macro-region of Bolivia, is constructing excavation cutoffs, ferrocement tanks and reinforced concrete tanks (OTN -PB - GAD Tarija, 2014).

The cutoffs must be lined with polyethylene to avoid losses and provide a longer useful life to the infrastructure, contemplating incorporating all the works that capture water and prevent sedimentation. Ferrocement-type ponds are structures that would function as reservoirs of different capacities; they are built with materials such as concrete and chicken wire of a variable thickness and have much lower infrastructure costs than any storage infrastructure. The reinforced concrete type ponds are structures that will function as large capacity reservoirs, they are built with materials such as concrete and corrugated iron of variable thickness, with intake works such as adduction through pipes for the catchment of slopes, streams and ditches (OTN- PB - GAD Tarija, 2014).

Family water tanks

Rainwater collection systems are empirical techniques that have been developed over time; there is a large variety of techniques adapted to the specific situations in each place. Some examples of water capture techniques that will be used in the project are shown below (García, 2012) (PNUD, 2015)[152].

Collecting rainwater from roofs: as can be seen in Figure 65, rainwater is collected on the roof of a house, shed or building; rainwater that falls on the effective roof area is usually transported in pipes to the discharge or storage area and finally stored in an above-ground, underground or raised concrete, ferroconcrete metal or plastic tank. It is estimated that one millimeter of water that falls on a square meter of roof can collect a liter of water; however, there may be losses of 20% due to splashing and possible losses along the gutters, which reduces the water per millimeter of water that falls on a square meter of roof to 0.8 liters of water. Each tank will collect 20,000 liters.

[152] PNUD. (2015). Cosecha de agua de lluvia para enfrentar la escasez de agua en áreas de secano. Chile: PNUD / García, J. (2012). Sistema de captación y aprovechamiento pluvial para un ecobarrio de la CD de México. México: UNAM.

Figure 65 Rainwater storage structures or reservoirs.

The criteria for selection of technologies and location for implementation under Activity 2.1.1 include:

Table 43 Criteria for selection of beneficiaries for activity 2.1.1

Activity	General criteria	Indicators	Specific criteria	N beneficiaries	Municipality selected
Activity 2.1.1 Improve and expand the water reservoirs network to optimize water harvesting activities linked to on-farm climate-proofed irrigation systems.	Residence within the project Municipalities. High dependence on agriculture and/or natural resources. Small-scale family farmers. Those whose primary source of income depends on agriculture. Vulnerability due to exposure to environmental and climate change risk. Household with 5 or more members. Agrarian property titled by INRA. Manifest willingness to implement	1,000 community reservoirs	Criteria for the selection of the direct beneficiaries for the community reservoirs:	Total of beneficiaries: 8,896 of which 4,626 are males and 4,270 are females	**Municipalities Very High Risk of drought**: Aiquile, Anzaldo, Tacopaya, Arque, Vitiche, Tapacarí, Puna, Poroma, Tacobamba, Mizque, Cotagaita. **Municipalities High Risk of drought**Sipe Sipe, Totora, Yocalla, Villa Rivero, Sicaya, Capinota, Potosí, Alcalá, Yotala, Yamparáez, Tomina, Ocurí, Villa Serrano, Sucre, Omereque, Pocona, San Lucas, Tinquipaya, Pojo, Vila Vila, Tupiza, Ravelo
		5,000 family water tanks	i) Communities in areas with very high risk of drought		

	project management practices. Those who can provide an in-kind contribution (like labor).				

Activity 2.1.2 Update the inventory of irrigation systems implemented, to enable the implementation and revitalization of climate-proofed on-farm irrigation systems

This activity aims to update and complement the water inventory to maintain up to date information for the monitoring of irrigation systems to achieve the interventions' best efficiency and effectiveness. This information will also be necessary to contribute to the implementation of the PTDIs (under activity 4.1.1) but it also contributes to the MMAyA's basin master plans and the PSDI, as well as to SENARI.

Sub-activities:

- Collect updated data on the status of the irrigation systems implemented
- Analyze collected data and develop updated inventory

Deliverables:

1 updated inventory of irrigation systems prepared, published and distributed to sub-national authorities to contribute to PSDIs, PTDIs and other key actors as SENARI.

Activity 2.1.3. Implement and revitalize technified and on-farm climate-proofing irrigation systems.

This activity aims to upgrade the irrigation system to optimize water-harvesting activities in the face of prolonged drought periods. The municipalities in the project intervention area with a very high and high risk of continued drought are prioritized.

Sub-activities:

- Implement solutions for revitalizing of the on-farm irrigation systems including differentiating seasonal and perennial crops.

Deliverables:

- 4,448 farm hectares have been revitalized and/or equipped with technified and resilient irrigation systems.

The direct beneficiaries will be selected using the following criteria:

i) Family farmers living in areas with water deficit as demonstrated in the results of the hydrological balance
ii)Family farmers producing products for basic food supply
iii) Farmers who can provide an in-kind contribution (like labor).
viii) Areas with existing or near future irrigation investments from the government, to improve irrigation systems and food production.

Description:

In this activity, selected agricultural areas will be revitalized and equipped with technified and resilient irrigation systems. The modernization of irrigation, is proposed as an intervention to optimize water harvesting activities linked to a modernized irrigation system. The municipalities or zones in the project intervention area with a very high and high risk of continued drought are prioritized. From a financial point of view, the intervention is feasible, with a positive NPV. According to the global goal established by the project, this intervention is viable since technified irrigation systems are more accessible to smallholders and represent a cost-effective alternative.

Most of the irrigated agriculture in Bolivia (97%) uses flood or gravity irrigation; which, despite being a traditional system, is inefficient in the use of water. In Municipalities with high risks of drought, gravity/flood irrigation is not a viable alternative, and it must move towards modernization. Although, in recent years, technical methods such as sprinkling and dripping have been introduced that, at the national level, do not reach about 9,000 ha (which represents 3% of the irrigated area of the country) (National Irrigation Inventory, 2012). There is also rainfed production, that is, production without any irrigation, taking advantage of water availability during the rainy season. For the municipalities of the Valles Macro-region of Bolivia with a high and very high risk of drought, the largest area of crops maintains production without irrigation, which implies high and very high vulnerability for producers. The following table illustrates as an example, this situation, for the three main products of the Macro-region (corn, wheat and potato).

Table 44 Main crops in the Valleys Macro-region of Bolivia

Crops	Irrigation Area (Ha)	Non Irrigation Area (Ha)	Total Area (Ha)	Irrigation %
Corn	12.894	24.633	37.527	34
Potato	10.869	21.413	32.281	34
Wheat	2.110	22.096	24.206	9
TOTAL (ha)	**25.873**	**68.142**	**94.015**	

Source: INFO SPIE, 2013

For the three main crops in municipalities with a high and very high risk of drought in the Valleys Macro-region of Bolivia, there are around 25,873 hectares with irrigation, and approximately 68,142 ha cultivated rainfed.

According to the testimony of technicians who work with irrigation systems in the study region, the new technical irrigation systems by sprinkling, micro sprinkling and drip, allow increasing agricultural production in the Bolivian territory. Tests were carried out on potatoes and sugar cane, which showed that with these technified systems the use of water is reduced, it contributes to the fertilization of the soils

and improves pest control, in this way, the technified irrigation systems allow to enhance the quality of life of small producers. With technified irrigation, families' income and benefits increase and the appreciation of the labour used in this production (GTZ - PROAGRO UCORE, 2009). Hence, farmers will achieve better yields with an attractive cost-benefit ratio and a guarantee of average duration of the systems of at least ten years.
Increased water efficiency by the farmers for irrigation has shown to be important to tackle water scarcity and food security issues. Water saving irrigation (WSI) can mitigate the negative impact of climate change on water resources available to agriculture and overcome the constraint of water scarcity by reducing water consumption and increasing water productivity whilst at the same time increasing grain production. Sprinkler irrigation is indicated to contribute significantly to increased yield and water use efficiency of winter wheat[153]. In another study, performed in Bolivia, results show that the drip system is flexible and time-saving and can be dosed according to the needs of the crop. The technified irrigation systems maintain the average level of production. In other words, it is possible to produce the same amount as was produced with the flood irrigation, but using less water, less time, and more flexibility and comfort in irrigation tasks[154].

It is important to note that there will be different approaches, depending on the hydrological balance of the area. The results of the hydrological balance can be found in section 7, page 77. Following the results of this hydrological balance, the following technologies and interventions are proposed

- **Drip and sprinkler irrigation technologies** will be promoted to enhance the water efficiency. The water to be used will be solely rainwater, and the technologies as implemented under activity 2.1.1 (building water storage reservoirs) will complement the irrigation practices of drip and sprinkler. Also, the system will be based on gravity, without the requirements of purchasing a pump or connection to the electricity grid.

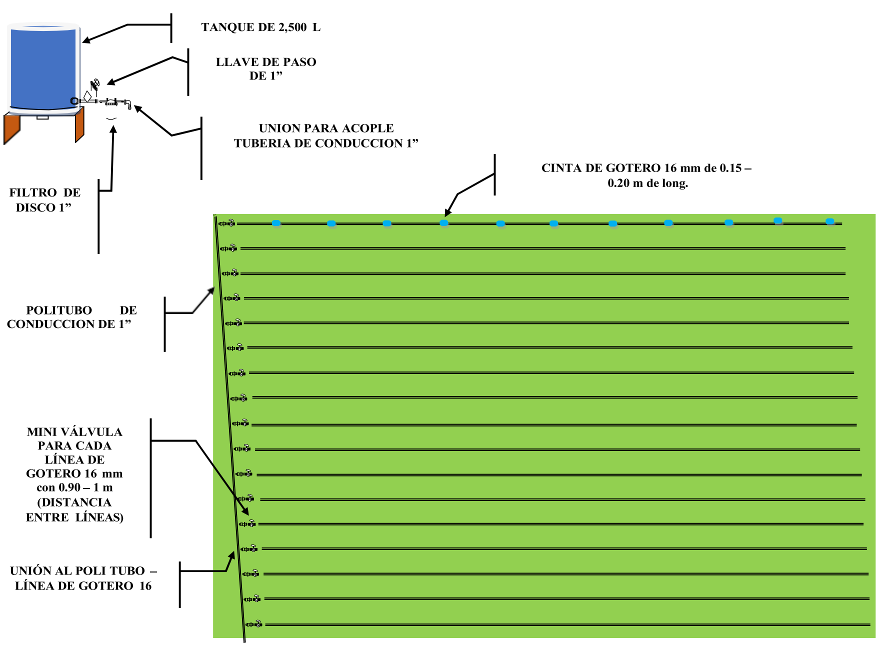
- **Drip irrigation system for using the harvested rain water:** rainwater is collected in a raised tank; when required by the crop, water is released through drip pipes or tapes with small holes located directly at the planting point or very near the plants. The water is only applied to the growing areas, preventing waste and saving a large amount of water through very focused application (Figure 66). Drip irrigation consists of applying water drop by drop, directly to the foot of each plant. The water is carried through plastic pipes or hoses, which are distributed throughout the plot along each furrow. The hoses have small drippers (emitters) through which the water exits. Each plant has its own emitter, which is responsible for maintaining the humidity in the area where the roots grow. These hoses are already manufactured with a determined distance between one dripper and another; the discharge of the emitters fluctuates in the range of 2 to 4 liters/hour per dripper.

[153] ICID: Resources - Irrigation - Irrigation and Environment - Irrigation and Climate Resilience
[154] Escobar Z., Gabriel A. 2018. Impacto de los sistemas de riego y microriego en tres regiones de Bolivia. Estudios de Caso en Valles interandinos, Altiplano y Chaco boliviano Alejandro Gabriel Zegada Escobar; Heber Pastor Araujo Cossío. Cochabamba: Centro de Investigación y Promoción del Campesinado, 2018.

Figure 66 Drip irrigation using captured rainwater.

The water is propelled through the pressure source, then passes through the filter, and circulates under pressure through the conduction pipes and then through the drip tapes (distribution network) until it reaches the emitters or drippers, where the flow and speed are regulated so that the output is drop by drop.

Figure 67 Scheme of drip irrigation system



2. Sprinkler irrigation for using the harvested rain water: Sprinkler irrigation is **a method of applying irrigation water which is similar to natural rainfall**. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. In this system, water is applied in the form of a more or less intense and uniform rain on the plot so that the water infiltrates at the same point where it falls. This methodology requires a distribution network that allows the irrigation water to reach the emitters (sprinklers) with sufficient pressure.

In order to obtain a homogeneous sprinkler irrigation and uniform plant development, there must necessarily be an overlap or overlap between sprinklers. Common or general distances that can be applied with medium pressure sprinklers are in the order of 10 meters by 10 meters, up to 15 meters by 15 meters.

Figure 68 Examples of sprinkler irrigation

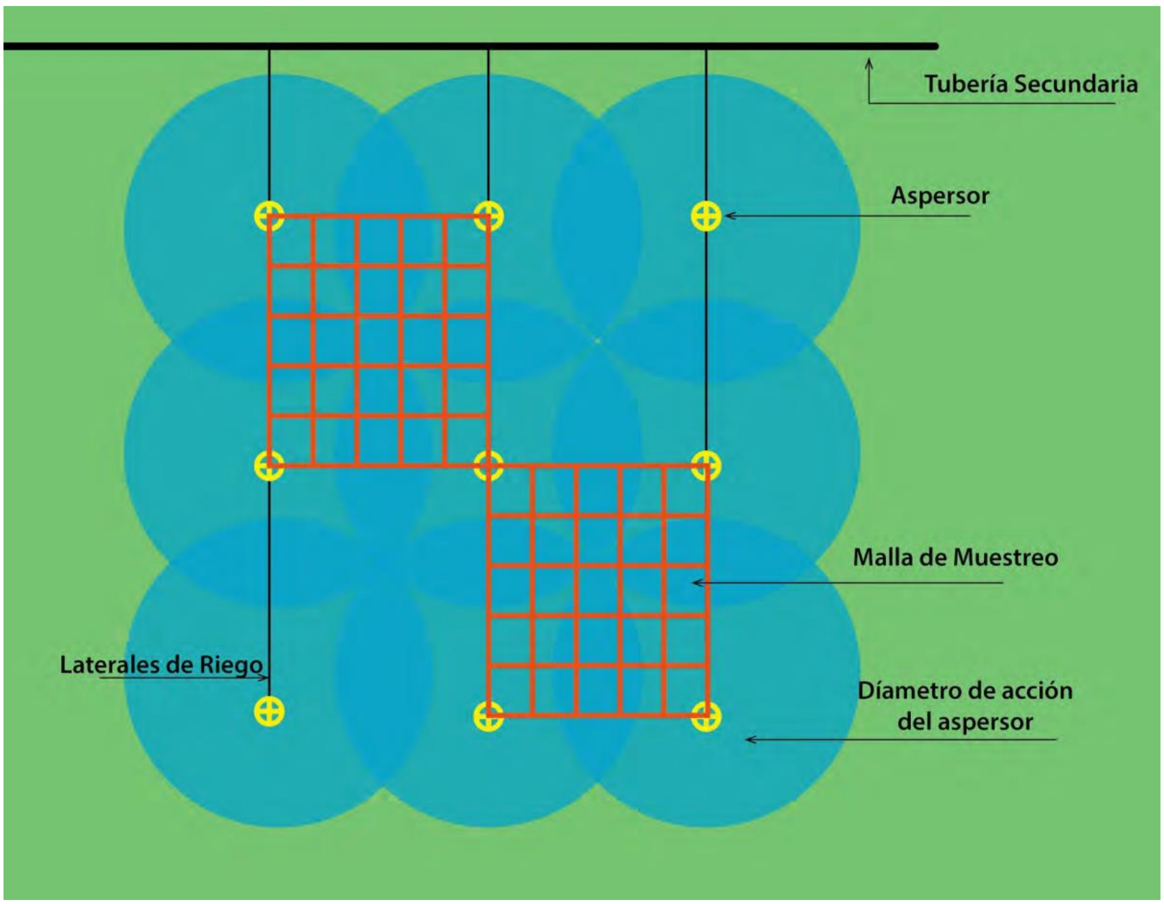


Figure 69 Scheme of sprinkler irrigation

The following figure indicates the type of irrigation most appropriate for the type of agricultural product:

Table 45 Most appropriate irrigation system for key agricultural crops

Type of crop	**Irrigation methodology**	**Frequency of irrigation required**	**Time of irrigation recommended**	**Other aspects to take into consideration**
Root vegetables	Drip irrigation	Approximately 2 – 3 days	1.5 to 2 hours per day	As the crop grows and in high temperature crops, even more irrigation hours per day may be required.
Potato, pea and bean	Riego por goteo /riego por aspersión	Approximately 3 - 4 days	3 hours consistently	• Check the type of soil, for example, if the soil is sandy, the frequency of irrigation will be higher. • Sprinkler irrigation on very steep slopes does not work • slopes does not work properly.
Leafy vegetables	Drip irrigation	1 to 2 times per day generally	Approximately 0.5 hour	Weather circumstances must be considered.
Fruit vegetables (tomato, paprika, strawberry)	Drip irrigation	Approximately 2 – 3 days	Average 1 - 2 hours	• In the case of strawberries, irrigation could be done 2 days a week and for approximately 1 hour. • Sprinkler irrigation is not recommended for tomato, paprika, garlic, onion and watermelon crops, as it causes a lot of loss of ripe fruit due to rotting.
Fruit trees (Peach, Grape, Citrus)	Drip irrigation	2 times a week	Average 4 – 5 hours	• When the plant is small it requires little water, an average of every 6 to 8 days. • When the flower is setting, water should not be lacking and the same during fruit development.
Corn	Drip irrigation	Every 3 days		Corn is a plant with significant water requirements throughout its growing season.

Adaptation practices will be focused on: (a) changing the planting time to ensure that sowing starts in the rainy season and therefore there is no need for irrigation during the sowing season; (b) changing the existing crops to crops with lower water requirements

- Changing the planting time to ensure that sowing starts in the rainy season and therefore there is no need for irrigation during the sowing season; These practices help farmers adapt to climate change. Planting early reduces the risk of crop failure due to drought if the rainy season ends early. It is possible if land-preparation is done early, or if agroecological techniques are used: not ploughing saves time because the farmer does not have to wait until the soil is moist and soft enough for ploughing.

- Changing the existing crops to crops with lower water requirements. This consists of promoting the cultivation of crops that require less water such as beans and maize. And also other drought tolerant species.

  Following is a description of the crop water needs for the major crops in Bolivia and the project area.

Crop	**Crop water need (mm/total growing period)**
Alfalfa	800-1600
Banana	1200-2200
Barley/Oats/Wheat	450-650
Bean	300-500
Cabbage	350-500
Citrus	900-1200
Cotton	700-1300
Maize	500-800
Melon	400-600
Onion	350-550
Peanut	500-700
Pea	350-500
Pepper	600-900
Potato	500-700
Rice (paddy)	450-700
Sorghum/Millet	450-650
Soybean	450-700
Sugarbeet	550-750
Sugarcane	1500-2500
Sunflower	600-1000
Tomato	400-800

Investments in irrigation infrastructure are a solid stepping stone to overcome rural poverty in Bolivia; however, these measures must be continued and inserted within the framework of new challenges: comprehensive water management and sustainable soil management in the basin along with technical assistance for agricultural production and innovation.

The product selected for the financial evaluation is potato cultivation and it was carried out at the plot or farm level. According to the data found for the Project intervention area, potato cultivation is the second most important product for the area, reaching an approximate area of 51,583 ha. It is present in all departments of the intervention area.

The potato, in addition to being important for its commercialization, plays a decisive role in the diet of the producer families. The average yield of potato production per hectare in municipalities with high and very high risk of drought is 7,606 kg / ha.

Climate-proofing management systems under this Component closely relate to Output 1 since climate-resilient farming based on agroecological management will contribute to restore physical-chemical and biological characteristics that determine soil health and soil-related ecosystem functions that, at the same time, ensure adequate soil moisture for dryland farming

Output 2.2 Strengthened capacities for the management of on-farm climate-proofed irrigation

Total GCF budget; USD 1.8 M, to be executed by FAO.
Total co-financing budget from MMAyA: 1 M, to be executed by MMAyA (only for activity 2.2.2) and co-financing budget from FAM is USD 0.2 M (only for activity 2.2.4).
For the GCF contribution, the total direct beneficiaries are 8,896 of which 4,626 males and 4,270 females. For the MMAyA contribution, the total direct beneficiaries are 52,396 of which 27,246 males and 25,150 females. For the FAM contribution, the total direct beneficiaries are 8,896 of which 4,626 males and 4,270 females.

Activities under this output will develop capacities and provide training for the management of climate-resilient irrigation systems, based on experiences and innovative practices, with a comprehensive approach to basins and participatory research and action methodologies.

The technification of traditional irrigation systems must go hand in hand with capacity building for the farmers in the management of irrigation systems. This will be achieved by training community promoters in field schools and training professional technicians at the National School of Irrigation and/or Universities.

The technical capacities acquired by small-scale producers will give them greater opportunities to join the local and/or regional labor market. The municipalities demand local skilled labor to manage irrigation systems, especially now that the PDES provides for state investments in technified irrigation.

This output includes the following key activity:
Activity 2.2.1: Strengthen capacities of key stakeholders (including community promoters, technicians and professionals) to enable locally owned technological innovation processes related to on-farm climate-proofed irrigation systems. Total number of direct beneficiaries 8,896 of which 4,626 males and 4,270 females (only GCF contribution).
Activity 2.2.2: Replicate technological innovation processes related to on-farm climate-proofed irrigation systems to up-scale the knowledge to other communities through the strengthening of capacities of key actors, technicians and professionals in national and subnational levels. Total number of direct

beneficiaries is 52,396 of which 27,246 males and 25,150 females. This activity will be implemented solely with co-financing from MMAyA, for a total of USD 1 M.

Activity 2.2.3: Design an O&M Plan for the irrigation systems including the legal agreements arrangements between MiRiego, Municipalities and the Irrigation Committees. Total number of direct beneficiaries 8,896 of which 4,626 males and 4,270 females.

Activity 2.2.4: Promoting the signature of legal agreements and the O&M plans for the irrigation systems, between MiRiego, Municipalities and the Irrigation Committees. Total number of direct beneficiaries 8,896 of which 4,626 males and 4,270 females. This activity will be implemented solely with co-financing from FAM, for a total of USD 0.2 M.

Activity 2.2.1 Strengthen capacities of key stakeholders (including community promoters, technicians and professionals) to enable locally owned technological innovation processes related to on-farm climate-proofed irrigation systems.

The aim of this activity is to conduct training and strengthening technical capacities in irrigation for community promoters, as an incentive for local producers to effectively adopt and manage climate-proofed irrigation systems.

Sub-activities:

- Design the training curriculum through the Farmer Field Schools
- Conduct stakeholder consultation sessions to design the curriculum
- Conduct regular consultation sessions led by the extension workers
- Conduct training and demonstration field visits to manage the irrigation systems implemented under 2.1.3

Deliverables:

- At least 5 farmer's field schools have trained 448 (30% women and 10% youth) community promoters for the implementation of climate-proofed irrigation systems.
- Through at least 3 strategic alliances between the technical education entities and universities in the project's intervention area, 120 technicians from the National school of irrigation and the universities have updated their knowledge on climate – proofed irrigation systems.

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Description:

The paradigm shifting approach of the project foresees that technification of traditional irrigation systems must go hand in hand with capacity building for the farmers in the management of climate-resilient irrigation systems. This will be achieved by training community promoters in field schools and training professional technicians at the National School of Irrigation and/or Universities.

This activity will target key stakeholders relevant for the implementation of irrigation related activities under the project, training and strengthening technical capacities in irrigation for community promoters, as an incentive for local producers to effectively adopt and manage irrigation systems.

Similarly, the implementation of irrigation systems requires the accompaniment of specialists. The local training of technicians and professionals who provide advice to producers is essential. At the same time, local employment will be generated, reducing the costs of hiring external technicians. It takes advantage of the installed infrastructure and technical capacities with the National School of Irrigation and Universities in the project intervention area.

The training methodology used will be that of Farmer Field Schools (FFS). Training will include information on the impacts of climate change in water resources and agriculture and will aim at providing practical knowledge to enable adaptive capacities in the use of climate-proofed irrigation systems.

The gaps to be overcome by the capacity building under this activity 2.2.1 are the following:
- Deficiencies in concepts, methodologies and use of technological tools for agricultural and rural extension by technical personnel to be incorporated into the programs.
- Insufficient mechanisms and tools to facilitate the transfer of knowledge to producers.
- Little use of local information and communication media, as well as low use of communication networks and ICTs to support the technical assistance and rural extension process.

Through FFS, training will be provided to 448 farmers and community promoters, including 30% of the trained community promoters expected to be women and 10% young people. Similarly, women and young people will receive support to access technical training at the National School of Irrigation and Universities. They will have greater opportunities to join the local labor market. The characteristics that a farmer must have to be a community promoter are: 1) to be a known and respected person in the community, 2) to be an agricultural, forestry or agroforestry producer, 3) to have possession rights over the land on which the agricultural, forestry or agroforestry activity will be implemented, 4) to be able to read and write, 5) to be a leader in the community, 6) to be able to express himself in the local language, and 7) generally to be the head of the family.

Beneficiaries of the trainings must comply with the following basic selection criteria and other more specifics to be defined upon project inception:
i) Areas with very high and high risk of drought;
ii) Areas of family farmers with water deficit as demonstrated in the results of the hydrological balance
iii) Areas of family farmers producing products for basic food supply

120 technicians who will update their knowledge on climate-proofed irrigation systems will be selected based on working in the project area, especially on those areas where interventions will take place in Component 1 and 2.

In this sense, the RECEM Valles Project seeks to improve the capacities of irrigators and field technicians by incorporating climate change mitigation and adaptation measures in irrigation systems and food production, all with the aim of improving yield volumes, family income and responsible management of water consumption, as well as the management of soil resources, biodiversity, forests and/or vegetation cover associated with agricultural production units.

Activity 2.2.2: Replicate technological innovation processes related to on-farm climate-proofed irrigation systems to up-scale the knowledge to other communities through the strengthening of capacities of key actors, technicians and professionals in national and subnational levels.

This activity will be implemented only with co-financing from MMAyA, a total of USD 1 M.
The activity consists of conducting specialized training to promote and strengthen technical capacities of key actors, technicians and professionals in national and subnational levels to replicate knowledge and ownership and scale-up climate-proofed irrigation systems.

Sub-activities:

1. Strengthen capabilities of key actors, technicians and professionals in managing climate change risks and upscaling resilient technified irrigation systems.
2. Conduct specialized trainings and demonstration field visits

Deliverables:

- 5,000 agricultural production units have been trained that represent 52,396 direct beneficiaries

This activity will be focused in areas outside of the intervention areas, as it relates to replicate technologies to other areas outside of the GCF funded intervention
i) Areas with very high and high risk of drought;
ii) Areas of family farmers who are members of irrigation associations.
ii) Areas of family farmers producing products for basic food supply

Activity 2.2.3: Design an O&M Plan for the irrigation systems including the legal agreements arrangements between MiRiego, Municipalities and the Irrigation Committees

This activity aims to ensure the sustainability of the project results with regards to irrigation by promoting to the irrigation committees to develop O&M costs once project is concluded. Therefore, in this activity the content of the plan and the legal document will be designed whilst in activity 2.2.4 these plans will be and the legal agreements signed.

Sub-activities:

- Adapt content of the O&M plans according to each context and organization of the micro region
- Define content of legal agreements.
- Capacity building to implement the O&M Plans

Deliverables:

- 7 O&M plan designed in each micro region
- 1 standard legal agreement written and validated

The following selection criteria exist for the selection of the direct beneficiaries under activity 2.2.3 and 2.2.

i) Areas with existing or future irrigation investments from the government, to improve irrigation systems and food production.

Description:

Under this activity, O&M Plans will be prepared at the level of the municipality, which will not only integrate actions related to irrigation system operations and maintenance, but will also integrate the handling and management of the technologies to be implemented, such as anti-hail nets, thermal blankets, solar tents, etc. The plan's purpose is to ensure the irrigation committees are able to cover O&M costs once project is concluded. Therefore, in this activity the content of the plan and the legal agreement will be designed

All the technologies that will be provided for in the project have different lifespans, and this will be taken into consideration in the design of the O&M plans, depending on which of the technologies will be implemented in which municipalities:

16. Hydrogel in the soil has a lifetime of 8 years
17. Thermal blankets and anti-hail nets have a life span of 10 to 15 years, depending on the quality of the materials they are made of.
18. The lifetime of a solar tent is 10 years, although this depends on the level of solar radiation.
19. Drip irrigation: 10 years
20. Sprinkler irrigation: 7 years

Any operation and maintenance mechanism should be strongly linked to strategic river basins and their respective Basin Management Units and Platforms (the UGC and PdG). The coordination space for channeling the involvement of entities involved in irrigation management and the development of the new models required by the subsector is the Subsectoral Irrigation Roundtable, established under the direction of the MMAyA (Ministry of Environment and Water).

Furthermore, at the level of the farmers, there exists irrigation associations, with a maintenance and operations plan. The project will foresee strengthening of the capacities of the farmers and these associations so the associations are able to fulfill their role as guardians of the operations and maintenance of irrigation works at the level of community, in a timely and sustainable manner.

At the level of municipalities, the municipal budgets will always provide public investment resources for maintenance, in addition to the communal action of obligations in the maintenance of the irrigation systems that the producers and/or irrigation associations have.

WUAs (Water Users Associations): The WUA is a general definition given to users of water for human consumption and users of water for irrigation and food production. Where the WUA is concerned with the management of water for irrigation, these are synonymous with irrigation committees. The Irrigation Committee is an organizational structure formed by the users or irrigators of an irrigation system, created for the purpose of managing the irrigation system, maintaining and administering the infrastructure, conserving and protecting the water sources applied to productive processes of irrigated agriculture.

The irrigation committees usually have between 4 to 5 members. This Committee is headed by the President of the Irrigators' Association and/or Secretary General of the Community, and then gives way to specific portfolios for the management of water resources such as the Water Judge, the Recording Secretary, the Vocal Member and the Secretary of Finance.

Irrigation Committees usually operate at the level of the Irrigation Community or Association. The irrigation system whose management is linked to dams and reservoirs where there is a Water Management Committee with the participation of national and subnational entities, together with the irrigators, to make decisions on the management of water resources. Supreme Decree No. 28819 dated August 2, 2006, establishes in its articles 12 and 13, that the responsibility for the administration of the infrastructure of the irrigation systems is the responsibility of the beneficiary communities or organizations, of course, when the construction of the projects has been completed. Under these considerations, the State at the national level and with the support of the governments and municipalities will transfer the operation of an irrigation system, the administration, management and operation of the infrastructure, to the responsibility of the beneficiary communities or organizations for an indefinite period of time.

In this sense, the adequate routine and preventive maintenance of the infrastructure of the irrigation systems will be the responsibility of the irrigation organizations in charge of its administration. When the maintenance of the infrastructure of irrigation and/or micro-irrigation systems is an emergency or rehabilitation, it will be the shared responsibility of users, governments and municipal governments, with the cooperation of the SEDERI or SENARI, when appropriate. The ETA's in coordination with the VRHR should transfer the administration, operation and maintenance of irrigation projects to the irrigation organizations/communities (beneficiaries), according to current regulations. The Technical Assistance executors (contracted by the UCEP/MMAyA), will develop activities to strengthen the management of water resources for agricultural purposes during the operation phase based on what is defined in the Guide for Accompaniment/Technical Assistance in Irrigation Projects.

The main actions include the following:

a) Conformation and Institutional Consolidation of the Irrigation Organization.

b) Acceptance of the environmental conditions under which the projects are closed by the beneficiaries as well as by the corresponding municipalities.

c) Training of the Irrigation Organization in technical-administrative management.

d) Elaboration of the Operation and Maintenance Plan of the works, training the beneficiary population in preventive and corrective maintenance.

SENARI, through the respective SEDERI, will supervise the monitoring and technical assistance to ensure an effective transfer of knowledge and guarantee the operation and maintenance of the irrigation systems, according to the criteria and procedures established in the se’tor's Reference Guides. The departmental S’DAG's will guarantee the continuity of the productive Technical Assistance in the operation phase of the irrigation systems financed by the Program. The Basin Directorates or similar of the Departmental Governments will carry out protection activities in the basin for the medium and long term in coordination with the Social Organizations that live in the contribution basin.

The resources for operation and maintenance for the irrigation committees come from the municipal or departmental governments, to which are added the voluntary contributions of the irrigators. The definition of contributions is by consensus of an Assembly of Irrigators

Activity 2.2.4: Promoting the signature of legal agreements and the O&M plans for the irrigation systems, between MiRiego, Municipalities and the Irrigation Committees

The purpose for the signature of these agreements is to ensure the commitment for the O&M of the irrigation systems as installed under activity 2.1.1 and 2.1.3 as a requirement before the investment and to monitor the fulfillment of commitments. This activity will be implemented solely with co-financing from FAM, with a budget of USD 0.2 M.

Sub-activities:

1. Signing agreements between municipalities and the Irrigation Committees
2. Monitor the fulfillment of commitments for the signed O&M plans

Deliverables:

- 7 O&M plan signed in each micro region
- 7 Legal agreements signed (per micro region)

The contribution of FAM will be to facilitate the stakeholder engagements necessary to lead to the signature of the legal agreements and the O&M plans, which have been prepared under activity 2.2.3

Component 3: Restored and conserved micro-watersheds and ecosystem functions and services

Rational: Component 3 aims to improve communities and small far'ers' water security, ensuring the sustainability of their climate-resilient livelihoods under the participatory approach of comprehensive management of hydrographic basins.
This Component will facilitate the development of integral micro-watershed management and water use plans to enhance climate change adaptation. This effort will be based on an inventory of water sources and water balances of strategic basins and/or micro-basins as a tool for informed longer-term climate-sensitive planning processes.

Objective of Component 3: As part of the proposed investments under this Component conservation and restoration processes in micro-watersheds will be implemented, aiming to restore soil biodiversity, conserve forests, wetlands and native grasslands with key function to regulate hydrological and carbon storing function, to increase resilience and climate adaptation in the target area.

Goal: of Component 3, in five years the development of practices for the preservation and restoration of environmental functions with a micro-watershed approach for **water security is planned in 17,510 hectares**

Two outputs are proposed:

Output 3.1. Restored and conserved ecosystem management for enhanced climate resilient watersheds

Output 3.2. Information and long-term monitoring system for water sources at place

Output 3.1 Restored and conserved micro-watershed management for enhanced climate resilience

Total GCF budget; USD 3.8 M, to be executed by FAO with co-financing in-kind from MMAyA of USD 6.6 M. The MMAyA contribution is only for activity 3.1.2.

For the GCF contribution, the total direct beneficiaries are 46,531 of which 24,196 males and 22,335 females. For the MMAyA contribution, the total direct beneficiaries are 35,020 of which 18,210 males and 16,810 females.

Activities under this output will implement and develop integral and sustainable water sources management practices to ensure availability in permissible quantity and quality. To this end, both the inventory of water sources in municipalities and water balances in water basing in the target area will provide valuable information for the generation and strengthening of climate-responsive planning processes at local level, focused on conservation, access and use of water resources.

An inventory of water sources in municipalities will provide valuable information to make policies on conservation, access and use of water resources. At the moment, there are conflicts between communities over the use of water for irrigation. Also, the inventory of water sources will be helpful to propose measures for the protection, conservation and recovery of water sources, basin headwaters, water recharge areas and associated ecosystems.

In this sense, the inventory is a tool that helps prioritize and define what water sources require protection, conservation actions, while it can be used also to define the management modality.

Furthermore, the strategy for the conservation of forests, wetlands and native grasslands with a view to climate change adaptation in the Bolivian macro-region of the Valleys is an indispensable tool for managing these ecosystems in light of the environmental functions they perform and the environmental services they provide to rural communities and agricultural producers.

The protection and conservation of wetlands and native grasslands in areas of hydric importance through PNHRs, PAs, enclosures and other mechanisms, are the most efficient ways to ensure the availability of water sources associated with these ecosystems. The complementary agreements signed with producers, indigenous and/or peasant communities for the preservation and restoration of environmental functions will ensure the conservation of at least 70% of the area covered by forests and wetlands.

The 17,510 hectares to be restored are located in the headwaters of the micro-basins. The definition of these hectares was made through the analysis of the existing thematic cartography, prioritizing the areas of greatest degradation and their potential for water recharge. Also, the areas are characterized by not having a water deficit, and therefore sufficient water availability for the proposed agroforestry practices to conserve soil biodiversity and the water recharge functions.
The mountainous complex of the Valles macro region, which constitutes the head of the strategic basins, is in process of degradation of its natural resources, which implies that surface runoff generates significant amounts of eroded soil, which implies the need to recover vegetation cover in the micro-watersheds selected in the project. This will allow a greater water recharge where irrigation systems can have water in good quantity, quality and regulation. The selection process of these hectares to be conserved and restored follows the criteria potential provision to provide various environmental functions (water regulation, organic matter in soils) at the head of the basin and / or water sources, to producers in particular and the local population in general. Likewise, the restoration criteria relate to the prioritization of actions to recover vegetation in degraded areas important for water capture and provision.

In this sense, local authorities (e.g., majors and designated officials from the municipalities included in the project), ministerial officials (e.g. from the Ministry of Environment and Water, and Ministry of Rural Development and Land), and others (e.g. community, smallholders and women representatives) will work with community organizations to identify desirable Components in relation to water, soil and vegetation based on participatory modeling of hydrological dynamics in the watershed. Measures to achieve the desired Components will be identified and discussed, and land use plans developed, including required partnerships, costing and M&E activities. Participatory monitoring of increasing rainfall infiltration and stream flow and reliability of water supply in the irrigation schemes will help convince farmers and the wider communities to adopt and scale up management practices. Community organizations will meet periodically to analyze progress towards watershed Components and adaptive management measures.

Measures to achieve the desired Components will be identified and discussed through processes of development and implementation of a strategy for adaptation to climate change focusing on integral watershed management, and other institutional and governance processes related to Component 4 (i.e., design and implementation of national and sub-national policies and regulations that contribute to the adaptation and mitigation of climate change linked to watershed conservation; support the PTDI design and implementation processes for land use planning and conservation of watershed, among other actions; support at the national and sub-national level in the implementation of Watershed Master Plans in the project intervention area).

The Ministry of Environment and Water will co-finance: i) strengthening and implementation of water reservoirs, ii) conservation of watersheds, iii) restoration and conservation of ecosystems functions and services by developing and implementing of a strategy for adaptation to climate change focusing on integral watershed management system, iv) will prepare an updated the inventory of water sources in the valleys Macro-region, v) monitor ecosystem functions of restores and conserved watersheds, vi) based on the last two ones, to design and implement corrective measure on the irrigation infrastructure built by MiRiego, vii) participate in capacity building activities along the project, viii) support to the local governance processes related to the project, ix) support in the work with the private sector and financial regulatory entities, to develop access to credits and other financial mechanisms adapted to smallholders, and x) support the design and implementation of national and sub-national regulation and policies related to climate change adaptation and mitigation.

Community organizations will be assisted to develop participatory land use plans in targeted micro-watersheds to protect watersheds through soil and water conservation and restoration of forest and other vegetative cover. At watershed level, agroforestry practices and agroecological management practices will be the key activities for integrated biodiversity restoration, conservation and sustainable management. The practices mentioned will solely be using native species. Agroforestry systems will combine fruit trees, native timber species where appropriate, and other functional biodiversity (e.g., native leguminous shrubs and species). The agroecological management of agroforestry systems as well as biodiverse agroecological crop production, will also contribute to wider biodiversity and ecosystem restoration and conservation in productive plots thanks to the ecosystem functions derived from their management, e.g. reduction of soil erosion, water retention, and regulation of pest populations, among others.

The project will not have any direct intervention in protected areas. However, the project will provide capacity building to staff of the General Directorate of Biodiversity, and the National Service of Protected Areas (SERNAP) of the Ministry of Environment and Water, on integral watershed management and monitoring of ecosystem functions and services, under the activities of Component 4 through the activities "Enabling conditions created to implement and upscale climate-resilient agroecological management, climate-informed integral micro-watershed management, and access to financial mechanisms."

This output includes the following activities:
Activity 3.1.1 Development and implementation of integral micro-watershed management and water use plans to enhance climate change adaptation. Total direct beneficiaries is 46,531 of which 24,196 males and 22,335 females with GCF contribution only.
Activity 3.1.2 Implement restoration processes in micro-watersheds, to increase resilience and climate adaptation by enhancing ecosystems functions and services. This activity is to be implemented by both GCF resources as well as MMAyA. Total direct beneficiaries GCF contribution are 22,980 direct beneficiaries of which 11,950 males and 11,030 females. For the MMAyA contribution, there are 35,020 direct beneficiaries of which 18,210 males and 16,810 females.

Activity 3.1.1 Development and implementation of integral micro-watershed management and water use plans to enhance climate change adaptation

The Watershed Master Plans are instruments for planning and integrated watershed management, guiding decisions to solve problems in the watershed. These Plans were prepared with a focus on adaptation to climate change. Its elaboration must be agreed between the different actors and consider the multiple uses of water and other natural resources in the basin. One of the current limitations is the management of financing to implement the proposed solutions. Therefore, the Project seeks to support the implementation of these Plans. This activity aims to improve existing water use plans and implement these plans, which will allow local producers to make responsible water use from source to consumption. This will benefit the strengthening of diversified agricultural production systems and thus will support the resilience of agroecosystems. For the implementation of the water use plans, affected rural landowners, both men and women, will receive technical assistance regarding water use in productive systems.

Sub-activities:

Update and implement the different water use plans (3 levels; regional, municipality, community) through:

1. Update the inventory of water sources in the Valles Macro-region, including subnational and community-based territorial management practices
2. Implement a climate change adaptation strategy with a focus on the conservation of watershed ecosystems, that regulate the hydrological cycle in communal and/or municipal areas that will be used to mainstream climate change in the water use plans

Deliverables:

- An updated inventory of water sources for the municipalities prioritized by the project in the Valles Macro-region.
- A total of 14 water use plans implemented

The updated inventory will be carried out for all the 65 selected municipalities.

Selection criteria for the selection of direct beneficiaries for the implementation of this activity:
i) Areas with Basin Master Plans in design and/or existing plans that have been approved for implementation
ii) Areas with very high and high risk of drought and where project interventions have been implemented in component 2 and 3;

Description:

Watershed management to be implemented and enhanced on different levels and through different existing instruments (plans):

Planning is an essential process for the integrated management of water and natural resources in watersheds and micro-watersheds. One of its objectives is to promote sustainable use, conservation and protection in harmony with the rights of Mother Earth, as well as the maintenance of water quantity and quality availability in the micro-basins. The integrated management of water resources in watersheds is fundamental to understand the importance of water, the role of its users and of the peasant families, in the face of the growing conflict and competition for its use.

Basin Master Plan. It is an instrument for basin management and management at the strategic basin level, which aims to establish strategic guidelines, institutional framework and financial strategy to develop management and recovery projects with participation, social empowerment and joint efforts of the three levels of government; all this also in order to establish solutions to solve the following problems: i) Hydrological and environmental degradation of the upper basins; ii) Overexploitation and loss of natural resources; iii) Deficient land use planning; iv) Degradation and pollution. Strictly speaking, the CDP is a short, medium and long-term guiding and operational instrument that seeks to achieve integration and articulation between the actions of the various autonomous territorial agents present in the basin, with a view to prioritizing and implementing these actions in a coherent manner, in which the biophysical, sectoral and territorial interconnections present in the basin are recognized, making the basin an indivisible planning unit, all in a context of resilience in the face of natural disasters and climate change, ensuring access to water for human consumption and food sovereignty.

Local Water Development Plan is the management instrument for integrated management of water resources at the municipal level, it can include management and management at the level of sub-basins and direct tributaries of strategic basins, all with the purpose of establishing at another scale the supply and risks of medium and long term under climate change scenarios. In addition, this plan will contribute updated information on current and future supply and demand at the Basin Master Plan level.

Local Microbasin Management Plan, prepared and implemented by the Basin Management Organization (OGC), the communities, rural families and water users in general, with the support and endorsement of the municipality. Its purpose is to achieve sustainable water use; promote an increase in water availability and quality; improve soil fertility and productive capacity; increase vegetation cover in the micro-watersheds; and improve the quality of life of families. These actions contribute to the reduction of poverty rates and migratory movements to peri-urban and urban areas. The PGLM reflects the development potential and aspirations of families and communities, in pursuit of the use of water, soil and vegetation. It constitutes a simple, useful and adequate reference instrument that can be developed autonomously by the OGC boards, local leaders. This Plan contributes to the implementation of the Territorial Integral Development Plans (PTDI) at the municipal level, and at the strategic watershed level, with the Watershed Master Plans (PDC) at the departmental and national levels.

Activity 3.1.2 Implement restoration processes in micro-watersheds, to increase resilience and climate adaptation by enhancing ecosystem functions and services.

This activity aims to perform restoration practices for the conservation and restoration of watersheds and their environmental functions. Restoration measures as an intervention to recover water sources and degraded soils. The intervention will consist of the restoration with native species, according to each selected site's ecological and environmental characteristics.

Sub-activities with GCF grant:

3.1.2.A. Implement restoration practices in easements of small farmers and communities of the prioritized agri-food system and implement agroforestry and agroecological management practices for the conservation and restoration of water sources and valley ecosystems.

The contribution of MMAyA will support the following sub-activity:

3.1.2. B. Updated information of forested and reforested areas implemented by MMAyA and upscale the restoration process for the recovery of soil organic matter and environmental functions in areas outside of the scope of the GCF contribution, but still within the project area. Also, MMAyA contribution will aim to implement nurseries for seedlings provision for agroforestry and restoration practices, as well as monitoring the development of the reforested areas.

Areas of intervention: Municipalities in need of improving soil fertility conditions and the state of conservation of agricultural soils (23): Chuquisaca Centro Community (Alcalá, Azurduy, El Villar, Padilla, Sopachui, Tarvita, Tomina, Villa Serrano); Southern Cone Commonwealth (Aiquile, Mizque, Omereque, Pocona, Pojo, Totora, Vacas, Vila Vila); Valles Cruceños Association (Comarapa, Mairana, Pampa Grande, Quirusillas, Saipina, Samaipata, Vallegrande).

Deliverables:

- 17,510 ha under agroecological and/or agroforestry management
- Monitoring report for the restoration activities and conservation water sources and valley ecosystems.

The following criteria will be used for the selection of the direct beneficiaries under this activity:

i) Areas that are located in water recharge areas and/or existence of water sources with priority for those with a local plan such as water use plans and PTDIs
ii) Farmers, who can provide an in-kind contribution (like labor).ii) Presence of family farmers producing products for basic food supply
iii) Areas with high risk of land degradation

Description:

The Project intervention area has an approximate surface of 1,219,444 ha of forests (Geo-Bolivia, 2016), equivalent to 15% of the total project area. The western sector is characterized by scarce forest cover, due to the historical human occupation that has caused the transformation of the landscape and eliminated a large part of the native forests (FAN, 2018). While in the eastern sector of the Project area, which includes the ecoregions of Yungas, Southwest of the Amazon, Tucumano-Bolivian Forest and Inter-Andean Dry Forests, a vital forest cover is maintained and where it is possible to monitor deforestation (FAN, 2018).

Currently, Bolivia is one of the countries with the highest per capita deforestation rates globally. In the period 1990-2010, 10% of the total existing forest cover in the national territory was lost (Andersen et al. 2016). In Bolivia, the annual deforestation rate is 0.34%.[155] Annual deforestation has increased in Bolivia by an average of approximately 150,000 hectares per year during the 1990s, to almost 350,000 hectares per year during 2016-2017. 2016 was the year with the highest level of deforestation in the history of Bolivia, with more than 417,000 hectares deforested, but the figure fell to 263,000 hectares in 2017 (Andersen & Ledezma, 2019).[156] According to Gonzales (2019), the cost of deforestation in Bolivia represents a figure greater than 10% of the national GDP, considering that deforestation leads to CO_2 emissions, loss of biodiversity and variation of the hydrological cycle.[157]

Restoration of degraded areas are proposed as an intervention to recover water sources and degraded soils. The intervention will consist of agroecological management and agroforestry practices of 17,510 ha.

155 http://www.fao.org/bolivia/noticias/detail-events/es/c/1144425/
156 https://inesad.edu.bo/dslm/2019/01/nuevos-datos-sobre-la-deforestacion-en-bolivia-hasta-finales-del-2017/
157 http://www.iisec.ucb.edu.bo/publicacion/bosques-en-bolivia-una-estimacion-espacial-de-los-costos-de-la-deforestacion

Agroforestry Systems in the Bolivian Valleys.
Agroforestry or agroforestry is a productive system that integrates trees, livestock and pasture in the same productive unit. This system is aimed at improving land productivity and, at the same time, is ecologically sustainable (FAO, 2016).

Agroforestry home gardens in tropical areas represent one of the classic examples of agroforestry, due to favorable bioclimatic conditions, such as temperature and rainfall. By incorporating a wide variety of crops with different levels of acceptance in the local productive culture, these spaces constitute highly efficient forms of land use.

Family agroforestry gardens
The ecosystems of high Andean valleys, located above 3000 m a.s.l., represent one of the greatest challenges for agroforestry because these family systems require, in the first place, strength in family organization, confidence and decision; strong and solid principles in the families for their implementation because they have to "overcome" the high climatic instability of high altitude production systems due to continuous frosts, hailstorms and, mainly, droughts.

In this sense, in the municipality of Colomi, which is located in the Chapare province of the department of Cochabamba, in the central region of Bolivia, a series of agroforestry practices have been developed, so it is important to mention that family agroforestry is diverse and in its territory different ecological niches were identified with a diversity of local native species such as paja brava (Stipa ichu), muña (Minthostachys sp.), wild turnip (Brassica campestris) and wajcha barbero (Polygoniun arvensis). Special attention has been given to the queñua or kewiña, of which, according to Simpson 1979 and Baunman 1998, there are 12 to 15 varieties that are found in abundance on the slopes of the cultivated lands.

Since 1950, a process of strengthening local forest diversity began in the highland communities of the Colomi municipality with plantations of eucalyptus (Eucalyptus sp.), queñua (Polylepis sp), pine (Pinus radiata) and weeping willow (Salix babilonica). The latter is considered a "water caller", a definition gradually assumed by the local population. The introduced forest species complemented the productive systems and the new plantations were located on boundaries or as a natural division between properties, along riverbanks, roads, in t'oqos (small spaces within the micro-watersheds), etc.

The new forest plantations were articulated to the local culture and complemented it in an effective way under the premise "I build my new house next to my new forest plantations". The houses are located mostly on the municipal flatlands and some on the hillsides, according to the existing management between collectively-owned and individually-owned lands. This process has modified the local landscape and strengthened the production systems, which has benefited the families of the farming communities.

The agroforestry plots include Andean tuber crops such as potato (Solanum sp.), papalisa (Ullucus tuberosus), oca (Oxalis tuberosa), isaño (Tropaeolum tuberosum), associated with oats (Avena sativa), a grass, and legumes such as tarwi (Lupinus mutabilis) and fava beans (Vicia faba). Also on these plots, families raise cows, sheep, horses, pigs and other animals that complement the agroforestry strength of these production systems.

Regarding the tree species to be used under the SAF: have been matched per target territory conditions according to scientific knowledge from the Ministry of Ministry of Environment and Water, FONABOSQUE and FAO. The project supports only the planting of endemic or non-invasive domesticated tree species from the Valles Macro region, which do not pose an environmental, genetic or phytosanitary risk. Whenever possible, priority consideration will be given to conserving the biodiversity and genetic pool of endemic species that are becoming scarce or are under threat. Based on the types of forest and ecological zones consistent with ecoregions, 80% of the territory of intervention is concentrated in 3 ecoregions: Tucuman Bolivian Forest, inter-Andean dry forest, and northern puna, more than 40 species have been identified, mainly woodable; however, the species Cupesí, Quebracho, Cebil, Cuchi Mara, described below are prioritized for their availability, growth and uses:

Table 46 List of main vegetation species and their use.

Name	Cupesí (Prosopis nigra /Prosopis alba)	
	Description	Use
Family	Legume	
Tree	Medium up to 15 m; dark bark; creamy and fibrous inner cortex	Log wood is used for housing structures and ceilings, as well as tools and utensils for family use, while old trees are used as wood for cooking by coal
Leaves	Alternate, bicomposed bipinnate; 1(2) pairs of pinnas; 20-26 leaflet lines, 2-5 cm long, opposite, petiole with cupular gland at apex; prominent and parallel rib; deciduous stypules	Cupesí leaves are traditionally used as cattle feed and as medicine for Indigenous Guarani
Flowers	Hermaphrodites, cream-colored actinomorphs, arranged in spiciform, axillary clusters, 5–15 cm long; short-belled chalice 5 denting; petals 5, free, pubescent on the inner side, with twisted white hairs; stamens 10, barely exertos of the corolla; super ovary.	
Fruit	Fleshy, indehiscent, light yellow loment, 16–18 cm long, with various seeds, sweet pulp.	Regarding the fruit of Cupesí, the main product obtained is the pod from which Cupesí flour is extracted. In its mature state, the fruit of The Cupesí is very desired by the children who collect it and consume it as if it were a candy, it is also an excellent source of protein for livestock
Distribution	It grows on a mountain on sandy and moist soils. It blooms in September and November; fruit from October to December. Seed dispersal is endozoococcal through mammals	In Bolivia, it grows naturally in the wet building association of the Temperate Dry Forest, in the arid valleys of the Andean interior, foot of mountain and Chaqueña plain, in the departments of Santa Cruz, Cochabamba, Chuquisaca and Tarija.

Name:	**Quebracho**	**(Horco Quebracho)**
	Description	Use
Family	Apocynaceae	
Tree	Medium to large tree, with trunk 30 to 100 cm in diameter, rough bark, thick and cracked, characteristic ochre chestnut, presents young twigs usually pendulums.	This species, for popular medicinal purposes, is used from the collection of material from specimens that grow wild or cultivated as ornamental.

		Wood is used in outdoor constructions, such as bridges, beams, columns, pylons, sleepers, poles, rods and as strong firewood.
Leaves	Simple persistent leaves, lanceolate ellipticals, briefly petiolate, cuneadas at the base, with remarkable central rib, leathery, rigid, spinescent and sharp at the apex, arranged in whorls of three or sometimes two opposite.	The bark and aqueous and alcoholic extracts obtained from them are used as a remedy against respiratory disorders, febrile diseases and liver illness, as well as toning.
Flowers	Flowers arranged in cyky, axillary and terminal inflorescences, hermaphrodites, yellowish white, scented, between 8 and 10 cm long.	
Fruit	Bivalve woody follicle fruit, dehiscent, greyish green and 7 to 12 cm long. Numerous seeds, alada.	
Distribution	The northern Puna landscape	

Name	**Cebil**	**Adenanthera macrocarpa**
	Description	Use
Family	Legume	
Tree	It grows 5-30 m tall (rarely 60 m) and its trunk, 20 60 cm in diameter, has brown-dark conical bumps. The dark grey bark, with conical bumps.	For wood especially for tools, in construction, for doors, window frames, fences, beams, platforms, floors, sleepers. The wood is reported as a preferred source of firewood for the kitchen, because it gives strong fire and long breath. Widely used to make fences, as termites don't seem to attack her. It was once used to build houses, but it is becoming increasingly difficult to find enough trees for that purpose.
Leaves	Mimosa-like leaves, bipainted and alternated.	Rubber is used to treat upper respiratory tract infections, such as expectorant and soothes coughing
Flowers	produces flowers from September to December and pods from September to July	
Fruit		
Distribution	It grows at altitudes between 315-2200 m. above sea level, with rainfall of 250-600 mm/year, and an average temperature of 21oC. It tends to grow in rocky hills with well-drained soil, often in the river neighborhood. It grows rapidly at 1-1.5 m/year in good condition.	

Name	Cuchi Mara	astronium urundeuva
	Description	Use
Family	Anacardiaceae	

Tree	Dioic tree is medium up to 25 m tall, and up to 90 cm diameter. Treetop: Narrow, open and irregular, with thick, tortuous, ascending and horizontal branches. Shaft: Cylindrical, no flutes. Outer bark: Cracked dark grey. Pink inner bark.	As for cuchi wood, its hardness and durability makes it suitable for external constructions such as bridges, poles, sleepers, fences, beams and stakes
Leaves	Composed, odd, alternate, their ribs fork near the edge, strong smell of green sleeves when squeezed	Non-commercial uses, in turn, are varied, including the collection of resin for the production of homemade soap, its leaves used as fodder for animals especially in the dry season, bark, leaves and root are used in traditional medicine either as an infusion or as balsamic emplasts
Flowers	Arranged in axillary panicles	
Fruit	Drupe with acrescent chalice in the form of a dried flower	
Distribution	Deciduous and light-demanding species, common in seasonal dry forests. It grows on well-drained soils. It blooms when the trees are deciduous between July and August. Fruiting occurs from August to October and the fruits are dispersed by the wind	

Agroecological management practices

Crops under conventional systems have a growing demand for agrochemicals and heavy machinery in agricultural work. This causes degradation and compaction of farming soils, causing ever deeper subsoils to be used and enabling more fallow areas and dredges; in addition to the need for agricultural expansion towards new lands, which does not necessarily have a vocation for agriculture, etc., thus making agricultural activities less profitable and going against the conservation of natural ecosystems not suitable for crops. Three principles have been assessed when selecting the agroecological practices are: leaving organic residues; less soil movement, and crop rotation, combining these principles the soil horizon increases, humidity and porosity is maintained, achieving a balance for the proliferation of beneficial fauna such as worms, which breaks the cycle of pests and diseases (Granados -Orosco, 2013). Agroecological management requires careful planning of crop rotations.[158]

Agroecological management practices is proposed as an intervention to promote and favour conservation and restoration of environmental functions and as an alternative to conventional production systems characterized by the intensive use of agricultural inputs. The restoration of the environmental functions aim to restore soil and land degradation and restoring the hydrologic balance of the watersheds. The municipalities or zones in the project intervention area with needs to improve the state of conservation of farming soils will be prioritized.

[158] http://www.fao.org/ag/esp/revista/0110sp.htm

According to specialists in agricultural issues, conservation agriculture offers enormous potential for all kinds of farm sizes and agroecological systems:

- It allows farmers conserve, improve and make more efficient use of natural resources.[159] Its adoption is most necessary for small producers, especially those suffering from acute labour shortages. Conservation agriculture combines profitable agricultural production with protection of the environment and sustainability; and it works in a wide range of agro-ecological zones and production systems (Mamani et al., 2015).

The practices included under agroecological approach that will be implemented under this activity are:

- Practices that include minimum soil disturbance and mulching with crop residues (no-till). The purpose will be to incorporate crop residue and stubble left over from the previous harvest, together with the biomass resulting from tree pruning, roots and tubers is to increase the soil's organic material content, hence increasing its humidity retention capacity, improving its structure and increasing its nutrient content. These conditions help reduce humidity losses, erosion and fertilizer use (FAO, 2017). This practice reduces tillage, avoiding moving the soil during the harvest period, during the harvest period and during establishment of the next crop; fallen leaves help conserve soil nutrients by producing soil cover. Additionally, other strategies are incorporated to manage crop nutrition, such as replacing nutrients extracted during harvest by applying fertilizers.
- Crop rotation, including the incorporation of legumes. Legumes are incorporated in crop rotations and associations, due to their ability to fix nutrients and contribute to soil regeneration. Legumes are the leading group of plants that can fix nitrogen from the air in their roots and transfer it to the soil, thus reducing the need for fertilizers. Besides, these plants' flowers attract bees and beneficial insects, creating more extraordinary biodiversity in crops. In the Valleys Micro-region of Bolivia, green beans, green peas and beans are the legumes with the largest cultivated area, and therefore with the potential to be used in associations and crop rotation with corn to promote conservation agriculture.

The goal of these practices is to provide a variety of benefits to farmers including increased soil fertility, reduced input demand, and reduced risk to yields from rainfall shocks (Brouder and Gomez-Macpherson, 2014). This last benefit comes, in the case of sub-optimal rainfall, through the use of planting basins, in combination with mulching, which increases water infiltration and moisture conservation (Thierfelder and Wall, 2009), while, in the case of excess rainfall, through the retention of crop residue, which reduces erosion rates (Schuller et al., 2007). In this regard, conservation agriculture has on one hand clear resilience benefits for agricultural production, while the minimal disturbance of soils also brings important mitigation co-benefits by minimizing disturbance of the soil, maximizing soil cover, soil carbon release is also minimized.

Importance of forests for the hydrological balance

Forests fulfil essential environmental functions such as climate regulation, control of the nutrient cycle, control of the hydrological cycle, etc. They can absorb atmospheric $CO2$ (carbon sequestration) through plants, mainly due to increased biomass. In the highlands and mountains of the Valleys Macro-region, forests and Andean vegetation are located, which are densely concentrated in streams and areas with

[159] http://www.fao.org/ag/esp/revista/0110sp.htm

optimal humidity and temperature conditions. Despite being dispersed in arboreal and shrub strata, this natural vegetation cover forms important biological corridors, which provide critical climatic benefits such as the availability of water resulting from a positive and / or surplus water balance (FAN, 2018).

In the Valleys Macro-region, high priority areas according to significant levels of water surplus (greater than 400 mm / year) are located mostly in streams and streams headwaters and coincide with those with the highest rainfall such as the North region of Cochabamba (TIPNIS area), East region of Chuquisaca and West of Santa Cruz. Likewise, considerable water deficit levels stand out in much of the Southeast region, reaching extreme limits higher than -600 mm / year (West of Potosí and South of Cochabamba) (FAN, 2018). In Bolivia, a large part of the water supply, both for household consumption and crop risk, depends on rain.

With the intervention of the Project, the annual loss of 0.34% of the 1,219,444 ha of forests are avoided through the enclosure of forests associated with water sources (water recharge areas, water sources), management and conservation of easements; Support for the management of protected areas and Permanent Forest Production Lands (TPFP)[160], for the implementation of conservation programs for water sources and the creation of conservation areas in sites of water importance. This forest area under management will contribute to the capture of CO2 and improve the conditions of the water balance at the local level, representing a key co-benefit arising from the implementation of the project.
Description of the nurseries:
The nurseries will be managed at the community, municipal and/or departmental level, considering the proximity to the prioritized restoration sites, which will generally be areas of water sources, ecological easements, among others. Undoubtedly, co-financing and GCF resources will contribute to the strengthening and implementation of forest nurseries, which will allow the restoration or conservation of ecosystems. The management of the nurseries will be the full responsibility of the communities, municipalities and governments that install them, without neglecting the technical assistance and advice that project technicians will provide at the time of planting and installation of agroforestry systems.

The forest nurseries will be managed within the framework of inter-institutional agreements signed between the MMAyA and the prioritized municipalities and/or communities where the nurseries will be installed. In this sense, the communities and municipalities will be responsible for the management of the nursery itself, with their own counterpart resources and with support from MMAyA.

The source of the seeds: The seeds provided to the farmers in the project will comply with the control mechanisms that exist in the country. The National Institute of Agricultural and Forestry Invocation (INIAF) to provide "seed certification and control services, variety registers, breeders and others, in the field of agricultural, forestry and seed research". The seeds will be purchased at local providers within the communities and also where applicable from local farmers, after the INIAF procedures have been followed.
Bolivian regulations and institutions established three forms of seed control: registration (the creators of new varieties register their seeds, protecting them from free use), certification (compliance with technical standards is required for their commercialization) and control (the "quality" of native seeds is controlled and they are authorized only for family use). Economic and administrative sanctions were also approved

[160] In the Project intervention area there are around 1,734,254 ha as TPFP.

for violators. The institution in charge of protecting seeds within the framework of Supreme Decree 29611 of June 25, 2008, is the National Institute of Agricultural and Forestry Invocation (INIAF) to provide "seed certification and control services, variety registers, breeders and others, in the field of agricultural, forestry and seed research". According to INIAF data, up to 2013, 859 varieties of 33 species were registered in the National Variety Register. Likewise, 13 new varieties have been protected (10 soybean varieties and 3 chia varieties), having a total of 48 protected varieties in the country (INIAF, 2015). The seeds provided to the farmers in the project will comply with the above mentioned control mechanisms that exist in the country. The seeds will be purchased at local providers within the community, and where needed, also from local farmers.

Output 3.2 Information and long-term monitoring system for water sources at place

Total GCF budget is USD 0.51 M to be executed by FAO. The number of direct beneficiaries are 58,000 of which 30,160 are males and 27,840 are females.

The objective of this output is to develop an Information and Monitoring Tool for Water Sources, allowing the Project and national and local authorities to monitor the state of conservation of these sites, and to make timely adjustments to the management, protection, conservation and/or restoration actions that are scheduled to be carried out under output 1.1 and 3.1. The Monitoring tool will also allow the generation of up-to-date information about the quantity and quality of available water resources over time. This will determine the effectiveness and sustainability of proposed adaptation actions under the irrigation Components of the project and the overall resilience of agricultural production systems in the target area. Similarly, the Monitoring Tool will be complemented by the calculation of the climate footprint (assessing both water and energy use) of traditional and climate-proofed irrigation systems in conventional and agroecological production systems. The calculation of the climate footprint will be used to further define the O&M plans, to be developed under activity 2.2.2 and which will guide the municipalities to make informed decisions on which irrigation systems are best suited under the current and future climatic conditions.

Under output 3.2, the following activity will be implemented:
Activity 3.2.1 Develop and implement an online tool (annexed to the MMAyA's webpage) for monitoring, consolidation and dissemination of information relevant for informed climate-sensitive planning and decision-making processes related to sustainable water use (based on climate, weather conditions, foot print of food production, water availability)

This activity aims to design a tool to generate up-to-date information about the availability of water resources in quantity and quality over time, climatic and weather conditions, access to water in the target region and agro-food system related to water balance monitoring in a context of climate change. The tool will allow farmers to make informed and effective decision making especially on the use of water resources for agriculture, but also for other uses (domestic, etc) and allow the country to monitor the progress of their NDCs

Sub-activities:

- Implement the methodology for calculating the water footprint in agri-food systems in the project's target area, to contribute to the micro and macro-regional water balance. The climate footprint (water and energy use) will be used to calculate the footprint of traditional and climate-proofed irrigation systems in conventional and agroecological production systems.
- Integration of the analysis and results of the water footprint and balance in agri-food systems into the state's integrated planning system in order to contribute to the reporting, monitoring and verification of the NDC water and food production sector.
- Design and implement the tool and provide capacity building on using the tool to national and subnational authorities
- Disseminate the information provided by the online tool for better planning and decisión – making processes
- Incorporate the online tool to the National Early Warning System

Deliverables:

1 Online tool for monitoring and dissemination of information

Description:

This activity will develop an Information and Monitoring tool for Water Sources and Instruments to use local water resources (quality and quantity). The Information and Monitoring System of Water Sources will allow the national and local authorities to generate up-to-date information on the availability of water resources in quantity and quality over time, climatic and weather conditions, access to water in the target region and agro-food system related to water balance monitoring in a context of climate change. The tool will allow farmers to make informed and effective decision making especially on the use of water resources for agriculture, but also for other uses (domestic, etc). The Monitoring System will also allow knowing about the availability of water resources in quantity and quality over time, which will determine the effectiveness of the Project's actions. The instruments of local water use will be used to make local producers aware of water resources' efficient use.

This tool will aim at serving as a centralized source of information on climate and weather conditions, food production, water availability and others, and will be used by all municipalities through the FAM and the agreements signed with SENANMHI.

Within the framework of the National Watershed Plan, the Vice-Ministry of Water Resources and Irrigation (VRHR) under the Ministry of Environment and Water (MMAyA) has been implementing water body monitoring systems at the national level in coordination with departmental and municipal governments, This will provide accurate and timely information that will contribute to decision making and implementation of actions to protect water bodies that may be affected by different environmental and anthropogenic factors, guiding efforts to prevent and control environmental problems generated mainly by mining activities in the area and contributing to the systematic qualitative and quantitative evaluation of the basin's water quality status. The beneficiaries of the information are decision makers for the construction and strengthening of technical and financial support policies for small farmers, communities and producers in order to prevent and control extreme weather phenomena, among other aspects of conservation and management of water sources.

The validation of monitoring points and parameters and the execution of the first monitoring campaign corresponding to the dry season was carried out with the participation of technicians from the Vice-Ministry of Water Resources and Irrigation, prioritized governors' offices and municipalities.
Throughout the monitoring network, field parameters were evaluated (electrical conductivity, dissolved oxygen, pH, sediment solids, temperature and turbidity) and water samples were taken for subsequent laboratory analysis, which will be monitored every six months during the flood and low water seasons.
Building on these existing experiences, the RECEM Valles Project will incorporate aspects of mitigation and adaptation to climate change in the monitoring system, as well as the incorporation of information survey processes and location of water sources, number of existing irrigation systems and their characterization, as well as the linkage to wetlands and natural grasslands and forests; all with the purpose of also integrating the information systems of forests, soil and biodiversity carried out by the MMAyA, the Plurinational Authority of Mother Earth and the Ministry of Development Planning.

The aspects referred to have to do with the joint mitigation and adaptation mechanism set forth in the JAMM, which establishes the implementation of conservation areas, sustainable resource management, subsistence agricultural production, among others. The information will be submitted to SPIE for processing and reporting to the Climate Change Convention on water NDCs and food production, as well as the implementation of responsible water consumption practices in food production.

The strengthening of this system and its articulation with the other information and monitoring systems will also allow the generation of reports on the situational status and implementation of NDC indicators related to the "Water and Food Production", "Forests and Agriculture and Livestock" sectors. Other relevant monitoring systems that already exist in Bolivia are: the Integrated State Planning System, which has implemented the SPIE Info, the SIMB (Forest Information and Monitoring System), the Water Monitoring System, the Protected Areas Monitoring System, the Watershed Information and Monitoring System.

Component 4: Enabling conditions created to implement and upscale climate-resilient agroecological management, climate-informed integral micro-watershed management, and access to financial mechanisms

Rationale: This Component has a strong innovative approach to facilitate the identification of financial mechanisms to support longer-term climate resilient agricultural production and irrigation systems. Particularly, the project will foster partnerships with existing national funders as well as financial institutions to develop innovative financial instruments tailored to enable the implementation of climate-proofed irrigation and ecosystems restoration investments. This will be topped with capacity development of local communities, smallholders and associations on financial management and access to innovative financial instruments to serve as enablers of climate resilient agricultural transformation.

Objective of Component 4: Enable conditions created to implement and upscale climate-resilient agroecological management, climate-informed integral micro-watershed management, and access to financial mechanisms

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Three outputs are proposed:

- Output 4.1 Strengthening capacities of national and sub-national government entities to implement policies and norms for climate-resilient food production under irrigation systems, integral watershed management and monitoring of ecosystems functions and services.
- Output 4.2. Improved financial mechanisms that support climate-resilient agricultural production and irrigation systems to mobilize increased finance for farmers
- Output 4.3. Strengthening local governance in participatory climate adaptation, early warning systems and long-term monitoring system

Under output 4.1, the project aims at facilitating strengthening of capacities and consultation processes to enable national and sub-national stakeholders to design and implement required policies, regulations and plans (including PTDIs) with a focus on adaptation and mitigation to climate change and linked to integral watershed management and conservation, monitoring of ecosystem functions and services, on-farm climate-proofed irrigation systems and production diversification. Similarly, this Component will enable the design and implementation processes of PTDI, targeting land use planning and prioritization of production activities appropriate for the aptitude for land use, resilience management and integral watershed management and conservation, among others.

At present, use and occupation of the land are based on land use plans developed at the departmental level. There is a need to have updated plans at a finer scale of analysis than the departmental level, allowing municipalities to make more appropriate decisions on use and occupation of the territory. It is therefore necessary to draw up land-use plans at the level of the municipal association and territorial management plans at the community level.

Under output 4.2, the project interventions under this Component 4 will include the introduction of innovative financial mechanisms such as:

- Design and implementation of pilot initiatives of green credits and concessional credits lines and provide technical assistance to farmers to access these credit lines - The project will establish alliances with national financiers and financial institutions (BDP (Productive Development Bank), FINRURAL (Association of Development Finance Institutions)
- Develop a Financial Strengthening Plan for FONABOSQUE to leverage new climate-related funds and scale up and increment the number of beneficiaries
- Provide specialized Technical Assistance to INSA to develop and implement innovative insurance mechanism and to analyze the possibility to expand this activity to other private financial institutions

Also, the project will explore, in partnership with non-reimbursable financing institutions (FINRURAL, FONABOSQUE), the support for productive diversification, conservation of water sources, and climate-resilient irrigation systems, among others.

Lastly, under output 4.3, Component 4 will strengthen local governance structures on matters related to participatory climate adaptation and early warning systems. Trainings and workshops targeting local stakeholders (including smallholders, public officers, local CSOs and relevant academia and private sector) are planned to increase their knowledge base on climate resilient agriculture, climate-proofed irrigation and watershed management for climate adaptation and resilience. These entities include local canton and municipality authorities and staff, as well as selected staff from provincial and departmental administrations, who will participate on multi-stakeholder platforms for watershed management. The project will build the capacities of public staff (central and sub-national government technical and extension officers) to understand climate change dynamics regionally, nationally and sub-nationally and, in particular, the effects on the hydrological cycle and temperature. The sub-national governments will participate in its steering committee, where all project decisions will be taken.

For the selection of beneficiaries under this Component and participants of the trainings, the following criteria will be applied according to the target groups:

Table 47 Description of selection criteria for beneficiaries

Type of Beneficiary	**Selection Criteria**
Farmers	✓ Farmers most threatened by the impacts of climate change ✓ Farmers participating in different consultation platforms which will allow them a greater capacity to work in groups and more inclined to share knowledge with others, enabling the design and implementation of national and sub-national policies, regulations and plans (including PTDIs). ✓ Farmers living in communities most affected by socio-economic vulnerability ✓ Farmers willing to assimilate new knowledge, with leadership capacity and willing to contribute to Climate resilient development of the target territories ✓ Farmers with interest in exploring and accessing innovative financial instruments for Climate resilient agriculture ✓ Farmers benefited/participating in innovative technology and practices (Component 1), irrigation schemes (Component 2) under the project or supporting agroecological and agroforestry activities (Component 3).
Producers Organizations	✓ Geographical proximity of these organizations to the project target areas. ✓ Organizations have been and/or will be identified based on alignment between the proposed activities and the organizations' mandates, expertise and/or services delivered. Note that these determinations have been/will be made by Ministry of Environment and Water, in consultation with FAO. ✓ Organizations must be assessed as possessing the potential capacity to access innovative sources of finance. ✓ Organizations must have financial independence to manage their financial resources including bank accounts to deposit their incomes. ✓ Identified organizations will be invited to nominate staff to participate in the activities based on the alignment between the contents of the proposed activity (e.g. technical focus of the training) and the respective beneficiaries' responsibilities and expertise within their organization. ✓ Gender balance prioritizing women and young people (over 18 years old)

Institutional staff(Professional Beneficiaries)	✓ Organizations have been and/or will be identified based on alignment between the proposed activities and the organizations' mandates, political roll, expertise and/or services delivered and territorial representation in the project target areas (note that these determinations have been/will be made by the Project Coordination Committee in consultation with the Ministry of Environment and water); ✓ Identified organizations will be invited to nominate staff to participate in the activities based on the alignment between the contents of the proposed activity (e.g. technical focus of the training) and the respective beneficiaries' responsibilities and expertise within their organization

Data generation and management (analysis and modelling) will contribute to strengthening local and participatory planning, decision making and early warning system for agricultural risks; therefore, it will be useful to information-based governance" with this, the link to institutional strengthening is made. Furthermore, the agencies that will generate such data are the National Meteorological and Hydrological Service (SENAMHI, according to its name in Spanish) of the Ministry of Environment Water; and of the Rural Contingency Unit - Early Warning System for Agricultural Risks, Ministry of Rural Development and Land.

The role of SENAMHI and MDRyT will be strengthened to ensure the continued generation and timely dissemination of locally-adapted information on meteorological/weather, hydrological, hotspots and forest fires, even after project closure; this information will be disseminated using the coordination and consultative territorial platforms to be established under the project to facilitate climate change adaptation mainstreaming intro the participatory design of norms, policies and strategies and to implement early warning systems for agricultural risks respectively.

The strengthened capacities of the local actors will be conducive to improve and participate in local and national governance mechanisms. The exercise of those strengthened capacities will be facilitated by the project in participate in the analysis and improvement of local and national policies and norms for the climate-resilient production of food under irrigation systems, including follow-up processes for the design and implementation of national and sub-national policies and regulations that contribute to the adaptation and mitigation processes of climate change linked to watershed conservation, on-farm climate-proofing irrigation systems, and production diversification; support at the national and sub-national level in the implementation of the Guiding Watershed Plans in the project intervention area; establish territorial consultative platforms to design norms, policies and strategies to combat climate change and food insecurity, as well as establishing agroclimatic platforms to implement early warning systems for agricultural risks. Other planning and decision-making processes will also be the scenario where key stakeholders realize their governance capacities, having as key coordination fora the local actors through the Coordination and Consultative Territorial Platforms and the agroclimatic platforms.

Information generated from this output will be disseminated to smallholders for use in climate risk management – e.g. scheduling of crop planting and other agricultural activities; irrigation scheduling; risk reduction from forecasted extreme events; watershed management and planning. All the mentioned approaches under other Components will benefit from the weather and climate information as well as the institutional and governance capacities to be generated through the activities of Component 4.

Integrated water resource management models will be implemented through a range of appropriate resilience-enhancing technologies at farm and community level that improve water conservation and its efficient use In this endeavor, the information generated and organization fostered along the implementation of the activities of Component 4, will be crucial for on-farm climate-proofing irrigation planning. In this regard, the weather/climate information to be produced with public entities, which will be strengthen from the cooperation with the project, will serve for carrying out information-based planning.

Output 4.1 Strengthening capacities of national and sub-national government entities to implement policies and norms for the climate-resilient food production

Total GCF budget is USD 0.28 M, to be executed by FAO. Total number of direct beneficiaries are 400 with 208 males and 192 females.

In this output, policies and technical standards for responsible water consumption in irrigation systems and conservation of water sources will be drafted and implemented to contribute to adaptation and mitigation of climate change linked to integral watershed management and conservation; monitoring of ecosystem functions and services; and on-farm climate-proofing irrigation systems and production diversification (to be added to the project description).

The activity under this output will strengthen the capacities of national and sub-national government entities in implementing policies and norms for the resilient production of food under irrigation systems with a focus on adaptation and mitigation to climate change.

Municipal government entities have limited technical capacities to draw up and implement policies and regulations related to water source conservation, management of water for consumption and irrigation, and the links to climate change.

One Policy and Standards Information and Monitoring System has been implemented and helps the entities control and oversee compliance with the regulations developed and put in place within the framework of the project. Planning instruments are supported with the aim that they will support the better targeting of project actions in order to ensure a greater effectiveness and perhaps deeper positive impacts. These instruments include support in the design and guidance of the implementation process of PTDIs for 24 municipalities as well as basin master plans.

At the level of the municipal governments, a total of 1,686 people, including women and youth will benefit from training to draw up the PTDIs. 30% of those trained are expected to be women and 10% young people. The municipalities selected will be those with high vulnerability to climate change, as indicated in Figure 59.

Activity 4.1.1. Implement national and sub-national policies and plans (including PTDIs) that contribute to climate change adaptation and mitigation processes, contributing to the JAMA and to the Bolivia´s NDCs.

Total direct beneficiaries are 400 of which 208 males and 192 females.

This activity aims to support the development and follow up on the implementation of territorial planning instruments (PTDI), with local actors to generate capacities and correct some of the technical problems that occurred with the first version of the PTDI. This will contribute to monitor and implementation of policies at the national and subnational level for climate change adaptation linked to the conservation of watershed, climate-proofed irrigation systems and productive diversification in de macro and micro region Valles (NDC, JAMA).

Sub-activities:

- Perform processes to monitor the design and implementation of policies at the national and subnational level that contribute to climate change adaptation processes linked to the conservation of watershed, climate-proofed irrigation systems and productive diversification.
- Strengthen the PTDI design and implement PTDIs to improve land for land use and the prioritization of productive activities in line with the soil aptitude, practices of resilience and conservation of water sources, organic soil capacity, among others

Deliverables:

- At least 10 institutions at the national and the 65 municipalities included in the project have been trained in the design and implementation of policies related to climate change adaptation.
- 24 PTDI updated with local actors that includes climate-sensitive planning and decision-making processes related to sustainable water use
- 12 PTDIs implemented

The selection criteria for the direct beneficiaries of this activity are:
All 65 prioritized municipalities will be trained in implementation of policies related to climate change adaptation.

National entities will be selected based on their existing work related to the integral management of water and the production of food, as well as mitigation and adaptation to climate change in those areas where project interventions have taken place in Component 1, 2 and 3.

Description:

The activity will strengthen the capacities of national and sub-national government entities in the implementation of policies and standards for resilient food production under irrigation systems with a focus on climate change adaptation and mitigation. Municipal state institutions have limited technical capacities for the design and implementation of policies and standards related to water source conservation, water management for consumption and irrigation, and their linkage to climate change.

In this sense, support for the design and implementation of planning instruments is supported so that project actions can have greater effectiveness and positive impacts. Among these instruments from RECEM Valles are the support in the design and accompaniment to the implementation process of PTDI for 24 municipalities in the area of influence, which are closely linked to the basin master plans, local water use plans and local management plans of the basins, among other public policy management documents.

According to the provisions of the State's Integral Planning System Law No. 777, the PTDI is a planning instrument for integral development and land use planning of departmental, regional and municipal autonomous governments for a five-year period.

The following participate in the design and implementation of the PTDI: i) Citizens of the territory, community and neighborhood social organizations of autonomous territorial entities, including the private sector and representative organizations of the territory where the planning process is carried out; ii) Entities of the territory, including decentralized and deconcentrated entities under the autonomous government's dependence, control or subjection; and iii) Public enterprises under the autonomous government's control.

Finally, it is important to mention that one of the problems of rural municipalities in the country is the implementation of their territorial planning instruments (PTDI) that were developed in 2016, from the enactment of Law 777 of the State Comprehensive Planning System (SPIE). This is due to the fact that in many cases they were prepared with little technical consistency, by poorly trained professionals, reduced budgets and deadlines. among others. Since the municipalities must update their IDWPs between 2020 and 2021, the RECEM Valles Project aims to support the development and accompaniment for the implementation of IDWPs, with local actors to generate capacities and rectify some of the technical drawbacks that were experienced with the first version of the IDWPs, for the development of this activity, priority will be given to the municipalities with greater vulnerability to climate change.

Output 4.2. Improved financial mechanisms that support climate-resilient agricultural production and irrigation systems to mobilise increased finance for farmers

Total GCF contribution is USD 1.84 M, to be executed by FAO. The total direct beneficiaries are 22,904 of which 11,910 males and 10,994 females.

Activities under this output will strengthen and design, together with national and sub-national entities and financial mechanisms, for the resilient production of food, installation and maintenance of irrigation systems with a focus on adaptation and mitigation to climate change. Stakeholders will be trained to ensure they are enabled to access finance for climate adaptation actions.

The following activities are envisaged to be conducted under this Output:

- **Activity 4.2.1** Establish partnerships with existing domestic funders and financial institutions to develop innovative financial mechanisms and instruments that enable the implementation of climate-proofed irrigation, climate-resilient agriculture and investments in ecosystems restoration Total direct beneficiaries are 2,224 of which 1,156 males and 1,068 females.
- **Activity 4.2.2** Strengthen the capacities of communities, smallholders and associations on financial literacy, management and access to innovative financial instruments relevant for climate resilient agriculture, ecosystems conservation schemes, climate-proofed irrigation systems. Total direct beneficiaries are 20,680 of which 10,754 males and 9,926 females.

Activity 4.2.1 Establish partnerships with existing domestic funders and financial institutions to develop innovative financial mechanisms and instruments that enable the implementation of climate-proofed irrigation, climate-resilient agriculture and investments in ecosystems restoration.

Co-design -together with public and private national and sub-national entities, as described in Table 9 of the FP- financial mechanisms and instruments for the climate resilient production of food, installation and maintenance of irrigation systems and mountain ecosystems restoration and conservation. This includes the development of market analysis, financial product and instrument co-design, needs assessments for deployment. The partnership includes strengthening the capacities of public/private national/sub-national entities for the development of tailored financial instruments and mechanisms.

This activity aims to achieve the following:
(1) **Design and implementation of pilot initiatives of green credits and concessional credits lines and provide technical assistance to farmers to access these credit lines** - The project will establish alliances with national financiers and financial institutions (BDP (Productive Development Bank), FINRURAL (Association of Development Finance Institutions), to provide technical assistance to design and implement pilot initiatives of green credits and concessional credits lines for small farmers so that they strengthen their capacity for resilience and adaptation to CC.

(2**) Develop a Financial Strengthening Plan for FONABOSQUE to leverage new climate-related funds and scale up and increment the number of beneficiaries** - project interventions will develop a Financial Strengthening Plan for FONABOSQUE to leverage new climate-related funds and scale up and increment the number of beneficiaries.

Sub-activities:

- Consolidate the refundable financial incentives policy with non-conventional guarantees, based on the implementation of new green financing mechanisms for irrigation and productive systems for communities, small-scale producers and associations.
- Provide specialized Technical Assistance and capacity building to BDP and FINRURAL to develop and implement an innovative financial mechanism and to analyze the possibility to expand this activity to other private financial institutions (including a market analysis and needs assessment).
- Provide specialized Technical Assistance to INSA to develop and implement innovative insurance mechanism and to analyze the possibility to expand this activity to other private financial institutions - GCF investment will be targeting the design and piloting of a parametric or indexed micro insurance that will be designed with the National Institute of Agricultural Insurance (INSA)
- The technical assistance to BDP and FINRURAL will include among others; design technical guidelines related to the current legislation to establish the climate resilient credits and concessional credits lines (see more details in table 9 FP).
- Provide technical assistance and capacity building to INSA for the design of the risk-indexed micro insurance for the Valles Macro region in a highly participatory manner.

- Provide technical assistance and capacity building to the different water funds to develop and establish an improved funding mechanism that takes into consideration climate change adaptation and mitigation.
- Develop a Financial Strengthening Plan for FONABOSQUE to leverage new climate-related funds and scale up and increment the number of beneficiaries

Deliverables:

- At least 10% of the loan portfolio for production and irrigation has been reactivated and/or increased for the Valles Macroregion.
- At least 1 green financial mechanism for production and irrigation loans targeting women and young producers has been designed and is being implemented.
- One risk-indexed micro insurance designed and implemented
- One funding mechanism designed and implemented (related to the water funds)
- 200 staff of INSA, BDP and FINRURAL, Water Funds trained
- One financial Strengthening Plan for FONABOSQUE

Description:

The project will support financial institutions to develop processes, products and services that: (i) assess and map the needs of and impediments for farmers, specially of smallholder farmers, to engaged in climate resilient agriculture; (ii) integrate climate resilience principles (both ecological and social) into their portfolios of products and services; (iii) conduct research on effective and affordable innovations related to credit assessment, financial products, and delivery mechanisms; (iv) design, test and implement financial products and services that are customized to climate resilient agriculture primarily to small-scale holders, better address the needs of borrowers and encourage engaging in climate resilient agricultural management.

Local producers currently have problems with national agricultural insurance benefits because its coverage is limited to specific crops. The idea of this activity is precisely to explore the economic and financial feasibility to expand coverage, especially to benefit the region’s most vulnerable to climate change. The benefit is expected to encourage small producers to make investments to support agricultural activities that are the primary source of family income.

In this activity, technical assistance will be provided to INSA for the design of agricultural insurance for the macro-region of Bolivia's valleys, including the production of vegetables, vines, corn and fruit trees. During the implementation of the project, more details on the insurance structure and the process for calculating the premium will be established. It is envisioned that the premium will be calculated based on the following information: market and concession value of the land, the damage and loss generated to the crop, the type of production system, classification of the agricultural property, among other criteria that may be extrapolated from previous experiences in the altiplano.

Current financial mechanisms

A justifiable credit history in the financial sector. Intermediaries review the applicant's credit history to evaluate his or her payment habits. In the case of small farmers who wish to undertake agricultural projects on their land for the first time or who have never obtained credit through a financial institution, this constitutes an access barrier that prevents the financing of productive systems because they have no credit history. This has prevented a high percentage of small producers from obtaining credit. For community-based social producers, agricultural properties cannot be mortgaged or pledged as collateral for loan payments.

- Transaction costs in the credit process. For a small producer, the costs of processing a loan can reach up to 20% of its value. These include travel expenses to bank branch offices, waiting times, document collection, commissions or assistance in filling out forms or preparing income tax returns, notary fees, opening savings accounts, and telephone calls, among others.

Table 48 Credit products and interest rates

Credit Products and Interest Rates			
Product	**Micro company**	**Small company**	**Medium to large**
BDP Agriculture	11,5%	7%	6%
BDP Small ruminants	11,5%	7%	6%
BDP Irrigation	11,5%	7%	6%
BDP Fisheries	11,5%	7%	6%
BDP Head of household	10%	7%	6%
BDP Tourism	11,5%	7%	6%
BDP Trade and direct services	11,5%	7%	6%
BDP Trade and indirect services	17%	11,5%	6,5%

The development of this activity will be strongly supported by the Productive Development Bank (BDP), a financial intermediation entity regulated by ASFI. It carries out first and second-tier operations aimed at granting financial and non-financial services. Currently, the BDP has several projects under management located in various municipalities within the Bolivian Valleys Macroregion. These are to implement technified irrigation systems for peach and potato crops, as well as for the "harvesting", management and administration of irrigation water. Although it is difficult to value this activity economically, the expected benefits for the communities include contributing to an increase in the economic income from the producers' agricultural production and reducing the vulnerability of their productive systems to climate change, through the activation of the credit portfolio and the implementation of a financial mechanism aimed at benefiting young people and women.

The BDP Head of Household Product is a credit aimed at strengthening the productive activities carried out by women throughout the country, seeking to improve their income and family welfare. The requirements and conditions of this product are as follows:

- The frequency of payment is Monthly, bimonthly, quarterly, semiannual, annual or customized.

- The requested will be based on the payment capacity, the productive activity and the purpose of the credit.
- Three years for Working Capital
- Ten years for Investment Capital
- The grace period is up to 2 years (Only for Investment Capital).
- Fixed installments, Variable installments and Customized installments based on the seasonality of the activity or productive cycle and the purpose of the financing.
- Guarantees: Personal; Nonpossessory pledge on personal property; Mortgage Guarantee; Time Deposit - DPF; Certificate of Deposit and Pledge Bond (Warrant); Non-Conventional Guarantees.

It is worth mentioning that the conditions and requirements are similar for all the cases listed and described in the preceding table, where the specifications of non-conventional guarantees can be seen, the same that are about to be developed and in which the project will contribute.

According to data from the Central Bank of Bolivia, as of July 2, the interest rate for the productive sector in local currency for loans varied between 4.53% (Banco Mercantil Santa Cruz) and 7.12% (Banco Unión). For small companies, the minimum was 7.37% and the highest was 8.93%, and for microenterprises it ranged from 11.05% to 23.14%. Since the enactment of Supreme Decree 2055, which regulates the Financial Services Law, the rates for loans to large companies now range between 5.5% and 6.4%; for small companies, between 8% and 11%; and for micro-companies in Bolivia, from 18% to 22%, according to the financial institution.

Agricultural insurance

In Bolivia most smallholder farmers do not protect their investments in productive activities through either conventional indemnity-based agricultural insurance or innovative index-based insurance products due to the lack of an adequate insurance product meeting their needs. The financial sector lacks incentive, capacity and skills to extend financial services to these populations, many of whom are remotely located, largely as the markets are not at scale and thus provide less lucrative returns than traditional and higher income market segments, unless reached at scale.

Index (or parametric) insurance products have emerged to help overcome some of these challenges with administrative costs and coverage, providing an affordable risk solution to vulnerable farmers. In the context of the project, innovative insurance products will contribute to improving families' climate resilience by providing timely financial payouts.

Introduction of index (parametric) micro insurance products for farmers in the target area aims to both protect and help diversify livelihoods. The financial compensation provided by insurance protection can help households maintain their level of wellbeing even when severe shocks occur. Index insurance has the benefit of being able to provide rapid pay-outs with a considerable insurance cover of the harvest value, and usually is offered at a lower cost than traditional insurance. This is because (parametric) index insurance makes pay-outs based on an index (such as yields or rainfall) reaching a pre-specified threshold (or trigger) vis a vis traditional insurance that requires a more costly and less timely loss assessment process.

The project will support the development and tailoring of an index insurance product for the targeted populations. A participatory index design approach will enable tailoring the product with farmers and their needs, establishing triggers for the insurance pay-out and windows of protection. It will raise awareness and improve vulnerable farmers' access to insurance products. For these farmers, the insurance premiums will be initially subsidized by the project. The subsidy will be reduced gradually to enable farmers to transition to pay for-insurance themselves. The project might also identify mechanisms that enable public/private financial contributions (such as subsidies or fee reductions) to reduce premium costs. Specific details will be defined through analysis and consultation with the communities and identified partners during the micro insurance product design phase, with the aim towards long-term financial sustainability and scalability.

This approach of index insurance will be discussed with the Agrarian Insurance Institute (INSA), in order to coordinate their approaches within the framework of the insurances that this institution handles in Bolivia (Seguro Agrario Universal Pachamama that focuses on producers and Seguro Agrario Minka which focuses more on municipalities).

WATER FUND TARIJA.

The Municipal Government of Tarija, through the Secretariat of Environment and Territorial Management, with the support of other agencies such as the Swiss Agency for Development and Cooperation (SDC) and the Andean Development Corporation (CAF), carry out a conciliation process for the creation of a Water Fund that makes it possible to meet conservation needs, research and management related to the sustainability of the basin and sub-basins.

Several institutions and academic entities have participated in the process such as the non-governmental organization Protection of the Tarija Environment (Prometa), Nature, Land and Life (Nativa), the Jaina Studies Community, Fundación Natura Bolivia, the Domingo Savio Private University, the Bolivian Catholic University and the Juan Misael Saracho Autonomous University, as well as persons from the Water and Sewer Services Cooperative (Cosaalt) of the city of Tarija among others.

The Water Fund will implement actions such as reforesting, protecting aquifers and ordering and regulating water consumption in Tarija. On the other hand, so far progress has been made on fundamental issues such as the determination of the geographical space of action of the fund, since the Central Valley of Tarija is a single unit in which the aquifers that we take advantage of all those who producers of vines, winemakers, civil society living in the city of Tarija and adjacent municipalities that are part of the metropolis of Tarija are developed.

SANTA CRUZ WATER FUND.

Municipal governments in the Santa Cruz Valleys have pioneered the use of reciprocity agreements between upstream owners and downstream water users as a tool to conserve natural ecosystems and improve local livelihoods. In each case, communities downstream increased their drinking water rates to capitalize on local water funds that were then invested in protecting vegetation to ensure water production at the top. Many farmers from the Valleys have agreed to protect the forest in exchange for in-kind compensations, such as hives or fruit trees. Other communities closer to Santa Cruz are also trying to establish their own water funds, but the necessary initial capital is missing.

Under these considerations, the Santa Cruz Water Fund is under the establishment period, so that together with the Department's Governorate and some water cooperatives compensation packages can be established in kind to help upstream landowners finance the opportunity cost of watershed conservation while improving their income. In addition to protecting water supply and aquatic ecosystems, the project will help conserve 15,000 hectares of forest in the buffer zone of Amboró National Park. Approximately 1,000 upstream residents will receive assistance through the program and some 5,000 downstream water users will benefit from a safer water supply.

AGRARIAN UNION TAQUIÑA COCHABAMBA AND NATIONAL BOLIVIAN BREWERY.
National Bolivian Brewery (CBN for its acronym in Spanish) has signed an agreement with the Taquiña Agricultural Union (SAT) that launches the installation work of technical irrigation systems in the Taquiña community. This project will benefit nearly 109 producers, including florists and farmers.

Within the framework of the Environmental Pillar, corresponding to the Social Responsibility program, CBN will invest half a million Bolivians for a momentous change in the production of this sector of the city of Cochabamba. The signing of the agreement took place within the activities of the Flower Fair and in commemoration of The Day of the Environment.

CBN has decided to install a "Technified Irrigation" system, through which effective use of water will be made, which will allow the plots to have greater productivity. Material and technology consisting of geomembranes for wells or reservoirs, pipes, couplings, fittings and sprinklers will be delivered. In contrast, the SAT will put the workforce in the development of the project.

The brewer seeks to support the community with materials and technology to reduce the consumption of water intended for irrigation by changing the current modality. This will avoid damage to the production and sale of products from the region that may arise due to water scarcity.

Production in the Taquiña community is currently carried out with a flood irrigation system, a rotation mode. This methodology has been present for more than a decade in the community and has generated significant water losses, an element that is vital to conserve. The flood irrigation system makes the water consumption greater than that required by other systems, such as those that will be installed from the agreement signed this Friday. In addition, moisture caused in the foliar area and on the stem of plants, along with high temperatures, could cause fungi to appear.

CBN's support within the Convention will facilitate the installation of spray irrigation systems. The investment in spray irrigation is lower than that required by other systems, it is also ideal for hilly terrain and allows to dose the water with good precision. It does not affect the plant material under irrigation and, as its distribution is homogeneous, its coverage is total and is gently distributed over the entire desired area.

Within the Environmental Pillar of its CBN Social Responsibility Program it helps with the cleanliness of the taquiña community gaps, it is also an active part of cleaning and fixing water ducts. Thanks to the implementation of the Taquiña Effluent Treatment Plant, farmers receive quality water for irrigation. These actions will complement the work foreseen under the project.

COOPERATION WITH NATIONAL BANKS AND FINANCIAL INSTITUTIONS IN RECEM-VALLES.
With the implementation of the Law on Banks and Financial Institutions, as well as the establishment of the Productive Development Bank, it is prioritized within the framework of the General Law of the Financial System and the Insurance and Organic System of the Superintendency of Banking and Insurance, the granting of credit with unconventional guarantees.

Furthermore, in accordance with Supreme Decree 2137, Banking is subject to the implementation of guidelines governing the process of corporate social responsibility, the same one that has to do with the financing of environmental and social activities in which different issues related to the criteria and indicators of the Project could be worked on.

Fonabosque
FONABOSQUE works with GAMs and GADs through programs of reforestation, watershed management and recovery of the vegetation cover activities. Once the projects are awarded, the awarded party has to submit a co-financing of 20%, which constitutes new leverages. This 20% of co-financing funds allocated by GAMS and GADs, ensure the ownership, implementation and sustainability of the investments.

In relation to FONABOSQUE, under this activity, the following will be achieved:

- Build capacities to increase its possibilities to access other climate-related funding, helping the fund being incrementally capitalized. Activity 4.2.1 refers to fostering collaboration between domestic funders such as FONABOSQUE and financial institutions. Regarding the interest of the government to enhance FONABOSQUE´s capabilities, efforts to develop organizational and operational capacities will be part of the activities of the GCF project as it is also expected to accredit FONABOSQUE to international financing entities such as the Green Climate Fund, the GEF, among others.
- Provide technical support to elaborate a financial assistance plan with participation of the private sector and the banking sector; to evaluate and then strength their technical capacities (landscape approach, watershed management, environmental services, etc.); to identify a map of actors to better perform in the context of climate change that helps to define and implement a FONABOSQUE Institutional Strengthening Plan. These actions will allow the institution to manage new climate-related funding (Joint Forest Mechanism, etc.).

Table 49 Overview of the financial mechanisms and the link with project activities and selection criteria for beneficiaries.

Financial mechanism	Actors	Project interventions to mobilize finance via the mechanisms	Link with project activities	Beneficiaries profile and selection criteria
Climate resilient credits and concessional credits lines	Productive Development Bank (BDP), FINRURAL Association of Development Finance Institutions (FINRURAL)	***Customizing agriculture financial products and services for climate resilient agriculture:*** The project will *provide the following technical assistance*: (i) assess and map the needs of and impediments for farmers (especially smallholder farmers) to engage in climate resilient agriculture; ii) map the current range of products that BDP and FINRURAL provide to the farmers (iii) integrate principles of climate resilience (both ecological and social) into their portfolios of products and services; (iv) conduct research on effective and affordable innovations related to credit assessment, financial products, and delivery mechanisms; (v) design, test and implement climate resilient credits and concessional credit lines that are customized to climate resilient agriculture (primarily to smallholders); better address the needs of borrowers. These products will foster climate resilient, biodiverse, and restorative agriculture of ecosystem functions and services. ***Foster measure to enable agriculture financing policies:*** The Project will provide technical assistance for designing and implementing financing policies as follows: i) conduct legal and administrative mapping of barriers that prevent an increase in agricultural financing; (ii) design technical guidelines related to the current legislation to establish the climate resilient credits and concessional credits lines; (iii) develop and implement an incidence strategy to promote public agriculture financing and private	The mobilised financial flows from this mechanism will support the small-scale holders organizations and municipalities to access financial mechanisms for implementing climate resilient agriculture, to primarily: (i) access to upgraded climate-proofed irrigation systems; water harvest, management, and administration for stable irrigation at communal level (activity 2.1.3), (ii) develop and implement communal or associative productive enterprises (activity 1.2.1), (iii) setting up collection and marketing centers for organic and/ or agroecological products (activity 1.2.2), and implementing climate resilient value chain for promoting production diversification (e.g.,	Beneficiaries: Smallholder farmers Cooperatives and farmer associations Rural communities Municipalities on the Valles macro-region Selection criteria: • The applicant (Debtor) must be the owner of a micro or small productive unit. If the loan you are requesting is greater than Bs. 24,000, you must have at least 1 year experience in the productive activity to be financed. • Or the applicant (Debtor) can be an entrepreneur who, having had experience of at least 6 months in the corresponding productive activity, requires financing to start as the owner of his productive unit. • The debtor and spouse must not have credits in the regulated or unregulated system, except for the housing credit (current). • The debtor and spouse must not have a history of penalized credits in the

		investments in climate resilient credits and concessional credits lines and (iv) design the eligibility criteria for the financial products to determine the benefits that small farmers will receive from climate resilient credits and concessional credit lines.	beekeeping). The financing mechanism will serve to support the upscaling and sustainability of the activities under Components 1 and 2. Moreover, foreseen interventions will be linked to activity 4.2.1 regarding to partnering with existing domestic funders and financial institutions.	regulated and unregulated financial system. • The debtor must be between 18 and 60 years of age. • The debtor and spouse must have Bolivian nationality. • Areas of high vulnerability to the effects of climate change
National funding	FONABOSQUE	***Technical assistance for FONABOSQUE to improve and implement the financial program for sub-national governments at the Valles Macro region:*** Considering that sub-national governments are among the beneficiaries of FONABOSQUE, the project will provide technical assistance for the improvement of the FONABOSQUE financing program tailored to the requirements of departmental, municipal, and sub-municipal governments located in the Valles macro-region. This will be undertaken through an actor-oriented process, within which the staff of FONABOSQUE and sub-national governments, together with members of the consultative territorial platforms (to be established by the project) will work together to define the scope and priorities of the program - focusing on integral micro-watershed management and restoration of ecosystem functions and services for climate change resilience. In this regard, the technical assistance will ensure that FONABOSQUE financing program integrates the inclusion of climate change mitigation and adaptation based on	The FONABOSOQUE financial assistance will support the development and implementation of integral micro-watershed management for climate resilience (activity 3.1.1); and restoration of ecosystem functions and services (activity 3.1.2). Given the participatory and actor-oriented process to be implemented in the coordination with FONABOSQUE and sub-national government, the territorial consultative platforms will also be activated and strengthened (activity 4.3.2). The actions under this financial	Beneficiaries: Sub-national governments (departmental, municipal and sub-municipal levels) Rural communities Farmers located at the micro-watersheds included in projects funded by FONABOSQUE Selection criteria: • In the calls, FONABOSQUE may also establish the following additional prioritization criteria for the evaluation of projects: • Social, environmental and economic impact • Development of the project in rural communities preferably.

		integrated forest management and restoration of conservation easements and water sources, as well as carbon sequestration and sequestration, soil organic matter. ***Strengthening capacities of FONABOSQUE's staff in climate-resilient approaches:*** The project will provide capacity building to the executive and technical personnel of FONABOSQUE, to develop their understanding of integral micro-watershed management, restoration of ecosystem functions and services for climate change resilience, with a view to include such products in their financing criteria***.*** ***Strengthening capacities of sub-national governments in development of funding proposals to FONABOSQUE:*** Sub-national government staff and participants of the consultative territorial platforms will be trained in the formulation of proposals, to be presented to FONABOSQUE, for financing integral micro-watershed management and restoration of ecosystem functions and services for climate change resilience. ***Strengthening capacities the territorial platforms to prioritize co-financing allocations for climate resilient projects***: Considering that FONABOSQUE provides a maximum funding of 70% of the total project costs, RECEM Valles will train the consultative territorial platforms in designing and prioritizing annual public budgets. This will enable the 30% of local, public contribution to implement the projects to be submitted to FONABOSQUE.	mechanism will be linked to activity 4.2.1 on partnering with existing domestic funders and financial institutions.	• Comprehensive and sustainable forest management • Transfer of innovative and accessible technologies for the sustainable use of timber and non-timber forest products. • Decrease in deforestation levels in permanent forest production lands. • Restoration of forest lands in the process of degradation or vulnerable. • Reestablishment or implementation of conservation easements. • Promotion of forest plantations. i) Other strategic criteria defined by FONABOSQUE.
Risk-indexed micro insurance	National Institute of Agricultural Insurance (INSA)	In terms of agricultural insurance, the project will initiate the development and implementation of a specific agricultural insurance for the Valleys Macro region,	The agricultural insurance provided by INSA will especially benefit farmers most	Beneficiaries: Smallholder farmers Cooperatives and farmer associations

		which will consider the application of non-conventional guarantees, and generate economic and productive reactivation processes and investment in traditional agri-food systems that are resilient to climate change. **Design of the risk- indexed micro insurance:** The project will provide technical assistance in the design of the risk-indexed micro insurance for the Valles Macro region in a highly participatory manner. In this regard, roundtables will be organized to provide a platform to engage between farmers, INSA and relevant stakeholders, to ensure that the design takes into consideration the needs and the local situation of the most vulnerable farmers. **Design and dissemination of the implementation methodology**: Technical assistance will be provided to support the design of a methodology for implementing and accessing financial and insurance mechanisms, The methodology will also include operational details and a strategy for roll-out and scaling up the risk-indexed micro insurance to other insurance institutes and other geographical areas within Bolivia. **Capacity building of relevant local actors:** smallholder farmers and their organizations, will receive capacity building support on the relevant procedures required to secure insurance against damages (to their produce) caused by climate events and natural disasters. To be able to deliver on the capacity building, educational material will be developed in innovative formats targeting the most vulnerable farmers. The capacity building will include disseminating the agroclimatic	vulnerable to climate change. This will encourage smallholder farmers to make investments to support their agricultural activities from a climate resilience perspective, contributing (activities 1.1.1 and 1.1.2). The information generation will be linked to activity 4.3.2 and 4.3.. Moreover, the participation of the agroclimatic platforms, will add to the activity 4.3.3. Based on above, INSA as financing mechanism, will support the upscaling and sustainability of the following activities 4.2.1.	Rural communities Selection criteria • The following are identified as beneficiaries of the Universal Agrarian Insurance "Pachamama": - Peasant, intercultural and Afro-Bolivian native indigenous communities with collective production; - Indigenous native peasant intercultural and Afro-Bolivian families with individual production; - Agricultural producers are heads of households or groups; that meet the requirements established by regulation. - Areas with high vulnerability to the effects of climate change

		information necessary to apply agriculture risk reductions practices to avoid losses. **Provision of agro climatic information relevant to insurance decision-making:** Through the institutional strengthening of public information services (such as SENAHMI and MRDyT). The project will help to enable agro climatic platforms and the meteorological, weather and hydrological information. This will enable constant access for INSA and its beneficiaries, to the information required for decision making about production planning and protection. With this, the project will enable wider access to insurance products for the most climate vulnerable smallholder farmers.		
Water Funds	Water Fund Tarija, Santa Cruz Water Fund, Agrarian Union Taquiña Cochabamba, and National Bolivian Brewery	**Improvement of water fund mechanism:** Staff of the different water funds will receive technical assistance to ensure that their funds are designated towards the improvement of on integral micro-watershed management, restoration of ecosystem functions and services, and climate resilient agriculture. The technical assistance will aim to: 1. Develop a line of financing for mitigation and adaptation to climate change, with the aim of generating sustainable and resilient agricultural practices, revitalizing irrigation systems through the technification of the current flooding system, conserving water sources and recovering ecological easements, as well as preventing and controlling agricultural risks. 2. Revise the funding criteria and the funding mechanism, including improved monitoring and evaluation frameworks as it relates to climate change adaptation and mitigation to be able to report on the implementation of	The Water Funds can be used for actions to support the implementation of climate resilient agriculture (activity 1.1.1 and activity 1.2.3); integral micro-watershed management for climate resilience (activity 3.1.1); restoring ecosystem functions and services (activity 3.1.2) for protecting the headwaters of the basin and forests. The development and implementation of the local watershed plans and to ensure that identified interventions	Beneficiaries: Smallholder farmers Cooperatives and farmer associations Rural communities Selection criteria: • The criteria for prioritizing water funds are: - Land title of the beneficiary - Be located in a water recharge area - Manifest willingness to change the production system for at least 5 years - Signing of an agreement for the conservation of water sources and responsible management of water resources.

		the funds and hence contribute to the PDES and the NDCs sectoral strategies. **Capacity building of potential beneficiaries**: Through the project, smallholder farmers, their organizations and the consultative territorial platforms, will receive capacity building on the relevant procedures and requirements to enable the farmers to access the water funds.	might be considered with the participation of the constituencies to be promoted by the project (i.e., the territorial consultative platforms) will support activity 4.3.3. The work to the carried out with the water funds, enhance the upscaling and sustainability of the following activities 4.2.1	

Activity 4.2.2 Strengthen the capacities of communities, smallholders and associations on financial literacy, management and access to innovative financial instruments relevant for climate resilient agriculture, ecosystems conservation schemes, climate-proofed irrigation systems.

Stakeholders (communities, smallholders and producers associations) will be trained to ensure they are enabled to access and manage finance for climate resilient agriculture, ecosystems conservation schemes, climate-proofed irrigation systems.

This activity aims to deliver training to key stakeholders to ensure they are enabled to access finance for climate adaptation actions.

Sub-activities:

- Design a training methodology accessing financial and insurance mechanisms.
- Strengthen capacities of communities, smallholders and associations on financial management
- Organize roundtables to connect farmers with financial and insurance entities

Deliverables:

- One methodology designed
- 20,680 persons trained.
- At least four roundtables realized.

Description:

Currently there is little culture of investment through agricultural loans. Parallel to improving agricultural insurance and supporting small producers with loans, training will be given on productive loans. This activity will have the support of the BDP, which as part of the projects it is supporting, producers are assisted with financial education.

Indigenous and/or peasant communities must have specific technical capacities that enable them to adapt to changes in the use of agricultural techniques and modern technologies that are complementary to their traditional knowledge. In addition, they need to understand and move towards access to productive credit to strengthen the resilience of their livelihoods. In this sense, the project will target strengthening capacities of local stakeholders on relevant innovative financial instruments to facilitate access to climate finance that ensures sustainability of project investments beyond project span, see inTable 49. Capacity building will take place on two levels:

Institutions:

- BDP, FINRURAL to receive capacity building with the purpose of strengthening their competences to design and implement efficiently financial instruments and mechanisms that foster climate resilient, biodiverse and restorative agriculture of ecosystem functions and services.
- Strengthening capacities of water funds staff on funding for climate resilience: to improve their funding criteria regarding integral micro-watershed management, restoration of ecosystem functions and services, and climate resilient agriculture.

- Strengthening capacities of FONABOSQUE's staff in climate-resilient approaches: to develop and include in their financing criteria integral micro-watershed management and restoration of ecosystem functions and services for climate change resilience.
- Sub-national government staff as well as participants of the consultative territorial platforms, will be trained by the project in the formulation of proposals, to be presented to FONABOSQUE, for financing integral micro-watershed management and restoration of ecosystem functions and services for climate change resilience.

Farmers/communities:

- Capacity building of relevant local actors on INSA: smallholder farmers and their organizations, will receive capacity building on the procedures and requirements to be entitled to insure their production against damages caused by climate events and natural disasters.

The beneficiaries are prioritized in the municipalities with high vulnerability to climate change, as explained in chapter 8. A total of 2,224 people will benefit from the trainings, including 1,156 male and 1,068 female participants. Beneficiaries for this activity will be selected based on:

i) Family farmers living in areas with very high and high risk of droughts, hailstorms and floods especially those farmers who have benefitted from project interventions in Component 1, 2 and 3.
ii) Family farmers who are members of irrigation associations.
iii) Family farmers producing products for basic food supply

Output 4.3. Strengthening local governance in participatory climate adaptation and early warning systems

Total GCF budget is 1.59 M to be executed by FAO and 0.3 M from FAM co-financing, to be executed by FAM. The contribution of FAM is only for activity 4.3.3. The number of direct beneficiaries for the GCF contribution is 81,551 of which 42,407 are males and 39,144 are females. For FAM contribution, the total direct beneficiaries are 400 of which 208 males and 192 females (only applicable for activity 4.3.3).

Activities under this output will ensure local governance structures have strong capacities to ensure the sustainability of the climate-adaptation investments beyond the project span. Particularly, SENAMHI and MDRyT will improve their capacities for information and data generation and dissemination. This information will be channeled through coordination and consultative territorial platforms and agroclimatic platforms to be established under the project with differentiated roles and objectives.
Lastly, systematic evaluation of damages and losses due to natural disasters in agriculture in the Valleys Macro-region will be facilitated through the development of common methodologies; the capacities to collect, store and analyze data to enable evaluation, monitoring and knowledge management of lessons learned through the implementation of the project, will also be strengthened.

This output consists of the following activities:

Activity 4.3.1 Capacity strengthening for local stakeholders (including smallholders, public officers, local CSOs, and relevant academia and private sector) on the integration of climate change risks for decision making to increase the resilience of smallholders and communities. The number of direct beneficiaries are 800 of which 416 are males and 384 are females.

Activity 4.3.2 Establish coordination and consultative territorial platforms (to facilitate climate change adaptation mainstreaming into the participatory implementation of policies and strategies) in accordance with the Comprehensive Management Plan for Watershed Resources and Integrated Watershed Management. <u>The number of direct beneficiaries are 800 of which 416 are males and 384 are females.</u>

Activity 4.3.3. Enhance capacity of municipalities to strengthen the monitoring and reporting base for the macro region related to climate change impacts. <u>The number of direct beneficiaries are 400 of which 208 males and 192 females.</u>

Activity 4.3.4. Generation and collection of evaluative data for the project. <u>The number of direct beneficiaries are 81,551 of which 42,407 males and 39,144 females.</u>

Activities under this output will result in community strengthening in administration and distribution of benefits, organizational and technical development for productive systems, and technical irrigation resilient to the climate with gender and generational approach.

Activity 4.3.1 Capacity strengthening for local stakeholders (including smallholders, public officers, local CSOs, and relevant academia) on the integration of climate change risks for decision making to increase the resilience of smallholders and communities

This activity aims to strengthen institutional capacities to govern the Early Warning System for Agricultural Risks' implementation process to provide timely information to local producers and decision-makers through the coordination and consultative territorial platforms as key channels of information for the smallholders and communities

Sub-activities:

- Integrate the municipalities of the Macro region of the Valleys into the national Early Warning System.
- Strengthen the dissemination of timely information to local producers

Deliverables:

- At least 80% of the municipalities established protocols for EWS dissemination
- At least 80% of the municipalities are linked to the national EWS to provide and receive agroclimatic information.

Description:

The increase in the intensity and frequency of extreme weather events has become one of the main challenges for agriculture and has resulted in an increase in public spending on response and rehabilitation of productive capacities that is becoming unsustainable for the States. In the last two decades, the agricultural sector and in particular family farmers and small and medium-scale agricultural and livestock sub-sectors have been affected by the aggravation of droughts, hailstorms, overflowing rivers, floods and frosts. These are causing diseases and pests that affect productivity conditions, consequently impacting food security, a situation associated with climate change and variability. The country's geographical location and the diversity of ecological levels determine a complex distribution of climate types, with social, economic and productive particularities. In this context, the agricultural sector is the most sensitive to the effects of disaster risk because it is highly dependent on interannual climate variability influenced by the ENSO phenomenon (El Niño Southern Oscillation) and by the incidence of extreme weather events due to climate change.

In Bolivia there are currently many institutions that generate data on agriculture, forestry and fisheries, but there is still a need to harmonize methods and variables to consolidate the information or database to estimate these damages and losses. Bolivia has developed an early warning system for agricultural risks, which serves as a warning system to mitigate the impacts of extreme weather phenomena, such as hail, frost, floods, drought and fires. The national EWS is expected to reach the plot level in prevention actions and also to identify damages and orders when the loss has developed.

FAO has been working in recent years on the establishment of risk management units at the municipal level, which periodically feed information to the SNAT and have developed protocols for the dissemination of the alert, allowing beneficiaries to receive agro-meteorological information in good time for decision making.

The current Agricultural Early Warning System (SAT AGRO) is only one component of SIPGRA and is not sufficient to meet the needs for warnings and contextualized information, mainly for the needs of small producers in the different agricultural production areas. At the national level, the SAT has warning communication protocols that are downscaled at the municipal level in most cases. Efforts are currently being made with SENAMHI MDRyT to reach the plot level. As part of these efforts, farmers will be reached through different mechanisms and platforms, including official communications through the UGRs (Risk Management Units), Rural Radio Stations, social networks, whatsapp, etc.

The project will contribute to strengthening the network of agro-meteorological stations, as well as improving the information and its timely distribution so that it can reach the beneficiaries, so the beneficiaries, the farmers, can make informed decisions on the agricultural production, such as the selection of crops (which crops would be more suitable related to the climate), crop calendar (when is as good time to sow and to harvest), and others. Methods of ensuring the information can reach the farmers will be improved, such as through user-friendly mobile applications and the Farmer Field School network.

The extreme phenomena (variables) that will be monitored are drought, frost, hailstorms and floods, which are causing considerable damage to small farmers' crops. The purpose of this data will provide for a repository of relevant climate data that can be used for climate modelling purposes, to further refine the climate trends that can be expected in the future. In addition, other variables to be monitored will be the water levels of reservoirs and rivers, as well as levels of soil degradation and forest cover. These variables are necessary to determine the success factor of the proposed interventions not only of this project, but of all other interventions being implemented in the project area.

According to the MDRyT, and the analysis of events reported at the historical level, summarizes the total number of events recorded by department between 2002-2015 with a total of 4,770 events with an average of 530 records per year mainly due to hailstorms, frost, floods and droughts. On the other hand, each dollar invested in early action to prevent and mitigate impacts of an adverse climate forecast in the agricultural sector generates an estimated return of between US$2.5 and 7.1 in avoided losses and damages and added benefits. It is essential to develop public policies, institutional capacities and coordination mechanisms for DRM and climate change in the institutional framework that deals with agriculture and natural resources.

In this sense, within the framework of the methodology of damages and losses, information will be generated to make it possible to compensate the damage caused by the extreme weather phenomenon through the application of agricultural insurance, the generation of voluntary compensations, among other elements that restore at least the investment generated by the farmer in the affected agri-food production system.

This activity will increase households, communities, and local institutions' resilience to prevent and deal more effectively with threats and disasters that affect agriculture and food security in the Macro-region. In this activity, training will be offered to 58,000 participants from indigenous and peasant communities as well as public officers, CSOs and academia. As a result of this training, the communities will set up governance systems that will increase their local resilience. The criteria to select participants for the capacity development under activity 4.3.1 will include the following elements:

✓ In the case of smallholders and farmers, they have to live in areas with very high and high risk of droughts, hailstorms and floods, and preferably would also have benefitted from project interventions in Component 1, 2 and 3.

- In the case of representatives of local CSOs, academia, their activities must have geographical proximity and be circumscribed to the target area. Must have strong ties to the communities and their mandate/area of work must have relevance for the sustainability of activities implemented under this project
- In the case of public officers, the participating institutions will be identified based on alignment between the proposed activities and the organizations' mandates, political roll, expertise and/or services delivered and territorial representation in the project target areas (note that these determinations have been/will be made by the Project Coordination Committee in consultation with the Territorial Consultative Platform and the Ministry of Environment and Waters); Identified organizations will be invited to nominate staff to participate in the activities based on the alignment between the contents of the proposed activity (e.g. technical focus of the training) and the respective beneficiaries' responsibilities and expertise within their organization

Activity 4.3.2 Establish coordination and consultative territorial platforms (to facilitate climate change adaptation mainstreaming into the participatory implementation of policies and strategies) in accordance with the Comprehensive Management Plan for Watershed Resources and Integrated Watershed Management.

This activity aims to strengthen coordination and consultative territorial platforms in line with Comprehensive Management Plan for Watershed Resources and Integrated Watershed Management and facilitate key stakeholders in decision making processes

Building inter-institutional risk management platforms provides a favorable environment for producers and local authorities in order to create spaces for dialogue, construction, and feedback for decision-making. In this activity, territorial advisory platforms for comprehensive and resilient water management and sustainable production systems will be set up and strengthened.

The project will aim at strengthening the territorial platforms for the implementation of early warning systems for agricultural risks. Training in the management and implementation of early warning systems for agricultural risks for timely reactions to prevent disasters. This is especially important in municipalities with high risks of hail and frost. With the platforms, it is possible to implement early warning systems for agricultural risks at the level of regions and municipal associations

Sub-activities:

- Strengthen and implement the territorial platforms for the prevention and control of agricultural risks
- Implement stakeholder consultations with key stakeholders to strengthen their capacities and ensure their full participation in the platform
- Develop guiding materials for the operation of the platforms

Deliverables:

- At least 7 territorial platforms for comprehensive and resilient water management and sustainable production systems have been strengthened and/or set up.
- Guiding documents for facilitation of platforms prepared

The following selection criteria will be used for the selection of direct beneficiaries under this activity:
i) Municipalities where family farmers are residing that have very high and high risk of droughts, hailstorms and floods especially those municipalities who have benefitted from project interventions in components 1, 2 and 3.
ii) Areas of family farmers producing products for basic food supply
iv) Municipal governments that show willingness to include a specific budget in their annual budget plans for aspects of mitigation and adaptation to climate change

Activity 4.3.3. Enhance capacity to strengthen the monitoring and reporting base for the macro region related to climate change impacts

This activity aims to strengthen the capacity of municipalities in using mainstreamed methodology to assess the damage and economic losses of (extreme) climate change as well as gathering the data and information related to the monitoring of the project indicators. This activity will be financed only by FAM co-financing, of USD 0.3 M and executed by FAM.

Sub-activities:

- Implement stakeholder consultations with key stakeholders to strengthen their capacities and ensure their full participation
- Implement capacity building for the relevant government officials to use the methodology and analyze the data and to be able to use the results for decision making

- Promote the implementation of a common methodology for the systematic evaluation of damages and losses due to disasters in agriculture in the Valleys Macro-region to assess agricultural damages and losses for temporary monitoring that supports decision-making for investments in more efficient techniques and technologies to face climate change risks
- Replicate and implement the methodology for the evaluation of damages and losses and its monitoring in the project intervention area

Deliverables:

- One training program to strengthen the capacity of Municipalities in monitoring and reporting climate change impacts.
- One methodology to assess damage and losses disseminated and implemented

Description:

One of the key aspects for reducing the damage and economic losses resulting from disasters is to quantify these damages and losses. Knowing this reality promotes and informs the design and implementation of policies to reduce these impacts. Today, governments and multilateral organizations assess damages and losses when major disasters occur, but they do not use methodologies that allow them to capture the specificities of the agricultural sector. It is therefore difficult to achieve accurate assessments. Moreover, there is no capacity in place at the national level to do so systematically. As a result, data are usually only available for large-scale emergencies, and the real economic loss suffered by the sector is underestimated when all adverse events are added together.

For this reason, the Food and Agriculture Organization of the United Nations (FAO) has developed a methodology to assess the damage and economic losses of small, medium and large-scale emergencies in all agricultural sectors (crops, livestock, forestry, fisheries and aquaculture). Since 2016 FAO has been supporting countries to become familiar with the methodology, understand its complementarity with other tools and how it facilitates the reporting of damage and loss indicators of the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals (SDGs).

To support capacity building in damage and loss assessment, FAO now offers a free online course in Spanish so that public service technicians, academics, insurance companies and other interested parties can learn more about the subject and understand its link with disaster risk management, emergency management, other methodologies and international frameworks. In addition, there is an advanced course that provides all the technical guidelines necessary for its practical application.

Activity 4.3.4. Impact evaluation and developing knowledge management products

This activity will generate and collect evaluative data to document lessons learned, best practices and generate evidence for the project impact on the reduction of farmers' vulnerability to climate change impacts. To be able to monitor the indicators at Component and impact level (as indicated in Annex 11, M&E), data needs to be collected in the field. This activity will support the data collection, and where local municipalities will be trained to improve their capacities to collect and analyze this data. This will also support the monitoring at municipal level of other project, programs and initiatives of the government, including the monitoring on NDC progress.

Knowledge management products will be designed and developed taken into consideration the local knowledge and context and the different audiences for these knowledge management products. The audiences for these products would be: 1) the Government representatives such as officials working at the municipalities and different government institutions such as the Ministry of Water and Environment (MMAyA), FONABOSQUE, and others and 2) local farmers and community members. According to the needs and the context of the audience, different types of knowledge management products will be developed. ● Local municipalities will also be involved in the design and the collection of data for the knowledge management products.

Sub-activities:

- Design the knowledge management strategy
- Develop the impact evaluation methodology
- Train local municipalities in collecting and analyzing data according to the impact evaluation methodology
- Implement field inspections to gather the data necessary according to the impact evaluation methodology
- Develop and disseminate the knowledge management products with data and information that will be generated from the project.

The knowledge management products will be disseminated through the various local community platforms such as the irrigation committees, agricultural associations and farmer field schools with the objective to share best practices and lessons learned not only within the project area, but also to other regions in Bolivia.

Deliverables:

- Two impact evaluation progress reports
- Five knowledge management products

One training report

19. Implementation arrangements

Governance arrangements

The following governance mechanisms for project execution, coordination and oversight have been agreed in close consultation with the Ministry of Environment and Water (MMAyA – on behalf of the GoB) and the Federation of Associations of Municipalities (FAM)
FAO will serve as both Accredited Entity (AE) and Executing Entity (EE) (GCF proceeds) for this project with a set-up that supports strong government ownership and implementation and serves the capacity development objectives of the project. The GoB, acting through MMAyA, and the FAM will also be Executing Entities for the activities that are funded with their own resources.

Accredited Entity Role

In its role as AE, FAO will be responsible for the overall management of this project, including: (i) all aspects of project appraisal; (ii) administrative, financial, and technical oversight and supervision throughout project implementation; (iii) ensuring funds are effectively managed to deliver results and achieve objectives; (iv) ensuring the quality of project monitoring, as well as the timeliness and quality of reporting to the GCF; and (v) project closure and evaluation. FAO will assume these responsibilities in accordance with the detailed provisions outlined in the GCF policies as well as Accreditation Master Agreement (AMA) and Funded Activity Agreement (FAA) between FAO and GCF.
To perform these AE functions, FAO will set up a FAO-GCF project supervision team comprising relevant staff from the FAO Country Office in Bolivia, the FAO Regional Office for Latin America and the Caribbean in Santiago (Chile), and FAO Headquarters in Rome. The project supervision team will remain independent of the EE functions also performed by FAO (see below).

Executing Entity Role

FAO will also act as Executing Entity through the FAO Representation in Bolivia and it will be responsible for the management of the GCF proceeds and will bear the overall responsibility for fulfilling the EE functions of this project.

More detailed implementations arrangements of the project are described in Figure 70.

Project Implementation Arrangements

The project will be implemented under the following structure:

a. **FAO,** the AE, will act as the EE for all GCF-funded project activities and will be responsible for the GCF proceeds.. In this context, FAO Office in La Paz- Bolivia will set up a Project Management Unit (PMU) with project-recruited staff. This PMU will coordinate the work of four Territorial Operating Units (TOUs), each with a combination of project-recruited staff as well as government staff. Led by the PMU, these units will collectively perform all EE functions on this project, including (inter alia) the preparation of Annual Work Plans and Budgets (AWPBs) in collaboration with key government counterparts, and the overall day-to-day project management, monitoring project progress, and reporting to the Project Steering Committee (PSC) and FAO-GCF project supervision team. These units will work with relevant partners to deliver individual outputs and activities, as outlined below. Along with specialized FAO technical experts who will directly support the project, the project-recruited staff and government staff in the PMU and TOUs will collectively comprise a project delivery team. This project delivery team will lead the execution of all GCF-funded activities included in this project. FAO will ensure that there is no direct overlap between (i) the staff who comprise the project delivery team, and (ii) the staff who comprise the project supervision team and fulfill FAO's AE functions. This will ensure built-in project oversight and supervision functions are fulfilled.

b. **The GoB, acting through MMAyA, and FAM** will be EEs for activities funded by their co-financing resources. As such, they will be responsible for managing and executing their co-financing funds but will not execute any GCF Proceeds. The GoB, acting through MMAyA, and FAM will coordinate the implementation of these activities through the Project Steering Committee.
c. The **PSC** will be the highest level of project governance, and will guide overall project implementation, ensuring inter-institutional coordination. The PSC will be comprised of high-level representatives from MMAyA, MDRyT, MDP, FAM, and FAO. MMAyA will chair the PSC and FAO will act as the Secretariat. FAO will keep the documentary and logistical record for the operation of the PSC.
d. A **Technical Committee (TC)** will be responsible for the overall project coordination and for ensuring its strategic approach, coordination among the partners and consistency of the outputs with the project's strategic framework. The TC will be comprised of technical staff from MMAyA, MDRyT, MDP, FAM, and FAO. MMAyA will chair the TC and FAO will act as the technical secretariat and provide support to the TC. The Executing Entities through Steering will retain final decision-making over the implementation of the Project and the use of proceeds and other final decisions and approvals
e. A **Project Management Unit (PMU)** will be responsible for the implementation of the project. The PMU is the technical-administrative unit for the project. The personnel for the PMU and TOUs will be procured and hired by FAO. The PMU coordinator and a team will be hosted in the offices of MMAyA in La Paz. The PMU will coordinate and support project implementation, performing day-to-day implementation, coordination, and supervision activities during the project lifecycle, operating in close consultation with the governing structures of the project. While the PMU will be located physically at MMAyA's offices, it will remain under the supervision of FAO, as EE. The PMU will follow FAO´s operative procedures and will operate according to AWPBs approved by the TC. Key administrative matters of the project (including procurement and financial plans, periodic reports, etc.) will be approved by the TC. The PMU will include the following staff (*inter alia*): (i) Project Coordinator, (ii) Finance assistant, (iii) M&E Specialist, (iv) Gender Specialist, (v) Knowledge Management Specialist, and (vi) Administrative assistant. All roles and responsibilities of PMU staff are described in more detail in Section 7 of the Feasibility Study.
f. Four **Territorial Operating Units (TOUs)** working at the local level will be established to serve as the key channel of communication between the PMU and local stakeholders and to assist with the implementation of activities on the ground. TOUs will be located in Cochabamba, Potosí, Sucre, and Tarija. Each TOU will be headed by a Regional Project Director, supported by technical staff including, for example, (i) Agronomists, (ii) Farmer Field School Specialists, (iii) Gender and Nutrition Specialists, and (iv) Safeguards Specialists, as appropriate. The Regional Project Director will ensure effective liaison and coordination with the PMU and other TOUs during the implementation of the project activities.

The governance and implementation structure and flow of funds for the project are shown below (Figure 70).

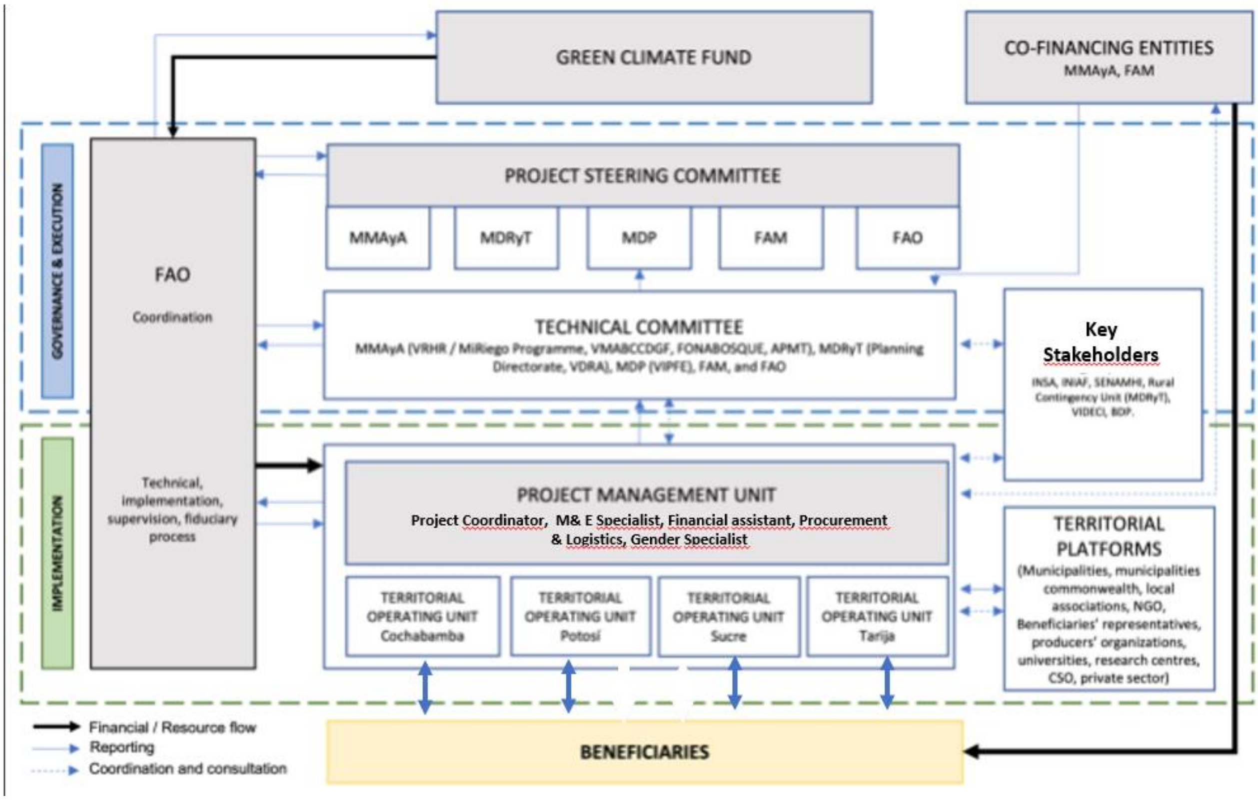

Figure 70 Governance structure of the project.

Annual reports

- The PMU will prepare Annual Reports for each year of implementation and FAO will review/clear them. The Project Director of the PMU and the M&E Specialist will ensure that the indicators in the results framework are monitored and reported annually. Annual Reports will be shared with the PSC, TC and other stakeholders. Annual Reports will be due to GCF 60 days after the end of the calendar year. The final Annual Report and the terminal evaluation report will serve as the final project report package.

Table 50 Roles and responsibilities of the key governance entities

Institution	Responsibilities
Project Steering Committee (PSC)	• Provide political and strategic orientation to the implementation of the project. • Recommend strategic elements based on the project progress, results and impacts. • Ensure alignment of the project with national policies. • Ensure transparency of processes. • Promote ownership of actions for addressing climate issues by national authorities. • Ensure sound inter-institutional coordination.

	• Ensure that co-financing is delivered in a timely manner.
Technical Committee (TC)	• Review and approve annual workplan and budgeting. • Monitor implementation, and safeguards compliance. • Invite, where relevant, to partner entities representatives or other relevant institutions to participate in special informative meetings. • Mobilize timely technical expertise from the participating institutions as per the agreed work plan. • Serve as a key channel of communication between PMU and key local stakeholders. • Assist in the implementation of the stakeholders' participation and engagement plan. • Assist in communication strategy of the project at the local level.
Project Management Unit (PMU)	• Prepare AWPBs for review and approval by the TC and FAO. • Report on annual/semiannual basis to FAO (results base, financial progress, etc) to complete the Annual Performance Reports (APR) to be submitted to the GCF and request of subsequent disbursements. • Establish and supervise TOUs for project implementation at the local level. • Ensure that recommendations by TOUs are discussed and addressed ensuring project adaptive management. • Manage the procurement, contracting, administrative and accounting process needed under the direct and permanent control, monitoring, and supervision of FAO. • Collect data and ensure reporting to the PSC is in accordance with the reporting to be provided to GCF.
FAO	• Responsible for the reporting, monitoring, implementation and fiduciary management of activities funded by GCF Proceeds. • Responsible for the reporting, monitoring, implementation, and financing of the co-financed activities. • Responsible for supervising the performance of the PMU and the timely delivery of management services provided by the PMU.
MMAyA	• Member of the Steering committee in charge of ensuring the integrated management of water resources for irrigation and food security, as well as the integrated management of the environment and life systems to Live Well. • Responsible for managing and executing co-financed funds provided. • Co-financier
FAM	• Member of the Steering committee that will ensure participation of selected municipalities in the project execution • Responsible for managing and executing co-financed funds provided.

	• Co-financier
APMT	• As National Designated authority, will supervise the project activities comply with the country’s national priorities for Climate Change
MDRyT	• Member of the steering committee in charge of ensuring that the implementation of the project produces decent employment for producers, communities, farmer and indigenous economic organizations and the business sector, under the principles of quality, equality, inclusion, transparency, reciprocity and cultural identity for food safety and sovereignty to Live Well.

	Financing/ Co-Financing (million (USD)	Financing source	Executing Entity (EE)	Project Partners/Financial Institutions (PP/FI)	Activities
Output 1.1 Climate resilient agriculture implemented and managed by smallholders for increasing the productivity and sustainability of their agroecosystems	F: 9.0 M	GCF	FAO		Activity 1.1.1 Activity 1.1.2
Output 1.2 Support on market access and development for climate resilient agricultural products	F: 1.9 M	GCF	FAO		Activity 1.2.1 Activity 1.2.2. Activity 1.2.3.
Output 2.1 Enhanced and modernized on-farm climate-proofed irrigation systems	F: 9.6 M	GCF	FAO		Activity 2.1.1 Activity 2.1.2 Activity 2.1.3
	CF: 21.5 M	MMAYA	MMAYA		Activity 2.1.1.
Output 2.2 Capacity building for the management of on-farm climate-proofed irrigation systems	F: 3.6 M	GCF	FAO		Activity 2.2.1. Activity 2.2.3
	CF: 1.0 M	MMAYA	MMAYA		Activity 2.2.2
	CF: 0.2 M	FAM	FAM		Activity 2.2.4
Output 3.1 Sustainable micro-watershed management for enhanced climate resilience	F: 5.1 M	GCF	FAO		Activity 3.1.1. Activity 3.1.2
	CF: 7 M	MMAyA	MMAyA		Activity 3.1.2
Output 3.2. Information and long-term monitoring system for water sources at place.	F: 0.92 M	GCF	FAO		Activities 3.2.1

Output 4.1 Strengthening capacities for national and sub-national government entities to implement policies and norms for the climate-resilient food production under irrigation systems, integral watershed management and monitoring of ecosystem functions and services	F: 0.205 M	GCF	FAO		Activity 4.1.1. Activity 4.1.2.
Output 4.2 Financial mechanisms for supporting climate-resilient agricultural production and irrigation systems to mobilize increased finance for farmers	F: 0.70 M	GCF	FAO		Activity 4.2.1.
Output 4.3 Strengthening local governance in participatory climate adaptation, early warning systems and long-term monitoring systems	F: 1.2 M	GCF	FAO		Activity 4.3.1 Activity 4.3.2 Activity 4.3.4
	CF: 0.20 M	FAM	FAM		Activity 4.3.3.

	Financing/Co-Financing (million (USD)	**Financing source**	**Executing Entity (EE)**	**Activities**
Output 1.1 Climate resilient agriculture implemented and managed by smallholders for increasing the productivity and sustainability of their agroecosystems	F: 11.45 M	GCF	FAO	Activity 1.1.1 Activity 1.1.2
Output 1.2 Increased market access of climate resilient agricultural products	F: 4.41 M	GCF	FAO	Activity 1.2.1 Activity 1.2.2. Activity 1.2.3.
Output 2.1 Enhanced and modernized on-farm climate-proofed irrigation systems	F: 5.33 M	GCF	FAO	Activity 2.1.1.A Activity 2.1.2 Activity 2.1.3
	CF: 20.5 M	MMAYA	MMAYA	Activity 2.1.1.B
Output 2.2 Strengthened capacities for the management of on-farm climate-proofed irrigation	F: 1.9 M	GCF	FAO	Activity 2.2.1. Activity 2.2.3

	CF: 1.0 M	MMAYA	MMAYA	Activity 2.2.2
	CF: 0.2 M	FAM	FAM	Activity 2.2.4
Output 3.1 Restored and conserved ecosystem management for enhanced climate resilient watersheds	F: 4.18 M	GCF	FAO	Activity 3.1.1. Activity 3.1.2A
	CF: 6.6 M	MMAyA	MMAyA	Activity 3.1.2B
Output 3.2. Information and long-term monitoring system for water sources at place.	F: 0.51 M	GCF	FAO	Activities 3.2.1
Output 4.1 Strengthening capacities for national and sub-national government entities to implement policies and norms for the climate-resilient food production under irrigation systems, integral watershed management and monitoring of ecosystem functions and services	F: 0.28 M	GCF	FAO	Activity 4.1.1.
Output 4.2 Improved financial mechanisms that support climate-resilient agricultural production and irrigation systems to mobilize increased finance for farmers	F: 1.84 M	GCF	FAO	Activity 4.2.1. Activity 4.2.2
Output 4.3 Strengthening local governance in participatory climate adaptation, early warning systems and long-term monitoring systems	F: 1.85 M	GCF	FAO	Activity 4.3.1 Activity 4.3.2 Activity 4.3.4
	CF: 0.30 M	FAM	FAM	Activity 4.3.3.

20. Identified risks

The following risks and appropriate mitigation strategies are identified below inTable 51.

Table 51 **Risk table**

Risk	Probability	Impact	Mitigation strategy
Limited implementation of commitments by political decision-makers in the design, preparation, presentation and public investment of the project	Medium	Medium	The design of the project has been co-created in tight collaboration with the national and local authorities and integrates their political priorities. Moreover, the project is designed in such a way that it will directly contribute to national and international climate change commitments (e.g. NDC). This is an incentive for the government authorities to engage in the project. Additionally, RECEM-Valles considers a holistic awareness and engagement strategy tailored to enhance the project ownership of national and sub-national institutions. The implementation arrangements of the project will mitigate this risk through the creation of an institutional strategy to facilitate political processes and enable national and local government involvement.
Change of central and local authorities during implementation of the project	High	Medium	The probability of this political risk is high given the likelihood of elections and changes in government officials in the project period. The risk that new officials will not support the project will be mitigated through information sessions to update them on the project actions and benefits to their constituencies. Additionally, the prioritisation of bottom-up agreements around implementation plans and strategies with local communities that benefit from the Project aim to establish a permanent and continuous work agenda.
Poor adoption and buy-in of agricultural practices and technologies by communities and producers' associations	Low	Low	This risk will be mitigated through the use of participatory approaches in planning and implementing activities at the local level. This approach incorporates extensive and inclusive consultation of different stakeholders including indigenous peoples and marginalized groups and their participation in the designing of interventions and plans relevant to their livelihoods as well as through actions that strengthen their participation and rights in natural resources management. The Environmental and Social Management Framework (ESMF) contains a framework for the development of an Indigenous Peoples Plan that meets the standards of GCF's Indigenous Peoples Policy. The ESMF provides a detailed account of the participatory process related to the various Components and activities of the project including the specification of the types of analysis on potential social, cultural or economic impacts required (incorporated in the vulnerability assessments). These measures are expected to further reduce the low probability of the risk.

Increased competition over land and water resource leads to community conflicts and could be exacerbated as economic opportunities increase.	Medium	Medium	The project is designed via participatory community consultations, and will be implemented largely by smallholder farmers, community organizations and farmer associations. The project will promote dialogue and consensus-building processes through consultation and coordination of territorial platforms to achieve inclusive decision-making and design solutions and actions to be adopted. When necessary, the project will support public authorities in enactment of local regulatory measures with participation of stakeholders. These mitigation measures are expected to reduce the probability of the risk occurring to 'low'.
Conflicting interests of the beneficiaries may lead to limited advances of the project activities.	Low	Medium	The project adopts a strong participatory approach from its design stage and mainstreamed in the project activities. Initial stakeholder consultation has already resulted in a good understanding of beneficiaries' priorities and needs. The project is designed based on these priorities and will promote participatory decision-making regarding the practices and technologies to be implemented. The project will apply a consensus building mechanisms through dialogue campaigns for concerted resolution of conflicts.
Lack of financial capacities at the level of local governments for counterparts to meet and participate	Medium	Medium	Strengthening and expanding the participation of the national and sub-national (e.g. departmental and municipal) government levels to contribute financially to the activities established in the project including resource mobilization and coordination.
Economic activities such as mining activities, concessions, and claims might affect the effectiveness of the restoration measures.	Medium	Medium	Although no major mining investments are foreseen in the project areas, the project will establish territorial management mechanisms, which are designed to manage competing land uses and claims. These mechanisms provide the means through which future land use changes can be coordinated and managed, particularly with regard to extractive activities. Those mechanisms operate at the municipal level, since the Municipality is the main decision maker over land reallocations. These measures are expected to lower the probability of the risk occurring to 'low'.
Extended period of the health pandemic (COVID-19) and related restrictions may affect the timeline for delivery of the project activities	High	Medium	The project will take all necessary measures to promote sanitary and safety measures to protect the health of project staff and beneficiaries. The project will establish healthy safety protocols and an operational strategy to ensure safe operations on the field. To the extent possible, if needed, certain activities as meetings at national level may be conducted online, depending on country's situation, in order to avoid delay in high-level decision-making. Additionally, the project aims to establish opportunities for the communities to achieve self-

and further affect rural livelihoods			subsistence which contributes to their increased resilience amidst multi-dimensional shocks such as a health pandemic.
Natural disaster events such as prolonged droughts or higher frequency of drought as well as torrential rainfalls destroy or delay project interventions.	Medium	Low	The project is designed to operate within the context of recurrent drought or torrential rainfall. The occurrence of such climate extremes will inevitably have consequences for project delivery but will also strengthen support for the role of the project in mitigating such risks in the long term. Enhanced information and early warning systems will strengthen drought management while restoration of natural resources will reinforce adaptive capacity and demonstrate the value of the project. Additional livelihood activities will also reinforce adaptive capacities and resilience of the communities.
Risks of money laundering and countering the financing of terrorism and UNSC sanctions	Low	High	FAO includes in the project agreement signed between FAO and the Government of Bolivia clauses related to AML/CFT and other sanctions, as follows: a)The Government shall comply, and shall require all persons and entities engaged in its activities under the Project to comply, with all internal anti-money laundering, counter-terrorism financing laws, rules, and regulations; b) The Government confirms it has obtained sufficient undertakings from all persons and entities involved in its activities under the Project that they shall not engage in any prohibited practices; the Government undertakes and confirm that it shall comply with the substantive objectives of the GCF's Policy on Prohibited Practices; c) Consistent with numerous United Nations Security Council resolutions adopted under Chapter VII of the UN Charter, the Government and FAO are firmly committed to the international fight against terrorism and, in particular, against the financing of terrorism. It is the policy of the Government and FAO to seek to ensure that none of their funds are used, directly or indirectly, to provide support to individuals or entities: i) associated with terrorism, as included in the list maintained by the Security Council Committee established pursuant to its Resolutions 1267 (1999) and 1989 (2011); or ii) that are the subject of sanctions or other enforcement measures promulgated by the United Nations Security Council. This provision must be included in all agreements that may be concluded with third parties for the implementation of activities under the Project. In accordance with FAO rules and regulations, FAO will perform all necessary actions to ensure that the project be implemented in full compliance with any UN sanctions list that may be of relevance. There are no entities or individuals who are the subject to or affected by United Nations Security Council sanctions regimes will be

			involved in such projects/activities, either as counterparties or as beneficiaries During project implementation FAO, as AE, will ensure close monitoring and supervision through its offices in the regional office and HQ in order to ensure that the activities are implemented in full compliance with the signed project agreement. FAO will apply its own fiduciary principles and standards relating to any "know your customer' checks, AML/CFT, and financial sanctions imposed by the United Nations Security Council, which should enable it to comply with the objectives of the Policy on Prohibited Practices and the principles of the AML/CFT Policy. In accordance with FAO rules and regulations, FAO will perform all necessary actions to ensure that the project be implemented in full compliance with any UN sanctions list that may be of relevance. There are no entities or individuals who are the subject to or affected by United Nations Security Council sanctions regimes will be involved in such projects/activities, either as counterparties or as beneficiaries. Within the framework of this project, the FAO will facilitate the resolution and/or clarification of any concern directly linked to implementation of the project that beneficiaries and involved stakeholders may have, following the Suriname conflict resolution mechanisms. In case the conflict refers to FAO, the NDA will present the complaints and claims to the Representation of the FAO in the country. If a notice of receipt of the claim is not received within 7 days, the complaint or concern must be sent to the FAO's regional office in Latin America and the Caribbean FAO-RLC@fao.org for action. The project beneficiaries may send a complaint to the FAO Office of the Inspector General, who shall carry out an independent investigation. The procedure for the claims is detailed at http://www.fao.org/aud/. Email: Investigations-hotline@fao.org. FAO is committed to ensuring that its resources are used solely for their intended purposes, that all operations are free from fraud and other corrupt practices, and to being held accountable to donors and beneficiaries for the implementation of its programs. To this end, the Organization has adopted a zero-tolerance policy in respect of fraud and other corrupt practices in all their manifestations. This policy applies, regardless of their location, to all activities and operations of the Organization, whether funded by Regular Programme or Extra-Budgetary Funds; administrative, technical or operational in nature; or implemented by the Organization and/or an implementing partner, including any government agency. This policy applies to all FAO personnel and all

			contractual arrangements between the Organization and implementing partners, suppliers or other third parties for administrative, technical or operational purposes. The FAO Whistle blower Protection Policy follows the guidelines to report allegations of possible wrongdoing in the activities of the project stated in the Administrative Circular 2019/06[161].
Local Government or Municipality might not endorse the plans or delay the endorsement due to changes in priorities and / or changes in administration.	Low	Medium	To ensure that there is a buy-in from the local government, the project will work in close collaboration with the municipalities for the implementation of activity 3.1.1, ensuring ownership from the start of the implementation of the project. The project will demonstrate how it will contribute to the country´s commitments established in the NDC 2022 - 2030 water sector, given that the increase in the area under resilient irrigation for food production is urgently needed. Additionally, the project is aligned to the Joint Mitigation and Adaptation Mechanism for the Integral and Sustainable Management of Forests and Mother Earth. In parallel, the project supports the Social Economic Development Plan 2021 - 2025, where axis 3 Food and Nutritional Security ” and axis 8 “sustainable and balanced environment with protection of mother earth, political, economic, social and environmental scope is established” numeral 8.5.

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Appendix 1 Municipalities involved in the project area

Department	Municipality	Department	Municipality
Chuquisaca	Alcalá	**Cochabamba**	Aiquile
	Azurduy		Anzaldo
	Camargo		Arani
	El Villar		Arque
	Padilla		Capinota
	Poroma		Cochabamba
	San Lucas		Mizque
	Sopachuy		Omereque
	Sucre		Pocona

	Tarvita		Pojo
	Tomina		Punata
	Villa Serrano		Sacaba
	Yamparáez		Sacabamba
	Yotala		San Benito
	Zudañez		Sicaya
Potosí	Caiza "D"		Sipe Sipe
	Cotagaita		Tacopaya
	Ocurí		Tapacarí
	Potosí		Tarata
	Puna		Toco
	Ravelo		Tolata
	Tacobamba		Totora
	Tinguipaya		Vacas
	Tupiza		Vila Vila
	Vitichi		Villa Gualberto Villarroel
	Yocalla		Villa Rivero
Santa Cruz	Comarapa		Vinto
	Mairana	**Tarija**	El Puente
	Pampa Grande		San Lorenzo
	Quirusillas		Tarija
	Saipina		Uriondo
	Samaipata		Yunchará
	Vallegrande		

Appendix 2 Geographical distribution of vegetables and fruits in the Macroregion

Vegetables with the largest crop area in the Valleys Macro-region

Product	Santa Cruz Area (ha)	Tarija Area (ha)	Potosí Area (ha)	Chuquisaca Area (ha)	Cochabamba Area (ha)	TOTAL Area (ha)
Green bean	196	846	4.917	1.296	1.793	9.047
Green pea	1.493	1.899	739	1.384	3.107	8.622
Onion	438	838	116	258	1.997	3.647
Tomato	973	269	12	78	927	2.259

Source: INFO SPIE, 2013

Fruits with the largest crop area in the Valleys Macro-region

Product	Santa Cruz Area (ha)	Tarija Area (ha)	Potosí Area (ha)	Chuquisaca Area (ha)	Cochabamba Area (ha)	TOTAL Area (ha)
Peach	1.252	340	836	1.914	502	4.844
Grape	119	2.050	181	260	24	2.635
TCV fruits	380	267	145	980	335	2.107

Source: INFO SPIE, 2013

Legumes with the largest crop area in the Valleys Macro-region

Product	Santa Cruz Area (ha)	Tarija Area (ha)	Potosí Area (ha)	Chuquisaca Area (ha)	Cochabamba Area (ha)	TOTAL (ha)
Green bean	196	846	4.917	1.296	1.793	9.047
Green pea	1.493	1.899	739	1.384	3.107	8.622
Kidney bean	4.525	77	2	2.693	1.812	9.108
Tarwi	-	-	239	60	149	448
Chickpea	26	44	-	110	2	182

Source: INFO SPIE, 2013

Cereals with the largest crop area in the Valleys Macro-region

Product	Santa Cruz Area (ha)	Tarija Area (ha)	Potosí Area (ha)	Chuquisaca Area (ha)	Cochabamba Area (ha)	TOTAL (ha)
Corn	11.569	9.123	10.407	21.919	20.820	73.838
Wheat	969	1.067	5.337	9.989	14.748	32.111
Barley grain	18	567	5.500	4.616	2.424	13.124
Oats	80	552	679	333	2.795	4.438

Quinoa	5	18	75	94	426	617

Source: INFO SPIE, 2013

Tubers with the largest crop area in the Valleys Macro-region

Product	Santa Cruz Area (ha)	Tarija Effective Area (ha)	Potosí Effective area (ha)	Chuquisaca Effective Area (ha)	Cochabamba Effective Area (ha)	Total (ha)
Oca	1	90	530	386	863	1.869
Potato	3.797	5.279	10.504	11.772	20.230	51.583
Papaliza	11	83	186	353	619	1.252

Source: INFO SPIE, 2013

Appendix 3 Report of the hydrological balance

Attached.

Appendix 4 Direct and Indirect beneficiaries methodologies

Attached.

Appendix 5 Socioeconomic and Environmental Baseline

Attached.

Appendix 6 EX-ACT – GHG calculations

Attached.