# Economic evaluation in the assessment process for decision-making about climate change adaptation

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Eco Adapt

Adaptación al cambio climático para el desarrollo local

SEVENTH FRAMEWORK PROGRAMME

# Deliverable N° 3.4
# Economic evaluation in the assessment process for decision-making about climate change adaptation

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## Executive summary

The economic assessment of climate change adaptation basically consists in balancing costs and benefits of actions considered when addressing climate change (CC) threats. The purpose of economic evaluation in the assessment process of CC adaptation actions is essentially to provide figures for the comparison of different possibilities. In the context of the 3 EcoAdapt south American sites (Los Perico-Manantiales watershed in Argentina – BMJ, Zapoco watershed in Bolivia – BMCh and Alto Malleco in Chile – BMAAM), economic evaluation is to rely on a shared understanding of local contexts and the economic drivers of current dynamics. We focus on specific actions considered in these contexts so as to address unsustainable dynamics. The present report D3.4 provides a framework for economic evaluation: its context and the approach under development; the elements of costs and benefits that enter the analysis; and how uncertainty and irreversibility can be accounted for when using economic evaluation results. The initial panorama of the context of the economic evaluation recalls synthetically what we know about the territories and their people in terms of scales, activities and living conditions and about the extent to which they are affected by climate. Such introduction aims at facilitating the understanding of the types of actions considered for climate change adaptation. Then the economist standpoint on climate adaptation is explained and the perimeter of the evaluation is defined: 15 actions in BMJ, 11 in BMCh and 9 in BMAAM.

Twelve fields of investigation are identified, for which available information is synthetized and on-going research on the elements of costs and benefits is described, so as to both make a progress status, and actualize the road map for integrating economic evaluation in modelling (task 3.2), scenario development (task 4.2) and implementation (task 5.3). A final section illustrates the possible use of the economic analysis to reveal or highlight specific characteristics of the actions considered, for instance: their time horizons and links with inexplicit future benefits or costs; their progressive definition that requires to start the evaluation; their reliance on resources considered free.

# Foreword

Deliverable 3.1 describes the scenario development methodology that has been agreed with the CSO partners, which is now based on Structured Decision Making (SDM). This change of strategy, as well as adjustments of the SDM method and timeline at the moment of implementation (cf deliverable 3.5), impacts task 3.3 and the current deliverable D3.4 in the following way: 1) economic evaluation now concerns concrete alternatives (i.e. a set of possible actions leading to specific outcomes) instead of broad scenarios as considered in the DoW; 2) Instead of a multiplicity of combined assessment tools, a specific economic evaluation is being developed during the assessment process, with the partner CSOs; 3) Priority is given in developing "economic thinking" of CSOs and agents of change engaged in developing adaptation plans, so that they can use it when selecting alternatives; 4) economic evaluation will be integrated into the models developed for assessing specific alternatives. This deliverable provides a framework for economic evaluation of alternatives and applies it to the plans that have been developed by CSOs based on the results of the first SDM workshops.

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## Acronyms

APR: Agua Potable Rural, in Chile, the local water management organization

BMAAM: Bosque Modelo Araucarias de Alto Malleco

BMCh: Bosque Modelo Chiquitano

BMJ: Bosque Modelo Jujuy

CC: climate change

CCA: climate change adaptation

CSO: Civil Society Organization

FCBC: *Fundación para la Conservación del Bosque Chiquitano* – Fundation for the Conservation of the Chiquitano Forest

MF: Model Forest, BM or *Bosque Modelo* in Spanish

OTB: *organizacion territorial de base*, in Bolivia, the local community management institution

SDM: Structured Decision-Making

SES: Socio-EcoSystem

T3.3: task 3.3 of the EcoAdapt project

# 1. Introduction: assessing adaptation to climate change

The EcoAdapt project aims at progressing in ecosystem-based climate change adaptation (CCA), on the basis of a nurtured science-society dialogue on water and development. For that matter different analyses are accompanying the project while it is advancing towards the design and preliminary implementation of CCA strategies focusing on water issues.

After an initial phase of filling the knowledge gaps about the contexts of intervention (work package 2), the project entered a phase of modelling and planning where climate change adaptation (CCA) actions require an assessment with an institutional, biophysical and economic perspective. The latter brings specific and mainly quantified insights on people and the resources they manage in each of the three study sites, three Forest Model (BM) territories.

## 1.1. The context of the economic evaluation in EcoAdapt

From the previous analyses led in these territories, their socio-economic context has been described synthetically (Cuevas et al., 2014) and prevailing sustainability issues are been acknowledged and partially explained (deliverables 2.4 and 2.5). Let's highlight important site characteristics for the economic evaluation of local actions towards climate change adaptation. The following table gives a first overview of the study sites (Tab.1).

| | BMJ | BMCh | BMAAM |
|---|---|---|---|
| Perimeter of the study site | Los Pericos-Manantiales watershed. 130,000 ha | Zapocó watershed<br>**137,000 ha - 10,000 inhabitants** | Lonquimay, Curacautín<br>550,000 ha |
| Corresponding administrative perimeter | Departments<br>San Antonio, El Carmen<br>**1,602 km²** (912 + 690)<br>**101,505 inhab.** in 2010<br>(97,039 + 4,466 ) | Munícipe<br>Concepción<br>28,514 km²<br>20,372 inhab. (est.2010) | Communes<br>Lonquimay, Curacautín<br>**5,578 km²** (3,914+1,664)<br>**26,858 inhab.** (est. 2011)<br>(15,376 + 11,482) |
| Urban population | Perico, San Antonio, El Carmen and 4 other towns | Concepción | Lonquimay, Curacautin and a few other towns |
| Rural population | appr. 20% in the productive zone around San Antonio and the Diques zone.<br><10 families in upper basin | 40%, diminishing.<br>16 community villages in the Zapoco watershed: 562 families, 3500 to 4000 pers. | appr. 40%, stable |
| Activities | commercial agriculture, cattle raising, tourism | Cattle ranching, subsistence agriculture, wood extraction, tourism development | wood plantations, non-wood forest products, extensive agriculture, fish farming, sand extraction, tourism |
| Agricultural production | **Tobacco**, sugarcane vegetables, livestock , fruits | Corn, cassava, plantain, bean, rice | livestock<br>alfalfa |
| Poverty | 29% suffering deprivation | 89% households with basic needs unsatisfied<br>Severe health problems related with water pollution | 34% (Lonquimay)<br>24% (Curacautin) |

**Table 1: Orders of magnitudes describing the three study sites**
***(adapted from Cuevas et al, 2014)***

In their respective countries, Argentina, Bolivia and Chile, the three sites are quite marginal rural areas with lower development and higher poverty levels than the national averages. Nevertheless, each territory has at least one town counting with primary education, health and administrative services. Scenic beauty (cf. mountainous Jujuy landscapes in Argentina), land and water resources provide opportunities for development and touristic attractiveness, which also benefits from local culture, especially in Chiquitania in Bolivia and Araucania in Chile.

Main activities in the three sites include:

- Agriculture and cattle ranching, relying on the availability of water;
- Tourism for which the conservation of water bodies and associated natural resources is of importance.

The corresponding drivers of socio-ecological dynamics include market demand and prices of several products as well as aesthetic demand.

| | BMJ | BMCh | BMAAM |
|---|---|---|---|
| Market demand & prices | sugar, tobacco energy commodities | meat and wood | salmon |
| Demographic (pop growth rate) | moderate population increase | immigration | Moderate/ stagnation |
| Energy demand | moderate | very limited | strong potential increase |
| Aesthetic demand | Strong in dam zone | Moderate in dam zone | Moderate scattered |

**Table 2: Main socio-economic drivers of socio-ecological dynamics**
***(adapted from EcoAdapt deliverable 2.5)***

In each site, water availability depends on its geo-morphology and the land-use dynamics.

| | BMJ | BMCh | BMAAM |
|---|---|---|---|
| Geo-morphology, water resources | - High altitudinal difference between stages of the watershed<br>- surface water seasonality<br>- Ground water available | Little difference between up and downstream<br>Ground water difficult to access | - Watershed heads with many other small rivers<br>- Uncertainty on groundwater available |
| Land use dynamics | Upstream: human desertification<br>Downstream: agricultural intensification, diversification | Rapid deforestation and agricultural colonization | Stagnation |
| Degree of artificiality (water access) | Highly artificial (dams, canals) and organized | Intermediate and deficient (dam and microdams) | low |

**Table 3: Main structural determinants of water availability and access**

In terms of water use, the three sites also show different characteristics, associated with their development trajectories.

| | BMJ | BMCh | BMAAM |
|---|---|---|---|
| Main water uses | Human consumption<br>Irrigation<br>Recreation<br>(+ hydropower in the futre) | Human consumption<br>Animal consumption<br>Agriculture<br>Recreation | Human consumption<br>Animal consumption<br>Fish farming<br>(hydropower in the future) |
| Water use priority | Provincial law with priority principle | Community and municipality decisions | Water use rights regulated by market forces |
| Irrigation | commercial crops | no | 1.3% agricultural land, for alfalfa principally |
| Main infrastructure | Dams: Ciénaga (5000ha irrigation); Las Maderas (20000ha). Canals. Distribution network | Dam (12Mm$^3$) and distribution network in Concepcion<br>Small dams in rural areas | Distribution network and used water treatment plants in Lonquimay (2011) and Curacautin (2006) |
| Water availability | seasonal scarcity in the upper basin (august-oct) | seasonal scarcity at the end of the dry season (october) , non-agreed water deviation, insufficient urban network | droughts; lack of water consumptive rights, high price of distributed water |
| Water pollution | incomplete sewage infrastruc, inundations, polluted dam area, agrochemicals. | unprotected water sources from livestock, sawmill, garbage, used water | water affected by "non-consumptive" activities |
| Institutions in water management | Direction of water resources, Agua de los Andes, + irrigation consortium | Water cooperative, municipality, OTB, water committees | Aguas Araucanias, APR (private institutions)<br>DGA (state authority) |
| Dominant type of regulation | Hierarchy and collective action | Community + state interventions | Market |

**Table 4: Water use**

Livelihoods and producing conditions are affected by adverse events, whose frequency can be related to climate change: storms destructing water infrastructure in BMJ and BMCh; and blocking people and their activities during winter in BMAAM; droughts reducing agricultural yields in all sites and increasing fire occurrence in BMCh.

Both the availability and the quality of water are suffering from the lack of infrastructure, and deficient infrastructure maintenance. They are also threatened by current activities and practices, revealing not only the lack of information and public awareness, but also the contradictory incentives of existing legislation (cf. FCBC, 2013 in the case of BMCh).

In this context where collective action is required, equity considerations reveal differences of standpoints amongst actors and latent conflicts, that state institutions seem unable to settle in their current functioning.

| | BMJ | BMCh | BMAAM |
|---|---|---|---|
| Economic power | upstream vs. downstream in land use activities and agricultural intensification | large holders – smallholders in livestock production | water right owners – land owners for the development of new activities |
| Environmental externalities | dependence towards the practices of upstream actors and tourists | controversies given specific support to communal producers and lack of law enforcement | non consumptive rights affecting more than expected water security |
| Public intervention | lack of public intervention | several laws infringed (cheaper to pay fine) | lack of effective monitoring |

**Table 5: Equity considerations**
***(Le Coq et al., ISEE 2014)***

These are the three contexts in which the objective of climate change adaptation is tackled by the EcoAdapt project. To a large extent, the contemplated CCA actions corresponds to highlighted characteristics, almost independently from climate change concerns. Therefore the economist' perspective on climate change adaptation shows little specificities, in a first instance at least.

## 1.2. Adaptation from an economist' perspective

Economics often promote simplistic views that facilitate quantification and logical reasoning, trusting that orders of magnitudes and stylized facts are respectively useful and analytically powerful for the management of limited resources. However these possible contributions depend whether simplifications and emphasis on quantifiable variables are done in an open way with concerned people, and can be revised and adjusted to new contexts.

In the most recent IPCC report (2014), a specific chapter (number 17 of WGII) is dedicated to the Economics of Adaptation. It recalls general principles (cost-benefit, optimisation, risk management…) and specific insights from models and quantification works. Models mediate a predefined understanding of what deserves evaluation, what to look at, specifically. For more direct cost quantifications we generally find simple calculations for adaptation costs where specific measures are considered (dengue treatment, crop irrigation for instance), a unit cost is estimated (treatment per person, water cost for one hectare), then multiplied by the size of the targeted population or area. Such evaluation relies heavily on the availability of specific studies for unit cost estimations or of expert sayings. A rapid overview of the sources used in different cost estimates (CEPAL, 2014; EACC, 2011; IPCC, 2014; GIZ, 2011; UNFCCC, 2011), confirm they are often quite site specific and many years old. Several assumptions are required to adjust the unit cost estimation (exchange rate, inflation, …). Such adjustments are little documented while the economic evaluation gives more importance to financial flows and the role of the discount rate. Back-of-the envelope calculations sometimes give rise to financial tables and graphs

mechanically generated to discuss on values taken by financial indicators (internal rate of return, net present values) or the sensitivity of the results to different discount rates.

Non experts might get lost in economic evaluation, not so much because it is complex, but on the contrary because important simplifications are not always easy to identify and understand nor the series of assumptions successively made in the calculations. For that matter in the context of the EcoAdapt project, we shall be very gradual in the economic evaluation of actions considered for local climate change strategies.

### 1.2.1. Basics

Adaptation can consist in:

- a hard investment, in equipment, infrastructure or other physical capital;
- a soft investment in learning, education, research and other investment in human or social capital;
- risk financing mechanisms such as management with financial instruments or insurances for instance;
- a policy action modifying incentives, regulation, legal obligations and rights,…
- an adaptation strategy combining various of these actions.

Before specific feasibility studies and without necessary focusing on financial variables, the economic analysis focuses on the costs and the benefits of adaptation actions, respectively in terms of resource use and generation. Derived from standard production functions named KLEM (for capital, labour, energy, material), a simple typology of costs facilitates systematization on their integration:

- ✓ Money, this is the cost of accessing funds, determined by the financing conditions (interest rate; counterparts…);
- ✓ Labour, or workforce of different types according to necessary skills;
- ✓ Natural resources which are often extracted without enough quantification: water, sand, vegetation, seeds…;
- ✓ Energy and materials, equipment, inputs, including their access costs (patents, logistics…).

Quantitative economic results can be useless or misunderstood; figures can be manipulated with validity domains either very limited (the results are determined by a lot of assumptions which correspond to very specific cases and situations) or undefined (assumptions remain implicit leaving unclear what the results mean). Facing these risks, economic evaluation must be anchored in an explicit and shared understanding of the local economy: at which costs and in which conditions are the mentioned resources available? To what extent these conditions might change in the future or according to specific case characteristics (isolation, degraded environment… or on the contrary)?

A second initial clarification stage of the economic evaluation is required, for the integration of the benefits of adaptation actions. Some benefits might be tangible (e.g. increased crop yields),

other more intangible (general welfare or sense of justice), some benefits are linked to random variables (occurrence of a droughts or a storm) others are more certain (improved health). This issue of accounting for benefits deserve specific attention and tailor-made methodological proposals as roughly undertaken in the fourth section of this report.

### 1.2.2. Objectives of the economic evaluation

The expected results from the economic analysis will allow to compare possible responses to climate change, in terms of management of resources (money, labour, natural resources, materials).

For that matter, standard cost-benefit analysis is proposed with a focus on monetary elements to start with, then and a particular attention to non-monetary elements (unpaid labour and natural resources for instance) when considered important so that they can enter the balance, without being necessarily converted in monetary.

It will also be accounted for that some actions are complementary, which means that the cost and benefits of one action depend whether another action is also implemented. The complementarities of CCA actions will be identified and lead to a specific revision of results.

Sensitivity analysis will allow to put in perspective the results, so that for a given action they can be adjusted when the context of the action changes (for instance market prices of agricultural productions for which adaptation benefit is evaluated in terms of avoided yield loss), or the action is partly redefined (inclusion of a new activity like training prior to implementation for instance).

When relevant for actions that will require better specification or revision in the course of their evaluation, we shall account for alternative decision-making processes, one-shot or sequential, and highlight the value of new information during the action implementation. The idea here is to contemplate the possibility that an action will be preferred to another one because it leaves more leeway for revision.

A general comparative framework will feed the multi-criteria analysis led at the level of the whole assessment process. Additionally to their monetary and non-monetary costs and benefits, actions will be compared on criteria of: risks and uncertainties, irreversibility and equity or distribution amongst actors of the costs, the benefits and the risks of a CCA action.

## 2. The scope of the economic evaluation

In April, May or June 2014, workshops were led in each site where local actors, including the EcoAadapt partner civil society organization, determined which actions to consider in the territory facing climate change. From the lists of options, we worked at delimitating the actions to be evaluated from an economist's standpoint (Tab.6).

| | BMJ | | BMCh | | BMAAM |
|---|---|---|---|---|---|
| **1** | to construct network of rain sewers (Perico, barrio San José) U | 1 | to identify and protect priority sites in the watershed (or only plan their conservation) | **1** | to reforest recreational areas of school with native species |
| **2** | to construct a rural runoff network (Lapachos-Pampa Blanca) R | 2 | to improve water pump and storage infrastructure R | 2 | to organize workshop for land-owners on reforestation with native species |
| 3 | to maintain farm dams (Monterrico zone) R | **3** | to construct mini dams to alleviate drought impacts in critical areas R | 3 | to protect water sources and menokos (wetland) R |
| **4** | to make canals waterproof with concrete coating in rural areas (a 10 km sample and the 400 km network) R | **4** | to implement irrigation systems in critical areas R | 4 | to establish enclosures in critical areas (water pool reserves and upstream from capitation points) |
| **5** | to close canals in urban areas (5km long canal 8 in Perico) U | **5** | to construct wells in rural areas R | 5 | to promote non wood forest products |
| 6 | to develop an irrigation improvement programme R | 6 | to manage solid and liquid residues in the whole basin | 6 | to develop forest certification |
| 7 | to manage runoff and irrigation in farms R | **7** | to build ecological latrines in houses with high pollution risks | **7** | to store water from rain and water sources |
| 8 | to improve the water monitoring system and its scope | 8 | to reforest critical deforested areas with species of high economic value | 8 | to recycle used water in rural areas, separating grey waters from sewage |
| 9 | to set up an early warning system for extreme events | 9 | to elaborate a monitoring plan for fire control | *9* | to raise awareness on the importance of water for tourism |
| *10* | To make up a committee on water management and set up an online information platform | 10 | to improve agricultural and forestry practices regarding land and water use R | | |
| *11* | (R) to technically assist cattle rancher for improved practices | 11 | to extend and manage the Zapoco protected area | | |
| 12 | to limit cattle ranching in the dam area R | | | | |
| 13 | to protect hillside forest cover R | | | | |
| *14* | to raise awareness and train people on water use | | | | |
| *15* | to conduct territorial zoning | | | | |

Bold: hard investment
Italic: soft investment
Underlined: technical assistanc
Blue: directly on water
Green: on land use
Bile green: on residues
U for urban, R for rural

**Table 6: Actions to be considered in the economic evaluation**

The initial idea to identify alternatives for each action was abandoned for the first stage of the economic evaluation, given the high number of actions to evaluate already. Alternatives were considered only for some specific actions where they exist in an obvious way. Otherwise, the

identification of alternatives is postponed to a later stage together with the sensitivity analysis (cf. in section 5).

Let's describe the actions considered in each site with available information, namely on the activities they comprises and on what will be evaluated. For some actions defined without details still, the delimitation requires fieldwork (interviews, visits) that will be done together with data collecting activities for the evaluation of actions.

## 2.1. Fifteen actions to be evaluated in BMJ

In BMJ, actions principally concern water management and the prevention of problems associated with the excess, the lack or the pollution of this resource. Hard and soft investments are considered within different time horizons. 8 actions are specifically for rural areas, 2 specifically for urban areas. Though strategy elaboration has not been mentioned yet, some actions are considered already within a set of actions, for instance those that concern the rural runoff network, the farm dam maintenance and the early warning system. Detailed information on actions is being gathered by Marianela Greppi with the help of the BMJ and synthesized here.

### 2.1.1. To construct a network of urban rain sewers

***Construir red desagües pluviales urbanos***[1]

The action consists in identifying new urban extensions often informal and there in channelling rain water runoff with an urban sewerage or drainage system.
The action will first be evaluated in Perico where new settlements have led to the creation of new settlements with little or no planning. A specific neighbourhood will be considered, probably San José de Perico.
The evaluation will account that 5 to 8 years are necessary for such action, with longlasting benefits and maintenance costs.
The costs to consider include
- construction material
- machinery services
- workforce (for initial territorial zoning, civil engineers, foreperson, construction worker).

Expected benefits include the avoidance of damages caused by rains and storms in terms of human lives and health and infrastructures (bridges, roads, light and gas distribution network…).

[1] There is a technical difficulty related to the English translation of specific terms in Spanish. *Tradurre è tradire*: given the risk of distortion, we'll indicate original formulations emanating from local actors when dealing with actions to be evaluated for instance.

### 2.1.2. To construct a rural runoff network

*Construir red desagües pluviales rurales*

The action consists in channelling rain waters in conductive canals or waterways.
Such canals can be built directly with earth or in concrete and cement, o as a combination of earth channel and concrete sections. The earth alternative would be initially cheaper than the concrete one but then require more maintenance.
The action will first be evaluated in the Lapachos rural area, where a 8km central waterway is necessary for the lower zone Pampa Blanca where water arrives with strong currents.
The evaluation will account that between 6 months (earth alternative) and 2 years (concrete alternative) are necessary for such an action, with long lasting benefits and maintenance costs.
The costs to consider include:
- construction material
- machinery services
- workforce (civil engineers, worker)
- annual cleaning and maintenance in the case of earth constructions, subject to the obstruction of growing vegetation and other matters.

Expected benefits include the avoidance of damages caused by uncontrolled rainwater runoff affecting settlements, electric and gas network, roads, agricultural productions and farms, ….
The action can be complemented by the connection to the farm ponds to increase their capacities beyond water provision for irrigation.
The action is related to the following actions: to maintain farm ponds and to set an early warning system for extreme events.

### 2.1.3. To maintain farm ponds

*Mantenimiento de represas de las fincas*

The action consists in cleaning from sediments the ponds that agricultural producers use to store water for irrigation. The actions include: cleaning the surrounding vegetation, emptying and drying up the pond so as to remove the sediments, sealing the basis and the walls of the pond.
Such operations can be done manually or mechanically to some extent.
The action will be evaluated in the Monterrico area because of its high concentration of farm dams, approximately 250 with an average capacity of 500,000 litres.
The evaluation will account that 10 days per pond are necessary for such action, which must be renewed every 4 to 5 years.
The costs to consider include
- workforce
- machinery service
- the lack of irrigation during the operations and the water wasted when the pond is emptied.

Expected benefits include improved water quality; increased dam volume and associated water use efficiency. This action is related to the runoff management in rural areas.

### 2.1.4. To make canals waterproof with concrete coating in rural areas

*Construcción de canal de hormigón*

The action consists in coating with concrete the existing water distribution canals that originate from the main canal in rural areas.
The evaluation will consider a 10 km canal before extrapolating to the estimated 400km network.
The evaluation will account that 2 years are necessary to make 10 km of canal waterproof for at least 30 years with regular maintenance (cleaning, breakdown repairs).
The costs to consider include
- construction material: cement, sand or prefabricated concrete
- machinery services and tools
- workforce: construction worker, master builder, civil engineer
- the interruption or the water service.

Expected benefits include reduced water loss due to infiltration. Such savings must be better evaluated than just monetarily given the relatively low price of water, for tobacco producer for instance (0.3 % of production costs).

### 2.1.5. To close canals in urban areas

*Cerramiento de canales en zonas urbanas*

The action consists in covering up the existing water distribution canals in urban areas so as to impede access to these canals and therefore prevent accidents and pollution.
The action will be evaluated for the canal 8 of Perico, representing 5 km approximately.
The evaluation will account that 10 months are necessary to cover up existing canals for a very long period if regular maintenance is ensured (cleaning, breakdown repairs)
The costs to consider include
- construction material: cement, sand or prefabricated concrete
- machinery services and tools
- workforce: construction worker, master builder, civil engineer
- the interruption or the water service.

Expected benefits include improved water quality, as well as human accident risk reduced to zero.

### 2.1.6. To develop an irrigation improvement programme

*Diseñar y ejecutar un programa de mejora del sistema de riego*

The action consists in designing and implementing an irrigation improvement programme, comprising the conduction and the distribution of water.
It contemplates shared dams, improved/more waterproof canals, pressurized irrigation in some sectors.
The action includes activities of planning and designing; construction of some 10 shared dams; making communal canal waterproof; irrigation pressurization in some 10 adjacent farms close to the primary canal.
The action will be evaluated in the productive zone of Monterrico – El Carmen, in 10 farms.

The evaluation will account that 6 months are necessary to plan and design the programme, 1 week to construct each shared dam, 2 years to make a canal waterproof (see action 4).
Costs elements include:
- a bricklayer and a technical expertise from an agriculture engineer and an hydraulic engineer for initial activities and the monitoring of following ones;
- earth for the dam, possibly expensive
- machinery services
- material for pressurization: pipes, mouthpieces and electric motor
Expected benefits include water savings at the level of the whole irrigation system network.

### 2.1.7. To manage runoff and irrigation in farms

***Manejo de desagües pluviales y de riego en finca***

The action consists in making use of runoff water from one pasture plot to the neighbouring one or to store it in internal ponds. This action implies a systematization on soils at the farm scale and will depend on its topography.
The action include the adjustment of irrigation and possible rescheduling in function of anticipated rainfalls. For that matter it is fully complementary to action 9 "to set up an early warning system of extreme events" and partially to action 3 "to maintain farm pond".
The systematization on soil will focus on furrows and their overall reconfiguration so as to limit erosion and sediment transportation, and to better circulate the water within the farm. Alternatively, irrigation systematization could rely on hoses instead of furrows.
The action will be evaluated at the farmscale considering a farm with 50ha of productive area and another farm with 15ha, both farms counting with a 500,000 litre dam.
Costs elements include those of the action 9 (early warning system), coordination costs for the rescheduling of irrigation, equipped workforce on furrow reconfiguration.
Expected benefits of improved water distribution and reuse, as well as of capturing rainwater at the farm level, can be evaluated in terms of increased efficiency and equity of irrigation, maybe even of additionnal irrigated areas and the subsequent increased production and revenues for 5 productive seasons. It will then require maintenance. It can also reduce labour when hoses are applied.

### 2.1.8. To improve the water monitoring system and its scope

***Mejorar sistemas de monitoreo hidro-meteorológico***

The action consists in completing water flow monitoring in the irrigation system by increasing the number of measurement sites, especially to account for the water flow leaving the watershed eastwards for the irrigation of sugarcane fields.
Cost elements are quite limited to a gauge per new measurement site (in the Intervalles canal) and its installation.
Expected benefits concern all producers counting on irrigation: water distribution will be more sustainable and fairer, especially in critical time.
The action will take one month to be implemented and there is no precise time limit for benefits be felt, it can be for more than 50 years.

### 2.1.9. To set up an early warning system for extreme events

***Sistema alerta temprana de eventos extremos***

The action consists in completing the hydro-meteorological system so as to improve the early warning of events such as: flooding, storms, frost/freeze, winds, hailstone…
It includes the use of available automatic weather stations (5) and the introduction of new ones (3) for the measurement of precipitations (in the valley and the mountains), of water flows in the main canals for irrigation (going out of Catamontana dam, Intervalles canal). The action also implies some work on data processing so as to make consistent the information of different sources; as well as adequate communication for early warning.
The costs to consider include
- 3 new weather stations (3,000 USD each)
- software to process data
- staff revising processing data (1 person)

Expected benefits include improved hydro-meteorological monitoring and indirect effect regarding water irrigation efficiency, as well as flood risk management and reduction of impact of flooding. The whole productive and urban zone of the valley will benefit from the action.

### 2.1.10. To form a water management committee and set up an online information platform

***Formar un grupo de trabajo conjunto interinstitucional y generar una plataforma de información online***

The action consists in forming a working group with institutions involved in water management and set up an information on-line platform publicly available so that people can take informed and adequate decision on water management.
They are alternative ways to implement this action, according to the legal figure taken by the committee, its organization and procedures, also according to the platform technical characteristics (software e.g.).
It is expected that each institution joining the committee will be represented by one or two persons, a policy maker and/or a technical adviser.
The evaluation will account that one year is necessary for the action, without finite horizon.
Cost elements include the opportunity cost of the time spend by the persons attending the committee activities (a monthly meeting) and the labour cost of the person in charge of the platform (one system engineer to start and maintain it, one information administrator to update it).
Expected benefits include better institutional and civil coordination through improved and shared information on water management.

### 2.1.11. To technically assist cattle rancher for improved practices

***Mejorar manejo ganado cuenca alta y áreas protegidas***

The action consists in taking measures to limit and improve cattle (bovine and ovine) ranching in the upper Perico basin. The measures to be promoted with cattle ranchers, a few families

(10) living in the upper basin, includes field rotation, reduction of animal charge and adjustment to field carrying capacity, breeding, improved market opportunities.
Four alternatives are considered and might be combined: 1) to buy cattle from cattle ranchers and employ them as environmental guards; 2) to elaborate a livestock management plan with specific procedures such as fencing; 3) to improve breeds for more productive cattle allowing to improve revenues and reduce head number; 4) to improve commercialization and optimize the age at which the animal are sold.
1000 cows are at stake, herded by 10 families.
The evaluation will account that 5 years are necessary to promote a change of activity and the type of herding for each family.
Costs elements include the labour cost of an expert in bovine production, commercialization also on fencing pastureland, the labour cost of an environmental guard, and the material for fencing.
Expected benefits include reduced vegetation loss, soil compaction and soil erosion, improved revenues and livelihoods of cattle ranchers.

### 2.1.12. To improve and limit cattle ranching in the dam area

***Mejorar el manejo de ganado en los Diques***

The action consists in restricting access to livestock in the dam area. It includes the installation of water dispensers for the livestock and the adjustment of the animal charge to the site capacity. These activities will be evaluated together and in a comparative way.
The area of consideration is the Cienaga basin, counting with 944ha half mountainous forest, half dam area with houses and pastures); about 140 cows, 40 swine around the lagoon (Villard et al, 2014).
The evaluation will account that one year (agricultural calendar) is required for the installation of fences and water dispensers and about five years to improve cattle ranching practices. .
Alternatives will be evaluated to improve and limit cattle ranching:
Cost elements are mainly labour cost for technical assistance and the cost of the equipment material to install.
Expected benefits include reduced soil erosion, enhancing of water quality and safety in the roads.

### 2.1.13. To protect hillside forest cover from livestock

***Elaborar un plan de manejo/protección de bosques en laderas***

The action consists in managing and conserving hillside forests, protecting them from the livestock in the upper basin and the protected areas.
The action include forest management specifying exploitation and conservation in steep slopes of farms, reforestation, forest use planning and the reduction of mulch or humus extraction.
Alternatives ways of conducting this action will be evaluated given that the action can either rely on the national law that fund reforestation with native species or on own local resources. The reduction of humus extraction can be achieved by awareness raising or by subsidies on substitutes of this natural humus for agronomic uses.

The action will be evaluated on the 300ha forest land of the dam area, accounting that planning and implementation will take about 5 years.
Cost elements includes land to be protected, plants for reforestation, labour costs of elaborating the plan, doing the administrative work, gathering information and training people. Material costs for humus substitution might include high import duties in the current national context
Expected benefits include reduced soil erosion, namely by wind (tree curtain) or by water flow, protection of natural resources and enhanced landscape value.

#### 2.1.14. To raise awareness and train people on water use

***Concientización***

The action consists in educating, training and disseminating about the adequate use of water for irrigation and drinking.
The action includes: campaigns in school, for rural and urban populations and for agricultural producers; recreational activities against pollution and for consumption reduction.
In terms of alternative, we consider the action can be led by different institutions and with different frequencies.
The costs to consider include
- highly qualified workforce
- services and material for events, workshops, courses
- leaflets
- services for media interventions

Expected benefits include improved water quality, as well as health benefits and the prevention of accident.

#### 2.1.15. To conduct territorial zoning

**Ampliación de red de cloacas**

The action consists in creating a territorial zoning for urban planning, and focused on riverside vegetation, infrastructure against inundations and the extension of the sewage network. The action is quite similar to the first action (rain sewers) except for its focus on sewage. Its scope requires further delimitation still.

## 2.2. Eleven actions to be evaluated in BMCh

In the Zapoco watershed, several actions imply prior hierarchy-setting with the identification of critical areas or cases and planning activities before implementation ones. Besides, the actions are still not completely delimitated and sometimes focus on specific activities without precision on the perimeter. This situation invites us to an iterative process of delimitation and evaluation of the climate change adaptation action, principally by Josefina Marin in dialogue with the FCBC. The following description of the eleven actions to be evaluated in BMCh is still preliminary then.

### 2.2.1. To identify priority sites in the watershed and plan their conservation

*Identificación y protección de sitios prioritarios para las funciones hídricas de la cuenca*

The action consists in identifying priority sites for their hydrologic functions in the watershed and elaborating a conservation plan.
The action includes the mapping of all water sources and streams, the diagnosis on their actual or possible pollution by local activities and the planning for their protection.
Contemplated cost items include the work of an hydrologist and GIS expert, and material to protect water sources.
Expected benefits include the prevention of problems due to lower water quality and the incidence of water scarcity.

### 2.2.2. To improve water pump and storage infrastructure

*Mejorar infraestructura de bombas y almacenamiento de agua*

The action consists in ensuring the regular maintenance of water pumps and repair them when necessary. The installation of new water pumps is also contemplated.
The action will first be evaluated in the community villages of Limoncito and Porvenir, where respectively 76 and 40 families (resp. 623 and 315 persons) are living according to investigation led at the beginning of the EcoAdapt project (FCBC, 2013).
The action will be evaluated accounting that 3 days are necessary to repair water pumps and tanks in a community village, 10 days are necessary to acquire new material.
Cost elements include the labour cost of workers and a technician, as well as material and machinery services.

### 2.2.3. To build small dams to alleviate drought impacts in critical areas

*Construcción de atajados para paliar la sequía en áreas criticas*

The action consists in building small dams, storing the water from rainfalls and possibly from rivers, in areas suffering droughts .
The foreseen capacity of each dam is 100 $m^3$.
The action includes a motivation workshop, the construction of one dam and of complementary infrastructure.
Costs elements include labour and machinery services.
Expected benefits include the reduction of agricultural production losses when the dry season is unusually long. The benefitted area for a 100 $m^3$ is 0.6ha of summer crops (sowed in November-December), 0.25 ha of winter crop (sowed in July-August).

### 2.2.4. to implement irrigation systems in critical areas

*Implementación de sistemas de riego en áreas críticas*

Critical areas are defined in terms of low production of food crops because of the lack of water or loss percentage during droughts (maize, bean, sorgo).

The action includes: the identification of such areas and of the crops to irrigate; and the installation of an irrigation system, by aspersion.
The scale of a single field will first be considered before extrapolation to a whole community village.
Cost elements include labour and material.
Expected benefits can be evaluated in terms of avoided crop losses or increased yields with respect to the observed or expected ones.

### 2.2.5. to construct wells

***Construcción de pozos***

The construction of wells is considered in community villages dependent on the Zapoco river for their water access, hence suffering from transportation efforts and poor water quality to rural communities.
The action includes the identification of suitable zones for the construction of wells, their dimensioning and their construction.
Cost elements include labour, machinery services and materials.
Expected benefits are those of improved water access and better water quality.

### 2.2.6. to manage solid and liquid residues in the whole basin

***Plan de Manejo de residuos sólidos y líquidos en la Cuenca***

The action consists in a series of activities to inform the public and specific sectors of activities or enterprises that are sources of pollution (cattle ranching, mining, sawmills,…) and to raise awareness on liquid and solid residues.
The activities includes: installation of informative signs/billboards and of garbage containers; diffusion of radio spots in the whole territory and of videoclips in the school; distribution of fencing material and drinking trough for the cattle; informative campaign on environmental norms and; training campaigns on recycling.
The action will be evaluated accounting that 6 months are necessary to implement it.

### 2.2.7. to build ecological latrines in households with high pollution risks

***Construcción de letrinas ecológicas en hogares de riesgo de contaminación alta***

This action consists in changing unhygienic habits in neighbourhoods where people relieve themselves in places that might connect with water sources.
It includes awareness raising, training and equipment installation.
The action will be evaluated in a urban neighbourhood and a rural one.
Expected costs include labour and material.
Expected benefits include improved health, reduced health hazards.

#### 2.2.8. to reforest critical deforested areas with species of high economic value

*Reforestación con especies que sumen valor económico en áreas críticas deforestas*

The action consists in reforesting some areas with trees producing fruits of high value (Chiquitanian almond) and generating revenues from their harvest.
Costs elements include labour, material and water. They may include financial investment if the area to reforest must be bought first.
Expected benefits are environmental and monetary in the longer term for rural dwellers.

#### 2.2.9. to elaborate a monitoring plan for fire control

*Elaborar un plan de monitoreo para control de incendios*

The action consists in installing weather stations and monitoring the use of fire (in the agriculture) by remote sensing. It will serve to prevent fire risks because of intense drought and high temperature.

#### 2.2.10. to improve agricultural and forestry practices regarding land and water use

*Mejorar prácticas agropecuarias y forestales para el uso sostenible de tierras y agua*

The action consists in training people from the community villages on: crop rotation, the use of agrochemicals, agroforestry cattle ranching.
The action will be evaluated for a community village where agricultural practices are characterized by their lack of sustainability.
Cost elements include mainly labour and material.
Expected benefits include improved yields in the short and the longer terms.

#### 2.2.11. to extend and manage the Zapoco protected area

*Plan de ampliación y plan de manejo del área protegida Zapoco*

The action includes a series of activities: organization of workshops gathering institutions engaged for the Zapoco protected area; public sharing of a plan proposal; technical activities to for the design and implementation of the plan.
Cost elements include labour and material. Financial investment might impose a specific cost if the land must be bought.
Expected benefits include environmental conservation and touristic attractiveness.

### 2.3. Nine actions to be evaluated in BMAAM

The territory on which BMAAM is working comprises Lonquimay and Curacautin. The civil society organizations BMAAM and SEPADE pay attention on equality of treatment for these two communes. For that matter, the same actions will generally be evaluated twice at least. Described by Juan Mardones, most of the nine actions deal with the conservation of natural resources so as to add value and boost local development. The link of natural resource

protection with economic development is often implicit, we shall analyse this link and account for it in the evaluation of benefits.

### 2.3.1. to reforest recreational areas of school with native species

***Reforestación de áreas recreativas de escuelas con especies nativas***

This action consists in planting native tree species in the schools where possible in their recreational areas.

The action will be evaluated for two schools on the basis of 0.5 ha area suitable for tree plantation in each of the two communes first.

### 2.3.2. to organize workshop for land-owners on reforestation with native species

***Parcela demostrativa con reforestación con especies arbóreas nativas***

The action consists in promoting the restauration with native species of areas that are degraded or ecologically important (water sources).

The action will led through the establishment of a demonstrative area, the modalities of reforestation will progressively be specified, namely in terms of maintenance practices and protection from animal.

Initially 5 years will be necessary for the demonstrative plot to be operational.

### 2.3.3. to protect water sources and menokos (wetland)

***Protección de vertientes y menokos***

The action consists in protecting areas of specific ecological importance for water quality, by fencing, the incorporation of native vegetation and the installation of water dispenser for animals so that they don't access the water natural source directly where they would affect it. Specific preliminary activities will be necessary to address the protection of sacred areas of wetland (menokos)

The action will start with four sites within one initial year..

### 2.3.4. to establish enclosures in critical areas (water pool reserves and upstream from capitation points)

***Establecer recintos reservados (reservas de pool de agua entorno a y aguas arriba de las captaciones)***

The action consists in legally formalizing the protection of forests around water sources providing water to the cities of the territory.

Costs will essentially be labour costs for the necessary competencies (environmental and water laws).

Expected benefits include improved sustainability of water urban supply (to be specified).

#### 2.3.5. to promote non wood forest products

*Promover productos forestales no maderables*

The action consists in developing supply-chains for the main non-wood forest products of the territory: the seed fruit of the araucaria tree (*piñón*), the *morchella* o morel mushroom and the eglantine or rosehip fruit. It includes the promotion of good collection practices and the analysis of market development opportunities.

#### 2.3.6. to develop forest certification

*Certificaciones forestales*

The action consists in processing a territorial forest certification for wood material. Managed forests would generate higher value products.

#### 2.3.7. to store water from rainfall and sources

*Almacenaje de agua lluvia y vertientes*

The action consists in investigating and promoting water storage and piping in areas prone to droughts.

#### 2.3.8. to recycle used water in rural areas, separating grey waters from sewage

*Sistema de reciclaje (tecnología) de agua en áreas rurales*

The action consists in separating used water (from washing) for their recycling in farming, at the household level for a whole commune. More information is required still on the scope of the action we shall evaluate, if it is rather demonstrative or if it includes wide implementation.

#### 2.3.9. to raise awareness on the importance of water for turism

*Aumentar la conciencia de la importancia del agua en turismo*

The action consist if strengthen territorial identity in relation with the water resources of the territory, so that people better value them and understand their contribution to local development, based on tourism for instance.

### 2.4. General process of implementation

In each BM territory or pilot site, the authors of this report have started a joint work for the economic evaluation of CCA actions. A specific process and its implementation calendar have been proposed to EcoAdapt WP3 and WP4 participants (cf. the note “2014 Metodologia Evaluación económica Alternativas EcoAdapt” in Annex). Given that economic evaluation can be tackled by back-of-the-envelope calculations as well as by sophisticated models, it was important to precise beforehand, the expected depth of the analysis and a provisional distribution of time available between the two stakeholders' workshops planned for the elaboration of climate change strategies.

### *2.4.1 A step-by-step progression in the economic analysis*

Seven successive stages are been planned to ensure a gradual and common understanding of the economic evaluation of CCA actions: 1) scope definition for an initial and concerted overview of expected results; 2) analysis of the socio-economic context for the localization of important cost data; 3) evaluation of expected benefits and consideration of how to take them into account; 4) calculations of costs and benefits; 5) integration of equity considerations and of uncertainties and the possibility to make decisions sequentially; 6) transversal reflection and deliberation on the value of ecosystem services.

Distinctive efforts are dedicated to the scope definition so that final results of the economic evaluation correspond to data and analysis useful to stakeholders. Preliminary outcomes have just been presented (sections 2.1 to 2.3). In a total of thirty-five actions (15 + 11 + 9), ten types of actions are considered in more than one of the three sites.

- Area protection for water conservation: hillside forest cover from livestock in BMJ [13]; a set of priority sites for the watershed and extended Zapoco protected area in BMCh [1 and 11]; critical water sources and sacred wetland and around the capitation points of urban water supply in BMAAM [3 and 4].
- Reforestation: of sloppy areas of farms in BMJ [13]; of critical deforested areas with species of high economic value in BMCh [8]; of school and farmland with native species in BMAAM [1 and 2].
- Technical assistance for improved land and water use practices: of cattle ranchers in BMJ [11,12 and 13]; at the community level in BMCh [10]; possibly for forest certification in BMAAM [6].
- Farm dams to store rain water: the maintenance of farm dams and the construction of shared dams in BMJ [3 and 6]; their construction in BMCh [3]; investigation and promotion in BMAAM [7].
- Irrigation: improvement programme and runoff management in BMJ [6 and 7]; system implementations in BMCh [4]; recycling of used water in BMAAM [8].
- Territorial zoning or mapping for the whole territory: prior to rain sewer and sewage network extension in BMJ [1; 15]; prior to plan elaboration on water conservation or fire control in BMCh [1, 9].
- Early warning on weather risks: extreme events in BMJ [9] and fire risks in BMCh [9].
- Institutional coordination and information: on water management in BMJ [10]; on protected area extension and management in BMCh [1]; on market opportunity of forest products (non-wood and wood) in BMAAM [5,6].
- Tourism development: by extending the Zapoco protected area in BMCh [11]; by raising awareness and strengthening the identity of the territory around its water resources in BMAAM [9].

- Public awareness raising: on water use in BMJ [14]; on residue disposal in BMCh [6 and 7]; on reforestation and on the importance of water for tourism in BMAAM [1 and 9].

Quite specific for only one territory, we have:

- BMJ: water network infrastructure extension/improvement [1,2,4,5], including waterflow monitoring [8];
- BMCh: addressing basic needs at the household and community levels [2, 5, 7]

In total therefore, there will be twelve fields of data collection and analysis.

| Kind of action – Field of data research | | BMJ | BMCh | BMAAM |
|---|---|---|---|---|
| I | Area protection for water conservation | 13 | 1-11 | 3-4 |
| II | Reforestation | 13 | 8 | 1-2 |
| III | Technical assistance on land and water use practices | 11-12-13 | 10 | 6 |
| IV | Farm dams to store rain water | 3-6 | 3 | 7 |
| V | Irrigation | 6-7 | 4 | 8 |
| VI | Basic water needs (availability and quality) | | **2-5-7** | |
| VII | Water network infrastructure | **1-2-4-5-8** | | |
| VIII | Territorial zoning or mapping | 1-15 | 1-9 | |
| IX | Early warning on weather risks | 9 | 9 | |
| X | Institutional coordination and information | 10 | 1 | 5-6 |
| XI | Tourism development | | 11 | 9 |
| XII | Public awareness raising | 14 | 6-7 | 1-9 |

**Table 7: Fields of data collection and analysis for the economic evaluation of CCA actions**

Those fields are all interlinked, and one action may belong to more than one field. Still this reduction of 35 actions to 12 fields of investigation facilitates:
- the organization of tasks for the economic analysis (findings in one field of research will be useful in more than one of the three BM sites);
- the evaluation of complementarities between different actions.

The definition of the scope of the economic evaluation in terms of CCA priority actions, mirrors the local contexts. Indeed, those twelve fields correspond to large types of problems identified in the territory in relation with water security (deliverables 2.4 and 2.5): bad and uninformed practices on land use, water use and residue management; water pollution through soil erosion and sedimentation processes; lack of water during the dry season; increased population vulnerability because of the deficiencies of the infrastructure and their exposure to extreme events; lack of coordination and planning.

# 3. Characterizing costs in the assessment process

Cost characterization relies on the analysis of the local and national socio-economic contexts. Attention is being paid on the traceability of the data, for each set of figures where they comes from and which period of time and place they concern. Given the lack of systematic and updated data in available documents (Cuevas et al., 2014), fieldwork will complete deskwork a specific mention will be done when the best information identified may be outdated (already or soon).

We use the standard cost typology presented in the introduction, distinguishing four types of cost: money, labour, natural resources and material. Cost evaluation will consider successively volumes and prices. When a resource is used freely or without payment, we shall still evaluate the volume at play and the conditions to access it.

## 3.1. Costs of accessing funds

Money is necessary for the different actions to be undertaken, and the access to funds requires investigation. It can be more or less costly, whether donation or loan, and according to the funding institution, its funding strategy and conditions.
For each of the twelve kinds of CCA actions, we first determine the range of funding required, for instance whether we are talking about 10,000 USD, ten or hundred times more. Then we inquire who gives or lend such amounts, within which programme or earmarked spending, and at which conditions. Special attention is devoted for each identified funding source, to: limits in the amounts potentially available; interest rates; required counterparts and deadlines for execution and for repay.

Expected results will not only be quantitative on interest rates and counterparts. They will allow to discriminate actions relatively easy to fund and actions. Sensitivity analysis will account for the future closure or the opening of special funding or credit lines on climate change adaptation or related sector of activities.

A first screening of funding opportunities was done in Chile (Mardones, 2014. *Fuentes de financiamiento local en el territorio de BMAAM*, 14p.) and some preliminary contact information gathered in Bolivia (Marin, 2014. *Primer informe Instituciones y Organizaciones*, 13p.).

In Chile, interest rates including all loan charges run from 16% until 29% and various sources of funding by loans or donations have been identified. Two governmental institutions offer loans: INDAP (national institute for agricultural development) and CORFO (corporation for the promotion of production). Seven other governmental bodies offer donations through a competitive process or subsidies: FIA (foundation for the agrarian innovation), CONAF (national forest corporation); DOH (directorate of hydraulic constructions); FNDR (regional development national fund); CONADI (indigenous development national corporation); FOSIS (Solidarity and social investment fund) and SERCOTEC (technical cooperation service).

In Bolivia, eight institutions were identified up to now, that bestow credits for actions with environmental purposes amongst banks, public institutions and NGOs. In some cases the support is not financial but in kind, such as the provision of seedlings by EMAGUA, an entity of the Environment and Water Ministry.

In the Argentinean context, determining the cost of accessing funds raises difficult issues related to a high and unrecognised inflation rate, as well as several parallel exchange markets where the national currency lies much below its official exchange rate. This context may change next year (2015) with the national elections, it is not clear however in what direction.

## 3.2. Labour costs for different competencies

A combination of workforce with different competencies is necessary for each action, possibly including: workmen, technicians, engineers and specifically qualified or experienced people.

Corresponding labour costs comprise: salaries or wages, social charges, and in some cases daily allowances and transportation or other mobilisation costs. Additionally we shall analyse local and national labour market situations, so as to determine whether costs might evolve soon (for instance: high demand for a specific competencies, or new road making the territory more accessible) or differ in reality from what is officially stated (informal labour).

In some cases, labour is to be provided by the existing staff of an institution. It will be evaluated anyway but then we shall precise if and how to account for the evaluated cost of labour: it might be considered gratis, reduced to the extra-cost implied by the CCA action, accounted for in terms of opportunity costs or entirely accounted for if the institution makes it conditional for its participation to the CCA action.

The delimitation of actions detailed above (section 2) allows to draw a first list of professional profiles required, in Argentina already where available information can be synthesized from Greppi 2014 *Definición del alcance de la evaluación*. In Chile, professional profiles have been listed in Chile and information gathered on their remuneration levels, prior to the delimitation of actions (Mardones 2014. *Perfiles profesionales*,4p). Some adaptations and precisions will be necessary once actions are better described in terms of activities. Therefore the following table is still tentative.

| | | workmen | technicians foremen | engineers | *additional specif.skills* |
|---|---|---|---|---|---|
| I | Area protection for water conservation | land use | agriculture forestry | forest hydrology | *agreement negociation environtl.laws* |
| II | Reforestation | land use | agriculture forestry | agriculture forestry | *communication* |
| III | Technical assistance on land and water use practices | | agriculture livestock commercial. | land use planning | *environmental custody training* |
| IV | Farm dams to store rain water | agriculture construction | agriculture construction | agriculture hydraulic | *water needs and flows* |
| V | Irrigation | agriculture construction | farm design | agronom. | *coordination* |
| VI | Basic water needs (availability and quality) | construction | water and sewage | water and sewage | *health com. Planning* |
| VII | Water network infrastructure | construction | construction | civil constr. hydraulic | *monitoring* |
| VIII | Territorial zoning or mapping | | remote sens. map design | land planning | *communication planning* |
| IX | Early warning on weather risks | | meteorol. data proc. | climate model | *communication* |
| X | Institutional coordination and information | | Institutional representation | | *coordination* |
| XI | Tourism development | | Local knowledge | Tourism promotion | *cultural identity* |
| XII | Public awareness raising | | media environmental matters | | *science-society dialogue* |

**Table 8: Sector of activities to investigate on labour costs**

## 3.3. Costs of natural resources

Several natural resources will be needed in the considered actions: water mainly, but also plants, earth, sand, etc. Though natural resources might be available and freely extracted, their use deserves evaluation.
For each action in a first stage, we shall estimate volumes mobilized or required. Then we'll check the conditions at which the resources would be available, if they have established prices or if some economic evaluation already gave them in prior studies. Finally we shall consider the best way to account for their limited availability or the risk of their degradation, whether to calculate access costs, maintenance costs or replacement costs.

Work has not started yet on these aspects, but we can already highlight which kinds of action will require the integration of environmental variables in their cost calculations.

| | Kind of action | Water | Plant | Soil | *Nature (biodiv….)* |
|---|---|---|---|---|---|
| I | Area protection for water conservation | | | | *X* |
| II | Reforestation | X | X | X | |
| III | Technical assistance on land and water use practices | X | | X | |
| IV | Farm dams to store rain water | X | | X | |
| V | Irrigation | X | | X | |
| VI | Basic water needs (availability and quality) | X | | X | |
| VII | Water network infrastructure | X | | | |
| VIII | Territorial zoning or mapping | | | | |
| IX | Early warning on weather risks | | | | |
| X | Institutional coordination and information | | | | |
| XI | Tourism development | X | | | *X* |
| XII | Public awareness raising | | | | |

**Table 9: Natural resources whose costs should be taken into account (tentative table)**

Instead of crosses we hope to get numbers soon, out of the further understanding and modelling of socio-ecological dynamics (on-going work in the aftermath of EcoAdapt task 2.4).

## 3.4. Materials and technology costs

Material for workshops, for fencing, agricultural inputs, software for territorial zoning or public awareness raising, construction materials and equipment or machinery services are examples of the remaining cost category, the costs of materials and technology. They may either integrate a fully defined technological package or be evaluated with details. They may include labour when corresponding to a service, then this labour won't enter labour costs (second cost type). Inversely a contracted professional might include cost of materials in his or her labour costs. In both case cost of logistics or access costs will be integrated to one of the cost categories and won't constitute a specific one. An important source of information for this cost category will be the catalogues and commercial information. Attention will therefore be dedicated to issues of added charges or taxes (shipping, import tax, user license ….).

| Kind of action | | Inputs | Equipment | Machinery services |
|---|---|---|---|---|
| I | Area protection for water conservation | X | | |
| II | Reforestation | X | X | |
| III | Technical assistance on land and water use practices | X | | |
| IV | Farm dams to store rain water | | X | X |
| V | Irrigation | X | | X |
| VI | Basic water needs (availability and quality) | X | X | X |
| VII | Water network infrastructure | | X | X |
| VIII | Territorial zoning or mapping | | X | |
| IX | Early warning on weather risks | X | X | |
| X | Institutional coordination and information | X | | |
| XI | Tourism development | X | | |
| XII | Public awareness raising | X | | |

**Table 10: Material and technology costs to account for (tentative table)**

## 3.5. Allowing for re-evaluation

Cost evaluation will rely on available information and lead to desk- and fieldwork with a limited time period of two to three months within EcoAdapt project. Costs will be calculated for the duration of the action implementation that still needs to be postulated for the actions considered in BMCh and BMAAM and validated in BMJ. As mentioned for each cost category, revisions might be necessary given the many sources of cost fluctuations. Scales might be adjusted in terms of target population and of duration of the action, which may have repercussions on cost given some scale and learning effects. For instance regarding reforestation, unit cost of seedling decreases with their number. An additional reason for re-evaluation is the accounting of complementarities between actions of different types. Some actions initially considered separately will be re-evaluated considered its association with another action. For instance in BMCh, the protection of critical water conservation sites (action 1) requires a different evaluation whether the extension of the Zapoco protected area (action 11) is achieved or not.

We shall make sure revisions are easy through the use of an excel table tool where exogenous variables (for instance unit cost) are clearly distinguished from calculated ones and calculations are done between variables entered in different cells (and not within one cell with little visibility). Simple aggregations will be proposed so as facilitate comparison of results with the still poor but rapidly increasing literature on the costs of adaptation through particular actions.

# 4. Evaluating benefits

Providing figures about the benefits of climate change adaptation to balance with costs may definitely influence decision-making, especially at the global level where very aggregated figures are handed out in terms of Gross Domestic Product (GDP) percentages. For instance when the Stern report assessed that adaptation may cost 2% of the world's GDP but should allow to avoid a 5% negative impact on PIB in the absence of adaptation measures, it made a strong point in favour of adaptation efforts… until William Nordhaus revised the latter estimation and brought the benefits of adaptation down to 1% of the global GDP.

Such estimations rely on large sets of conventions and hypothesis, much of the debate has finally crystallized on the controversy of the discount rate chosen in calculations. Locally where adaptation is understood as an investment, prevailing evaluation are financial indeed, focusing on indicators such as the net present value or the internal rate of return of the investment.

For the economic evaluation of EcoAdapt CCA actions, we won't adopt a solely financial outlook, therefore we won't be so keen on delivering results in terms of aggregate figures and pay more attention on the process of accounting for different aspects of the benefits of climate change adaptation.

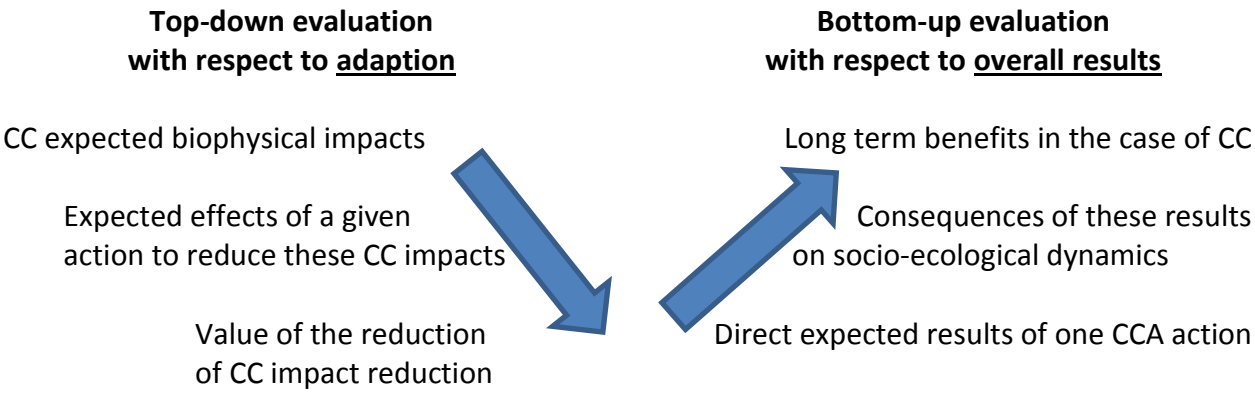
## 4.1 The tricky issue of evaluating climate change adaptation benefits

The evaluation of CCA benefits is based on a given understanding of the causality chain bringing together climate variables and human activities, for instance through: the biophysical negative impacts of climate change, the effects of adaptation action to reduce these impacts, and the value taken by this reduction of damages. This causality chain is not unequivocally defined and characterized, given the existing "cascade of uncertainties" (Schneider, 1983 cited in IPCC WGII assessment reports) that widens/multiplies the range of possibilities.

Before evaluating the effectiveness of adaptation actions to limit negative impacts or enhance positive ones, perceptions must be made explicit. They generally integrate both an overall understanding of mechanisms and some individual experience or projection of climate change impacts and the success or failure of actions supposed to be adaptive, cf. for instance Schillinger et al. (2011) in the case of Jujuy.

Such understanding mobilizes the scientific and local knowledge on biophysical process, before calling for economic analysis. The evaluation process of adaptation is intrinsically top-down in the sense that it starts with the understanding of global climate change phenomena and their impacts and it ends with a local economic valuation exercise. In the inverse way, given that most CCA actions responds to identified existing needs (more or less directly linked to climate change issues), they are locally contemplated within a more bottom-up process, starting with the tangible (local and short-term) benefits of an action, financial and biophysical, then tackles the further consequences of the action in order to address wider issues o CC adaptation.

Figure 1: Evaluating the benefits of a climate change adaptation action




Both ways of evaluating benefits, top-down or bottom-up, are incomplete and subject to uncertainties.
- The top-down way, first biophysical then economic, requires the additional evaluation of benefits that are not related to climate change, at least in the perception of the people involved in the evaluation. It leads to focus on biophysical uncertainties.
- The bottom-up way, directly economic, better corresponds to usual investment evaluations, leading to focus on technological uncertainties and generally at a loss to evaluate long term benefits given the lack of framed reflection to achieve it.

The comparison between the two evaluation procedures is rich, highlighting some complementarities namely for the scope of the evaluation and the alternative ways uncertainty can be accounted for. However they overlap and their combination might lead to double counting. For the economic evaluation of adaptation actions in EcoAdapt, we shall combine a descendent approach with complements for the ascendant one.

## 4.2. Available information on CC impacts, with or without action

### 4.2.1. The biophysical impacts of climate change and their expected reduction

Climate variability and its possible relation with climate change has been studied in the three sites where the extension of the dry season can be observed, accompanied with diminishing rainfalls and more intense rains. Impacts are principally related to water stress, further aggravating water quality problems that derive from socio-ecological dynamics.

The full list of expected impacts of CC in the three EcoAdapt BM territories is still under construction (namely with the products of task 2.4 of the project). The following table is synthetic and indicative. It shows that the impacts explicitly addressed are mainly related to extreme events and their expected increased frequencies and intensities.

| Kind of action | | Extreme event | Change in rain patterns | Change in temperature pattern |
|---|---|---|---|---|
| I | Area protection for water conservation | water erosion | | |
| II | Reforestation | x | x | X |
| III | Technical assistance on land and water use practices | x | x | X |
| IV | Farm dams to store rain water | | x | |
| V | Irrigation | draught | | |
| VI | Basic water needs (availability and quality) | | | |
| VII | Water network infrastructure | storm | | |
| VIII | Territorial zoning or mapping | | | |
| IX | Early warning on weather risks | draught | | |
| X | Institutional coordination and information | draught | | |
| XI | Tourism development | | | |
| XII | Public awareness raising | | | |

**Table 11: CC impacts addressed with the considered adaptation actions**

### 4.2.2. The value of reduced damages

We identified the following possible evaluations of the benefits that correspond to lower climate change impacts.

- A reduction of crop loss is evaluated through assumptions on the market value of the part of the crop that, instead of being loss will be sold and generate revenues.
- The reduction of destruction by fire or by inundation can be evaluated through the saved lives and assets (infrastructure). The latter will be evaluated through their replacement value or repair cost.
- When related to water quality, reduced damages can be evaluated with money saved, thanks to lower water treatment costs; less need medical care….

## 4.3. The evaluation of actions, accounting for more tangible benefits

Some actions might be profitable or generate revenues that partially cover their implementation costs. Those benefits are generally less uncertain than the benefits associated with a reduction of climate change negative impacts.

We shall evaluate them, investigating two types of benefits: revenues from commercial activities, and avoided expenses. Of the first type, let's mention the potential revenues from

tree pruning in a reforestation action. Of the second type, let's mention the savings from reduced fertilizer use in an action consisting in improving agricultural practices.

To evaluate the tangible benefits of a given CCA action, we shall identify:
- to what commercial activities it relates or could relate and the revenues it make possible;
- to what production/generation process it relates and the savings it makes available.

This evaluation will allow to distinguish actions called no-regret because they are profitable or beneficial even without contributing to the reduction of climate change damage.

# 5. Discussion on the use of economic evaluation

Numbers on costs and benefits on different actions can tell about efficiency and reveal rational choices or theoretically best options for resource allocation. But there are many situations in which they do not explain well observed decisions, obviously taken with wider outlooks. As a matter of fact, cost-benefit analyses have widely evolved toward multi-criteria analyses as a support to decision making. In EcoAdapt, the overall framework to consider decisions on CCA actions is borrowed from management sciences and distinguishes the economic from the socio-institutional and the biophysical. However, there are at least two issues that economic analysis tackles by integrating institutional or biophysical aspects, respectively: equity and uncertainty. Existing analytical frameworks for these insights on decision-making are quite theoretical, we shall try to keep it simple and make it very applied to actual situations of BMJ, BMCh or BMAAM.

## 5.1. Equity issues

With the efforts to build shared representations of problems that directly concern whole watershed territories and cannot be solved on individual bases only, the initial focus on collective action quite concealed equity issues. Yet we mentioned them in the introductory synthesis on the contexts of the three sites of study and intervention, see Table 5. Equity problems feed differences of standpoints and latent conflicts, for instance:

- upstream versus downstream actors in Argentina when reacting to water scarcity risks and trying to secure access to water for irrigation;
- communal smallholders versus private large holders in Bolivia when adjusting their cattle raising practices and pasture expansion to new policy measures that both promotes food security and reforestation;
- water rights owners versus water users in Chile when the legal conditions enhance speculative water management for future energy generation projects.

The comprehension of equity issues requires to account for both:

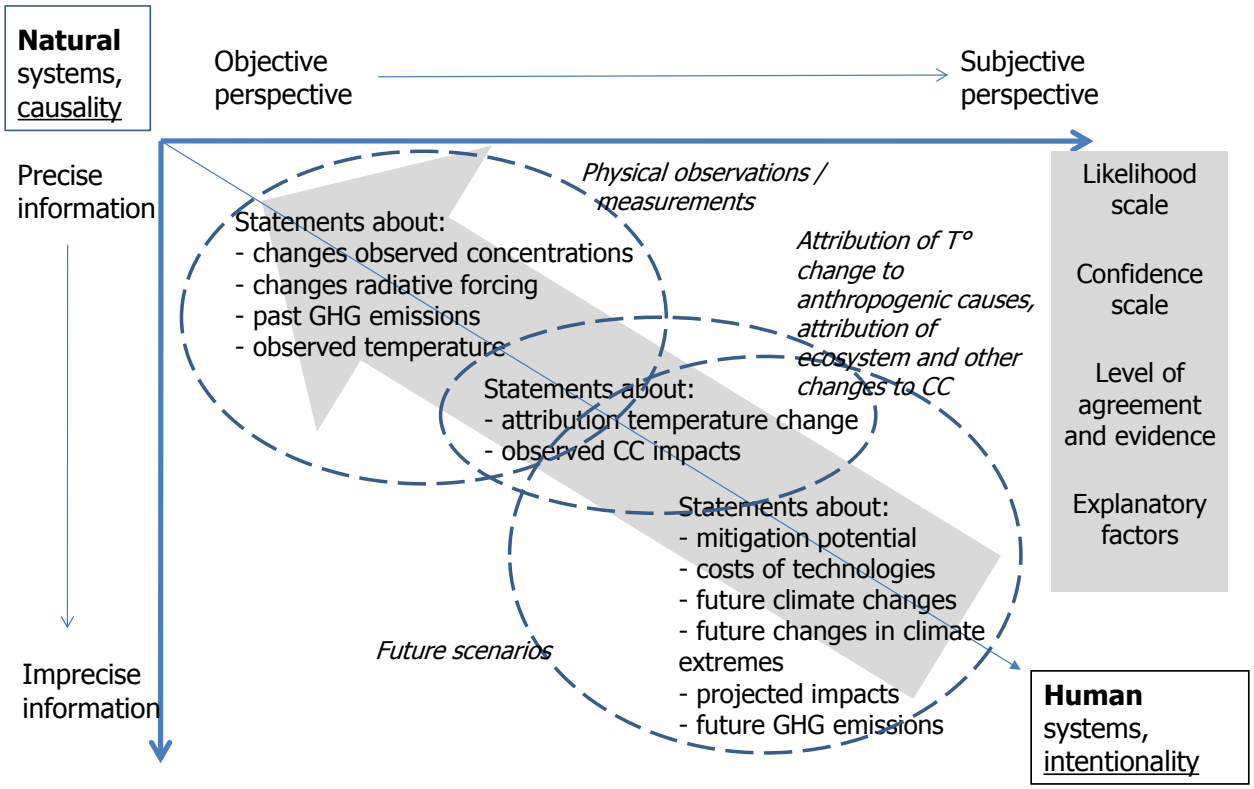
- unequally distributed/centralized economic power;
- environmental externalities and the way actual regulation succeeds in reducing them or at the contrary contributes to worsen them.

Then we shall clarify for each of the considered actions who will be in charge and assume main risks, who bear costs, who will get benefits. This investigation will basically serves to better understand the implications of each action in terms of power redistribution and empowerment or acquisition of autonomy. It will finally help to account for situations where actions are chosen for the compromise they represent instead of their purely economic performance.

## 5.2. Uncertainty

There are so many uncertainties on climate change adaptation, the way they combine and get amplified is so complex, we find it useful to first simplify in a schematic way the purpose of accounting for uncertainty in general, then think which are the main uncertainties to focus on. It is important to better understand uncertainty by accounting for the multiplicity of uncertainty types, given that they imply different ways of dealing with (Fig.2).

**Figure 2: Uncertainty of different types**




*edited from Swart et al, 2009 (Fallot, 2010)*

To complete the economic evaluation of CCA, the basic idea is to account for specific uncertainties which, associated with irreversibility, may lead to choices in favour of actions of relatively low economic performance and justify sequential decision-making often mistaken for procrastination. For instance in the BM territories, uncertainty on: the occurrence of extreme events that most affect the watershed (BMJ), the evolution of water quality (BMCh), the growing awareness on water scarcity (BMAAM).

In EcoAdapt for each cost and benefit element, we shall evaluate uncertainty using and simplifying IPCC terminology (Fig.3) with less categories, then conduct a joint reflection with local actors on which associations of uncertainty and irreversibility deserve specific attention.

**Figure 3: IPCC terminology on uncertainty**

| **Likelihood terminology** | **Likelihood of the occurrence/outcome** |
|---|---|
| Virtually certain | *>99% probability* |
| Extremely likely | *>95% probability* |
| Very likely | *>90% probability* |
| Likely | *>66% probability* |
| More likely than not | *>50% probability* |
| About as likely as not | 33 to 66% probability |
| Unlikely | *<33% probability* |
| Very unlikely | *<10% probability* |
| Extremely unlikely | *<5% probability* |
| Exceptionally unlikely | *<1% probability* |

| **Confidence terminology** | **Degree of confidence in being correct** |
|---|---|
| Very high confidence | at least 9 out of 10 chance |
| High confidence | about 8 out of 10 chance |
| Medium confidence | about 5 out of 10 chance |
| Low confidence | about 2 out of 10 chance |
| Very low confidence | less than 1 out of 10 chance |

***Swart et al, 2009***

This procedure will allow to highlight the value of information and the importance of learning processes in the course of a climate change adaptation project. It will complete the evaluation of action with the indication of their flexibility.

# 6. Conclusion and further steps

In the assessment process for making decisions about climate change adaptation, specific actions are being evaluated from an economist' perspective. These actions (15 in JuJuy, 11 in Chiquitania and 9 in Alto Malleco) are still being delimitated so as to best correspond to the priorities and the need for figures of the local people, given their understanding of the context, the possibilities to reduce their vulnerability to climate change impacts and their limited resources to do so.

Economics generally start by simplifying the reality so as to better analyse specific features of it. These simplifications are explained in this deliverable and will be somehow compensated by the complementary biophysical and socio-institutional evaluations to be led in the EcoAdapt project. In this deliverable we present a framework for economic evaluation tied to alternatives identified in the first SDM steps (task 4.2).

Further steps consists in data collection and processing in each of three study sites for integration in Fuzzy Cognitive maps and Agent-based models.

- In BMJ where more than 100,000 persons are potentially concerned by actions of adaptation to climate change, the economic evaluation will focus on showcases. Emphasis will be put on actions with a long term outlook and, in some cases, the joint involvement of public and private institutions present in the territory. For that matter, co-financing and counterparts might play an important role in the economic evaluation, as well as the choice of time horizons and differences of standpoints amongst actors.
- In BMCh where the pilot study site is almost as large but the population hardly reaches 10,000 persons with limited access to basic services, the actions address more directly the people's needs for improved livelihoods and reduced vulnerability. Given the extent and importance of these needs, and the lack of data to specify them much, several actions integrate initial stages of priority identification and planning, whose results might lead to partly redefine the actions as far as their implementation activities are concerned. Such peculiarity will be accounted for in the very economic evaluation considering sequential decision-making and the possibility for standpoints to change.
- In BMAAM where the territory is about four times wider and the population density still lower (with about 27,000 people), adaptation actions are also considered on a showcase basis. They focus on the conservation or restoration of natural resources, with the motivation that they are key for local development and the improvement of living conditions. For that matter, economic evaluation will mostly rely on environmental economics with a focus on the valuation of ecosystem services.

In the three cases both natural resources (water especially) and the livelihoods are the targets of the actions subject to economic evaluation. Basically, these actions all aim at contributing to a more sustainable development without being explicitly linked to climate change. The

economic evaluation tentatively establishes or highlights this link when tackling some aspects of climate change: long term horizons, uncertainties and irreversibility of different types.

Further improvement of economic evaluation will be tied to the modelling work (cf deliverable 3.1 and 3.2) that accompanies the development of adaptation projects (cf deliverables 3.1, 3.5 and 5.5). We now aim at building capacity of agents of change about the current framework and bringing specific inputs in the decision process concerning the best alternatives (beyond costs calculations) as a portfolio of actions, taking into account the progressive integration of new information.

## Annex list: available reports and analysis

The present document uses the following notes in Spanish:

- Greppi, M., ETAPA 1 Definición del alcance de la evaluación.
- Mardones, J., Acciones.
- Mardones, J., Fuentes de financiamiento.
- Mardones, J., Perfiles profesionales.
- Marin, J., Lista de acciones.
- Marin, J., Instituciones financieras.
- Fallot, A., 2014. Metodología para la evaluación económica de alternativas de adaptación al cambio climático en el marco del proyecto EcoAdapt. Note 8p.

Two presentations also provided direct inputs, namely in terms of synthetically cross-site analysis, and about equity issues, by Le Coq, J-F ,Fallot, A., Aguilar, T., Rixen, A., Vilugrón, L., Gonzales, D., Schillinger, R., Vides-Almonacid, R.:

- Equity considerations in a comparative analysis of the socio-ecological dynamics in 3 watersheds of Latin America. Presentation to the ISEE 2014 conference.
- Adaptation to climate change and resilience of territories: revealing the drivers of socio-ecological system changes in 3 watersheds of Latin America. Presentation at the Resilience 2014 conference.

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| | |
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