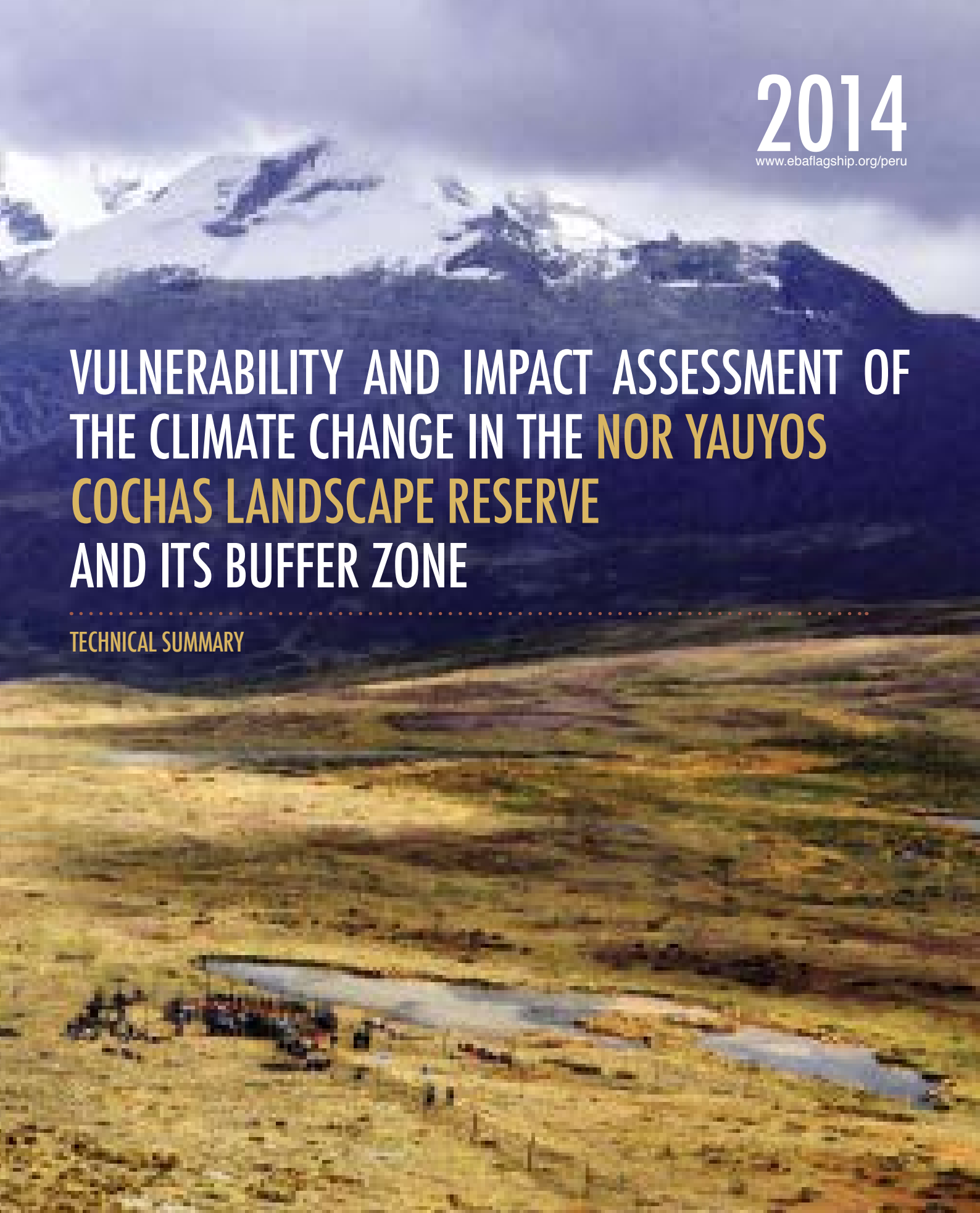

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VULNERABILITY AND IMPACT ASSESSMENT OF THE CLIMATE CHANGE IN THE NOR YAUYOS COCHAS LANDSCAPE RESERVE AND ITS BUFFER ZONE

TECHNICAL SUMMARY

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photo: NYCLR Headquarters

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TECHNICAL SPECIFICATIONS

This document is the technical summary of the “Vulnerability and Impact Assessment of climate change in the Nor Yauyos Cochas Landscape Reserve and its Buffer Zone - EVI NYCLR” by Fundación para el Desarrollo Agrario (FDA) from La Molina National Agrarian University (UNALM in Spanish) ended on December 2013.

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photo: NYCLR Headquarters

ACRONYMS

BZ	Buffer zone
EAP	Economically Active Population
EbA	Ecosystem-based Adaptation
ECHAM	European Centre Hamburg Model
ES	Ecosystem services
GCM	Global Circulation Model
GHG	Greenhouse Gas
INEI	Instituto Nacional de Estadística e Informática (National Institute of Statistics and Information)
IPCC	Intergovernmental Panel on Climate Change
NYCLR	Nor Yauyos Cochas Landscape Reserve
SAIS	Sociedad Agrícola de Interés Social (Agricultural Societies of Social Interest)
SDM	Species Distribution Modeling
VIA	Vulnerability and Impact Assessment

1 INTRODUCTION

Climate change is one of the most important challenges that we are presently facing. Its impact on people is not only direct from flooding and heat waves, among others, but also indirect, because of its impact on ecosystems, their functions and the goods and services they provide. Some of these services include provisioning of food, water, fuel, medicinal plants and raw materials, control of pests and soil erosion and purifying air and water.

Ecosystems are at the same time a key element of the global response to climate change by capturing and storing carbon, which contributes to mitigating this phenomenon. Thus, healthy, sustainably managed ecosystems help communities to increase their resilience and favor adaptation to climate change by providing resources that contribute to people wellbeing.

In this context, **the Ecosystem-based Adaptation (EbA) approach emerges as a climate change adaptation option. It consists of including biodiversity and ecosystem services within overall adaptation strategies to be able to cope with the adverse impact of climate change (CDB, 2009).**

This is done through diverse activities, such as integrated water management to regulate water flow, restoring ecosystems (wetlands, forests, etc.), reducing the risk of disasters from flash floods and flooding or diversification of agricultural production to cope with changing climate conditions, to name a few (UICN, 2012).

The EbA approach can be applied to projects and programs on a regional, national or local scale and can provide benefits both in the short and long term (CDB, 2009). Moreover it incorporates the traditional knowledge that local communities and indigenous people have developed throughout generations in response to changing climate conditions.

In Peru, ecosystem-based adaptation is implemented in mountain areas in the Nor Yauyos Cochas Landscape Reserve within the framework of the Ecosystem-based Adaptation in Mountain Ecosystems Programme. This is a collaborative initiative of the United Nations Environment Programme (UNEP), the International Union for Conservation of Nature (IUCN) and the United Nations Development Programme (UNDP), funded by Germany's Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

This document seeks to summarize the report on **Climate Change Vulnerability and Impact Assessment on the Nor Yauyos Cochas Landscape Reserve and its Buffer Zones (VIA NYCLR)** developed to support the identification of Ecosystem-based Adaptation measures for the Nor Yauyos Cochas Landscape Reserve. Some theoretical and methodological aspects are presented here, supplemented by the main findings and recommendations, with the aim of being useful for future climate change adaptation experiences.

2 THE MOUNTAIN EBA PROJECT IN PERU

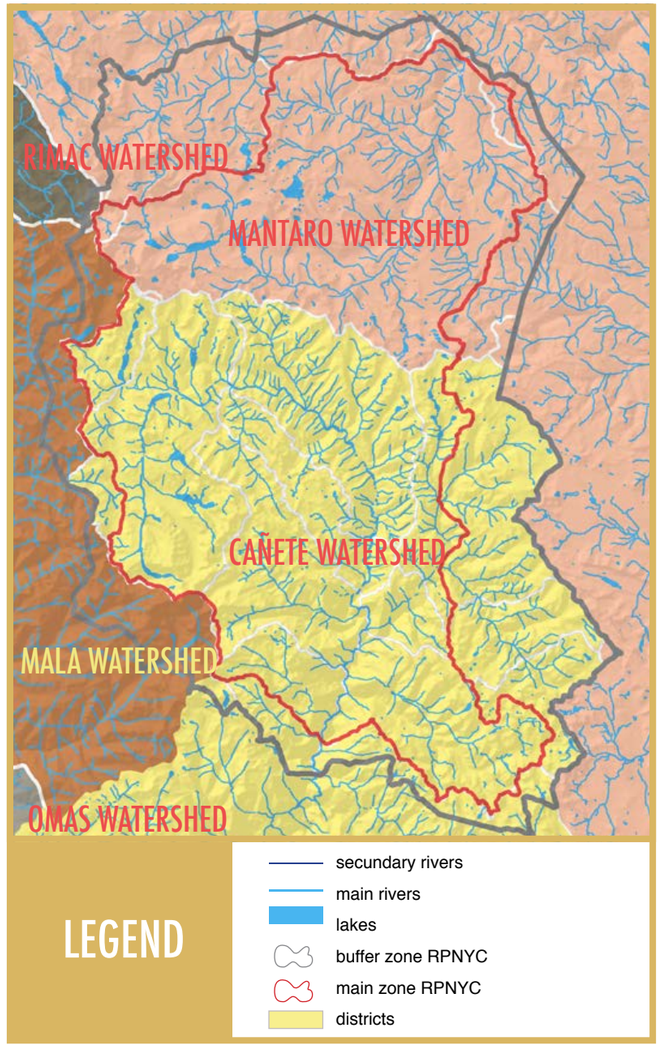
The objective of the Ecosystem based Adaptation in Mountain Ecosystems Programme is to support governments in their local and national adaptation strategies, so that ultimately, through conservation, restoration and management of ecosystem services and biodiversity, vulnerable rural communities can improve their capacity to adapt to climate change.

In Peru, the programme is commissioned by the Ministry of Environment of Peru (MINAM for its Spanish acronym) and is implemented in the Nor Yauyos Cochas Landscape Reserve with the support of the National Service of Natural Protected Areas (SERNANP for its Spanish acronym). The activities under IUCN's responsibility are implemented in partnership with The Mountain Institute (TMI) in the communities of Canchayllo and Miraflores.

THE NYCLR AND ITS BUFFER ZONE IS LOCATED IN THE PERUVIAN ANDES, BETWEEN THE LIMA AND JUNIN DEPARTMENTS, IN THE CENTRAL MOUNTAIN RANGE AT AN AVERAGE ELEVATION OF 4,000 METERS WITH A SURFACE AREA OF 330,714 HECTARES (INRENA-IANP, 2006).

The NYCLR is a natural area protected by the State of Peru through the National Protected Natural Areas Service (SERNANP,for its Spanish acronym). The Alto Cañete basin covers 57% of this area and the Cochas-Pachacayo basin covers the remaining 43% (fig. 1).

Figure 1. Cañete and Cochas-Pachacayo river basins and boundaries of the Nor Yauyos Cochas Landscape Reserve.



Source: Pablo Dourojeanni, 2014

With a slight decreasing trend, the total population settled in the NYCLR is about 10,000 people. This population is dispersed among the eleven districts that form the core of the NYCLR area and is settled mainly in the villages in the valley bottoms. All towns in the Reserve are accessible by road, although the only paved one is the one crossing the NYCLR.

There are at least five roads that provide vehicle access to the NYCLR and Tanta is the town and district capital furthest from any access. The main economic activities of the population involve the use of natural resources. Agriculture (mainly potatoes, barley, beans and corn), livestock (mainly cattle, sheep, goats and American camelids) and fish (trout) are the main economic activities.

THE NYCLR WAS SELECTED AS THE STUDY AREA FOR THE MOUNTAIN EBA PROJECT IN PERU BECAUSE IT IS CONSIDERED REPRESENTATIVE OF SOCIAL AND ENVIRONMENTAL CONDITIONS THAT MAY BE FOUND IN OTHER AREAS, WHICH FAVORS REPLICABILITY OF RESULTS.

3 VULNERABILITY AND IMPACT ASSESSMENT (VIA) OF CLIMATE CHANGE IN THE NOR YAUYOS COCHAS LANDSCAPE RESERVE AND ITS BUFFER ZONE (NYCLR-BZ)

photo: Mountain EbA project

In the framework of the project, a Climate Change Vulnerability and Impact Assessment of the Nor Yauyos Cochas Landscape Reserve and its Buffer Zone (FDA 2013) was carried out between August 2012 and December 2013[1].

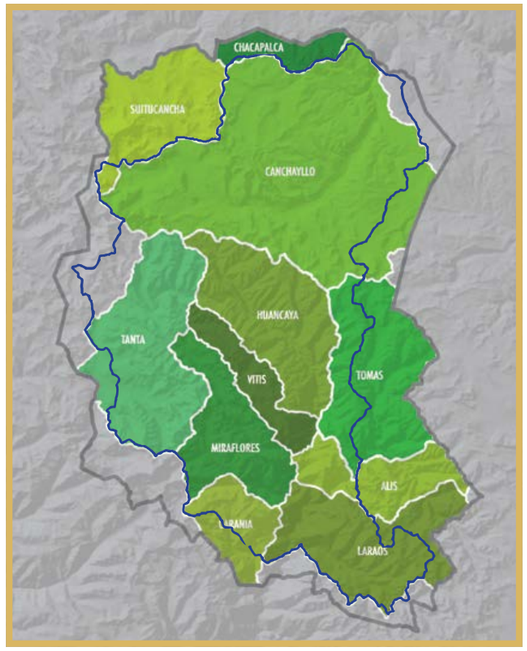
The study provides input for discussion on strengths and weaknesses in coping with climate change at NYCLR.

THE STUDY AREA INCLUDED ELEVEN DISTRICTS: ALIS, CHACAPALPA, CANCHAYLLO, CARANIA, LARAOS, HUANCAYA, MIRAFLORES, TANTA, TOMAS, VITIS AND SUITUCANCHA (fig. 2).

Figure 2. Location of the Reserve and districts selected for the VIA[2]

Source: FDA, 2013.

The study assessed the impacts of climate change on the NYCLR for the present and near future (2012-2030), determining the level of impact from global warming on ecosystem goods and services (water, natural grasslands, agricultural surface area, among others). It also considered the current and future repercussions of climate change on the local population.



Source: FDA, 2013.

The assessment was conducted by a team of researchers from the Centro de Datos para la Conservación (CDC, Center for Conservation Data) and the Faculty of Economics and Planning of the Universidad Nacional Agraria La Molina (UNALM, La Molina National Agrarian University), the International Research Institute for Climate and Society (IRI) and the Earth Institute – Center for Environmental Sustainability (EICES) of Columbia University (FDA, 2013).

{ 1 The VIA NYCLR study was conducted by an international team of experts listed under Appendix 1.
2 The bold blue line shows the boundaries of the Reserve and its buffer zone. }

3.1 CONCEPTUAL FRAMEWORK

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007).

The livelihood of most of the population living in the NYCLR depends on the services provided by the ecosystems. Therefore, the vulnerability of the population is also associated with the availability of these services. At the same time, the availability (or supply) of ecosystem services (ES) is affected by variations in climate, the dynamics of the ecosystems themselves and the pressure exerted by human activities on the services (demand for ES).

Keeping these considerations in mind, the study proposes an analysis of variability based on ES supply and demand, as shown on Figure 3, that outlines the methodology applied and the relationships between the different components.

TABLE 1: ECOSYSTEM SERVICES

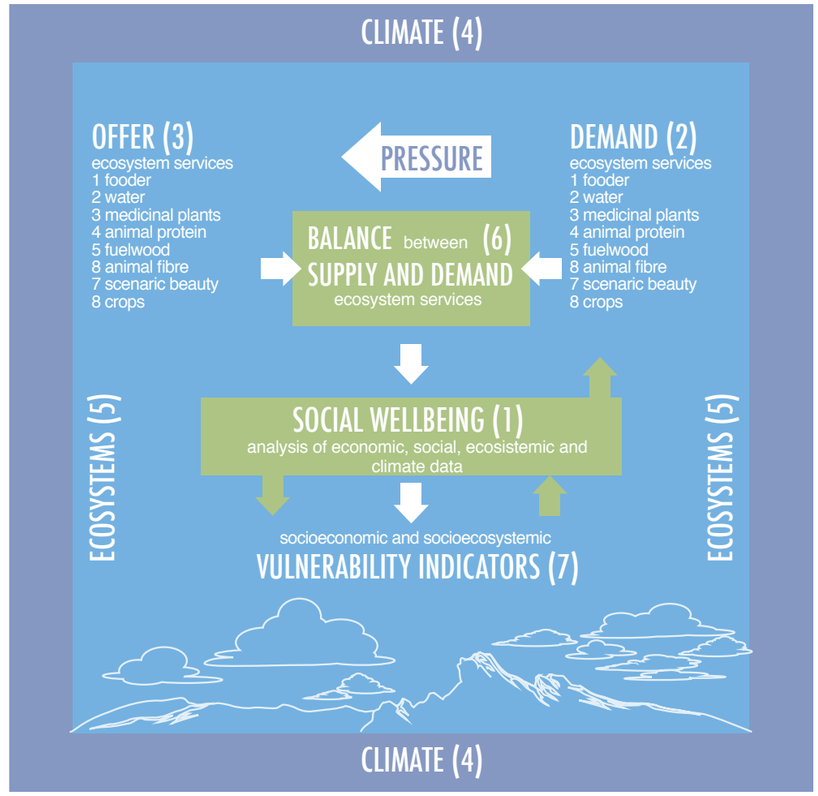
Ecosystem services are the benefits people obtain from ecosystems (Daily, 1997; Millennium Ecosystem Assessment, 2005).

These include provisioning, regulating and cultural services, as well as support ones.

Examples of ecosystem services provided by the NYCLR are:

Provisioning: Wood, forage and water
Regulating: Water purification
Cultural: Scenic beauty
Support: Soil formation

Figure 3. Outline of the ES Supply and Demand Methodology Used.



Source: Prepared by Pablo Dourojeanni.

The figure shows that social wellbeing (1) depends on economic activities to satisfy livelihood that, in turn, generates a demand for ecosystem services (2). This demand exerts pressure on the supply of ecosystem services (3) that depends both on climate (4) and the status of the ecosystems themselves (5). The interaction between demand (2) and supply (3) generates a balance between supply-demand balance (6) of ecosystem services that then impacts on social wellbeing (1). Social wellbeing is also affected directly by climate (4) and the status of ecosystems (5). All of these interactions generate socioeconomic and socioecosystemic vulnerability indicators (7).

3.1.1 COMPONENTS OF THE STUDY

The Vulnerability and Impact Assessment analyzed for each of the districts the components described below: climate, hydrology, ecosystems and ecosystem services and the socioeconomic factors.

a CLIMATE

Future climate scenarios are the cornerstone and the basis on which the study is constructed. Climate contributes to defining ecosystems characteristics and their services, which, in turn, are sensitive to climate variability, extreme values and changes in average values of the indicators.

To better understand the impact of climate and its variability on physical, biological and human systems, the analysis studied the longer term changes in climate conditions at the NYCLR. Specifically, it studied average air temperature, specific humidity and potential convective energy available [3] using projections of general climate trends in the future[4].

b HYDROLOGY

Changes in surface runoff produce an impact on conditions with regard to access to drinking water, as well as productive activities depending on rainfall and surface runoff. Therefore, hydrology is an important factor to be considered in analyzing the vulnerability of the population and the distribution and supply of ecosystem services.

Within the context of the study, a water resources vulnerability index was developed to understand the availability of water-- the ratio between the total demand for surface water and the supply of water – and to identify the districts that are most vulnerable to the threat of changes in surface runoff (fig. 8.).

c ECOSYSTEMS AND ECOSYSTEM SERVICES

As mentioned above (fig. 3), the vulnerability caused by human pressure exerted on ecosystem services was studied through a supply and demand analysis that compares (i) the impact of demand on resources originating from ecosystem services and (ii) changes in their supply. The ecosystem services considered were: the production of medicinal plants, the production of fuelwood, provisioning of animal protein, animal fiber, scenic beauty and tourism, and forage. Also included in the calculation of supply and demand were the supply and access to water using a surface runoff and water scarcity index. In this way, the “hydrology” component has been, for purposes of this study, a subcomponent of the ‘ecosystems and ecosystem services’ component. Therefore there isn’t an independent section on hydrology included in the key results section (3.4).

The analysis was done based on indicators of population growth, and changes in the future supply of ecosystem services due to climate change. The latter was modeled using the future distribution of species that are considered key for such services. The magnitude of variations in supply and demand, either positive (demand greater than supply) or negative (supply greater than or equal to demand) of the index complete the analysis. This was used to identify the NYCLR districts where there is most pressure on the different services.

d SOCIOECONOMIC CHARACTERISTICS

Certain local socioeconomic characteristics have an influence on the intrinsic vulnerability of a population and its ability to adapt to potential changes in the future. Within the framework of this study, the analysis of different local socioeconomic properties provides a description of district vulnerability (using a vulnerability map, among others).

3 The potential convective energy available is the quantity of energy available for a mass of air that is elevated during the convection process. It is measured in joules per kilogram of air (J/Kg). As the potential convective energy available increases time becomes more unstable.
4 The process for preparing the climate analysis encountered several difficulties because of the lack of a complete series of climate data (temperature and rainfall) covering the minimum sufficient time lapse and given information limitations, the analysis has been projected only to the year 2030 in order to limit uncertainty. In addition, extreme events have not been studied either. This task will remain pending for later initiatives.

The following are the socioeconomic index and indicators used to calculate the sensitivity and vulnerability to climate change of the local population:

The weighted socioeconomic index that takes into account the percentage poor local population (as defined by the INEI), the percentage of the economically active population (EAP) and the rate of malnutrition among children aging between 6 and 9 years.

The indicator of economic dependence on ecosystems (agricultural and livestock), that represents the percentage of the population whose main source of income derives from agricultural or livestock breeding (as opposed to other activities, such as tourism, trade, transport, agroindustry, fish farming, mining, etc.).

The health service indicator that measures medical service coverage based on the number of medical personnel (with general medicine education) for every one thousand inhabitants, estimating that a lack of coverage results in greater sensitivity of the local population.

The level of education indicator that measures the level of basic studies completed by family members.

Table 1 summarizes the range of socioeconomic vulnerability of each indicator and the weight attributed in calculating the indexes.

TABLE 2: VULNERABILITY TO CLIMATE CHANGE

According to the Intergovernmental Panel on Climate Change (IPCC, 2007), VULNERABILITY TO CLIMATE CHANGE IS UNDERSTOOD TO BE THE DEGREE OF SUSCEPTIBILITY OR INABILITY OF A SYSTEM (ECOSYSTEM OR SOCIO-ECONOMIC SYSTEM) TO COPE WITH THE ADVERSE IMPACTS OF CLIMATE CHANGE, INCLUDING THE OF CLIMATE VARIABILITY AND EXTREMES. Vulnerability depends on the character, magnitude and rate of climate change to which the system is exposed, its sensitivity and its adaptive capacity.

Table 1. Range of Indicators and the Index of Socioeconomic Vulnerability at District Level.

WEIGHTED SOCIOECONOMIC INDEX			ECONOMIC DEPENDENCE ON ECOSYSTEMS	HEALTH	EDUCATION	VULNERABILITY
% of poor population (Weigh = 2)	EAP % (Weigh = 2)	Malnutrition Rate 6-9 year old children (Weight = 1)		(Ratio medical personnel / 1000 inhabitants)	(Education of family members)	
≤10%	≥ 70%	≤10%	<20%	> 1,0 a más	>70%	Baja
11%-20%	60-69%	11%-20%	21%-40%	N/A	61%-70%	Baja a moderada
21%-30%	50%-59%	21%-30%	41%-60%	0,6-0,9	51%-60%	Moderada
31%-40% 3	36-49%	31%-40%	61%-80%	0,1-0,5	31%-50%	Moderadamente alta
>40%	<35%	41%	>81%	0,0	<30%	Alta

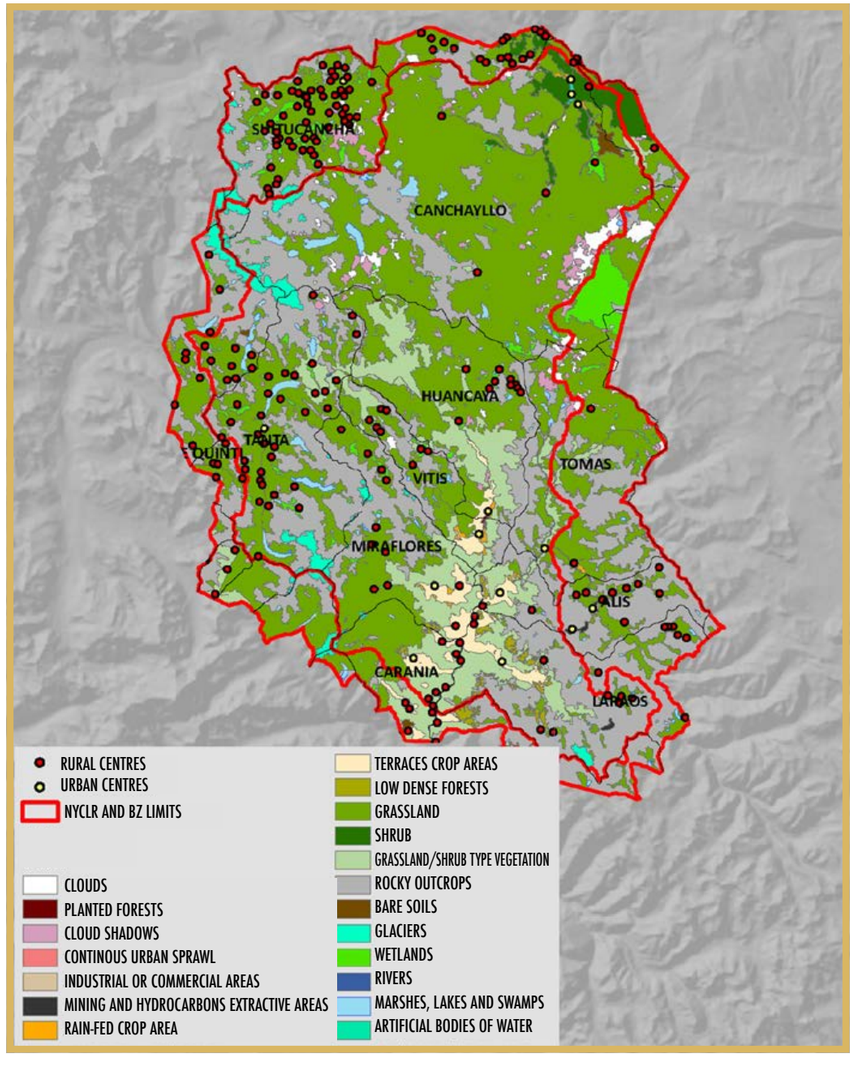
Source: FDA, 2013.

3.1.2 METHODOLOGY

The first step consisted of modeling the future climate (2030) of the Reserve in terms of temperature and rainfall; this was used as a basis for calculating the future availability of water, both for ecosystems and for the population.

A land cover map of the Reserve was developed, a novel product of this study, (fig. 4) to identify the ecosystems present there.

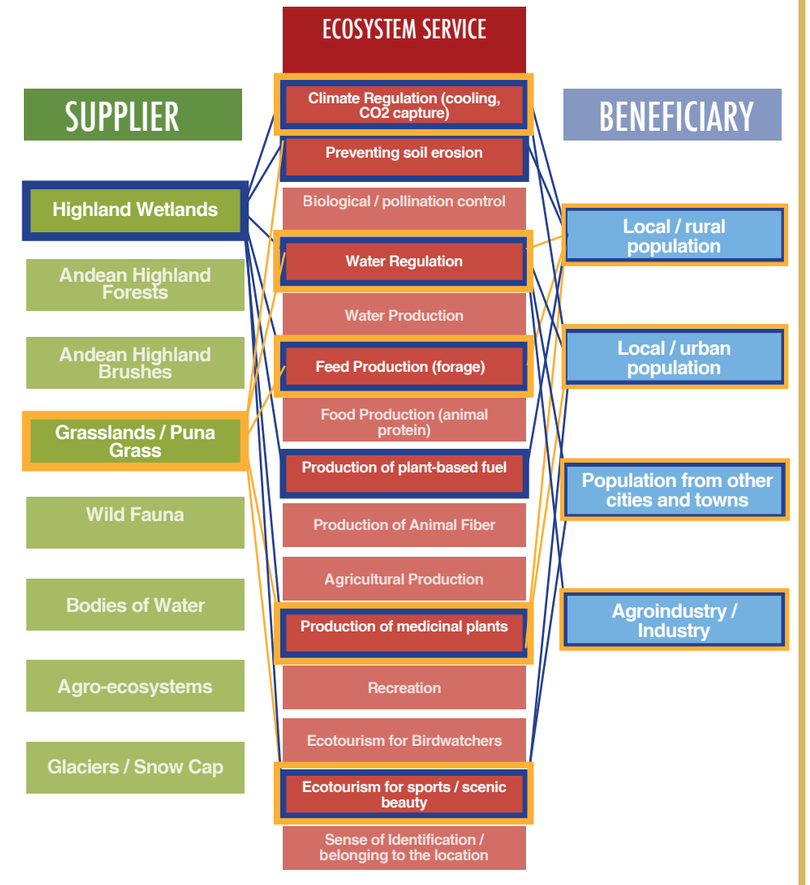
Figure 4. Land cover and land use of the reserve.



Source: FDA, 2013.

Figure 5. Outline of Relationships between NYCLR Ecosystem Services and their Respective Suppliers and Beneficiaries.

Throughout this process, an exercise was also conducted to identify the ecosystem service providers and their beneficiaries (fig 5). The key species were identified for each ecosystem and based on information on future climate conditions, a model of the future species distribution was compiled and consequently the ecosystems and their services (Future supply of ES). A methodology for integrated ecosystem analysis was also developed, which, because of limitations in time and resources, could only be applied in upland (puna) ecosystems.



Source: FDA, 2013.

In addition, using an analysis of available census data and data compiled through extensive surveys, it was possible to obtain a detailed description of the socioeconomic component that includes components regarding the adaptation ability of the population. Using this information, an analysis was made of the use of ecosystem services that, projected to the future using the population growth projection, results in the future demand for ecosystem services.

3.2 KEY RESULTS

3.2.1 PERCEPTION OF CLIMATE RISK

The results of the VIA NYCLR-BZ study were based on the primary information compiled on the field through visits to prepare the map of ecosystem services and 334 socioeconomic surveys, inclusive of questions on climate change perceptions and group interviews to confirm the information compiled.

The analysis of perceptions of extreme events and locally proposed adaptation alternatives to cope with climate risk have served to feed the discussion about the list of recommended adaptation measures contained in section 4.

The perception of risk in the face of climate change was studied through different mechanisms.

a **Maps of hydrologic and climate disruptions risk** in which district representatives identified the areas perceived to be the most impacted by extreme events related to climate change.

b **Analysis of the main concepts of risk reflected in the descriptors included in the survey questions.** Additional to the questions in the family survey, climate change perceptions of boys and girls, adolescents and young people were also included.

334 socioeconomics surveys

c **Identification (type and frequency) of the main extreme events and responses by the population** in order to understand the knowledge, practices and strategies used by the population to manage the vulnerability and risk arising from extreme climatic events.

d **Identification of possible time lines described by the population,** such as points of references or thresholds of change (for example, one or two decades or some year particularly recalled).

The following table summarizes the results of the perception analysis.

Table 2. Actions to reduce crop losses in drylands by type

ACTION	FREQUENCY	PERCENTAGE	ACTION	FREQUENCY	PERCENTAGE
DRYLAND CROPS					
Fertilize	35	34.30%	Living fences, mesh, barbed	2	2.0%
Change Seeds	20	19.60%	wire, defensive barriers		
Medicines	9	8.80%	Fences for wild animals	2	2.0%
Better irrigation, irrigate	8	7.80%	Firecrackers, noise makers	1	1.0%
Spread ashes	6	5.90%	Shed	1	1.0%
Fight pests	5	4.90%	Wind kreaks	1	1.0%
Place cassette tape	4	3.90%	Disease prevention	1	1.0%
Burn or smoke around them	3	2.90%	Plant at the right Ttme	1	1.0%
Training	2	2.00%	Impacted by climate change	1	1.0%
			TOTAL	102	100.0%
IRRIGATED CROPS					
Fertilize	14	21.50%	Don't pollute	2	3.1%
Improve irrigation, irrigate	9	13.80%	Human use	2	3.1%
Plant at the right time	6	9.20%	Help to improve quality of life	1	1.5%
Set up Scarecrows / bird traps	5	7.70%	Barriers against freezing	1	1.5%
Living Fences / mesh, barbed	4	6.20%	Change seeds	1	1.5%
wire, defensive barriers			Training	1	1.5%
Medicines	4	6.20%	Burn or produce smoke	1	1.5%
Technical assistance	3	4.60%	Don't irrigate during freezes	1	1.5%
Fight pests / spray pesticides	3	4.60%	Barrier against freezing	1	1.5%
Spread ashes	3	4.60%	Disease prevention	1	1.5%
Seek place unaffected by climate	2	3.10%			
			TOTAL	65	100.0%

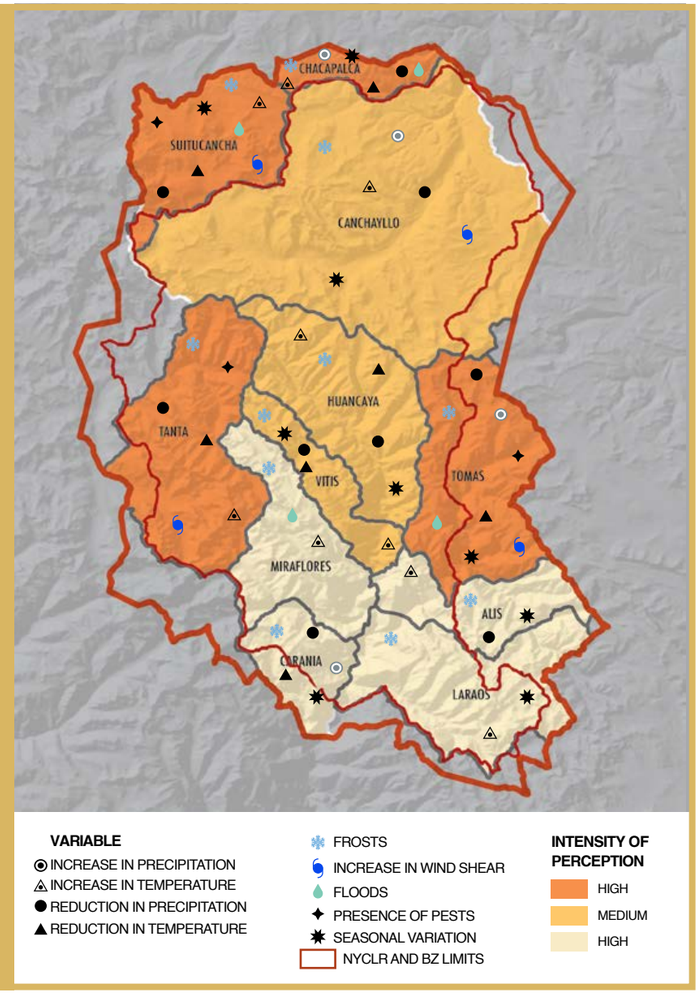
ACTION	FREQUENCY	PERCENTAGE	ACTION	FREQUENCY	PERCENTAGE
NATURAL GRASSLAND					
Improve irrigation, irrigate	45	39.10%	Shed, stable, sawdust	5	4.3%
Fertilize	20	17.40%	Change seeds	2	1.7%
Living fences, mesh, barbed wire, defensive barriers	17	14.80%	Firecrackers / noise makers	1	0.9%
			Training	1	0.9%
Dams, ponds, drinking pond	8	7.00%	Don't pollute	1	0.9%
Conservation, plant cultivated grasses, forage	7	6.10%	Disease prevention	1	0.9%
			Hay pastures	1	0.9%
Medicines	6	5.20%			
			TOTAL	**115**	**100.0%**
CULTIVATED GRASSLAND					
Fight Pests	7	30.40%	Shed, stable, sawdust	1	4.3%
Improve irrigation, irrigate	4	17.40%	Control planting and nature	1	4.3%
Living fences, mesh, barbed wire, defensive barriers	3	13.00%	Create micro climates by planting pine	1	4.3%
Fertilize	2	8.70%	Dams and ponds	1	4.3%
Plant at the right time	2	8.70%	Set up scarecrows and traps	1	4.3%
Agro-forestry	1	4.30%			
			TOTAL	**23**	**100.0%**
LIVESTOCK					
Medicine and vaccination	124	57.70%	Disease prevention	2	0.9%
Sheds, stables, sawdust	55	25.60%	Firecrackers / noise makers	1	0.5%
Technical assistance	12	5.60%	Improve pasture	1	0.5%
Bring livestock down from highlands	10	4.70%	Burn or produce smoke	1	0.5%
			Dams, bonds, drinking ponds	1	0.5%
Conservation, plant cultivated grasses, forage	3	1.40%	Mineral salts	1	0.5%
			Disease prevention	2	0.9%
Training	2	0.90%			
Living fences, mesh, barbed wire, defensive barriers	2	0.90%			
			TOTAL	**215**	**100.0%**

Source: FDA, 2013.

The following is a distribution map of the intensity of perceptions by the local population regarding climate phenomena that impacts on natural grasslands (Fig. 6). We can clearly see that the population in the northern half of the NYCLR perceives that there is a higher intensity of adverse climate phenomena for natural grasslands. Also the largest quantity of livestock breeding is developed in these regions and the population depends economically to a larger extent on this activity. This is also the region with the highest elevations and largest continuous extension of natural grasslands.

We should explain that the location of the points that represent the climate phenomena are a reference value for the district as a whole and do not represent a specific location of the phenomena within the district itself.

Figure 6. Distribution map of the Intensity of perceptions by the local population regarding climate phenomena that impacts on natural grasslands



Source: FDA, 2013.

3.2.2 EXPOSURE TO CLIMATE

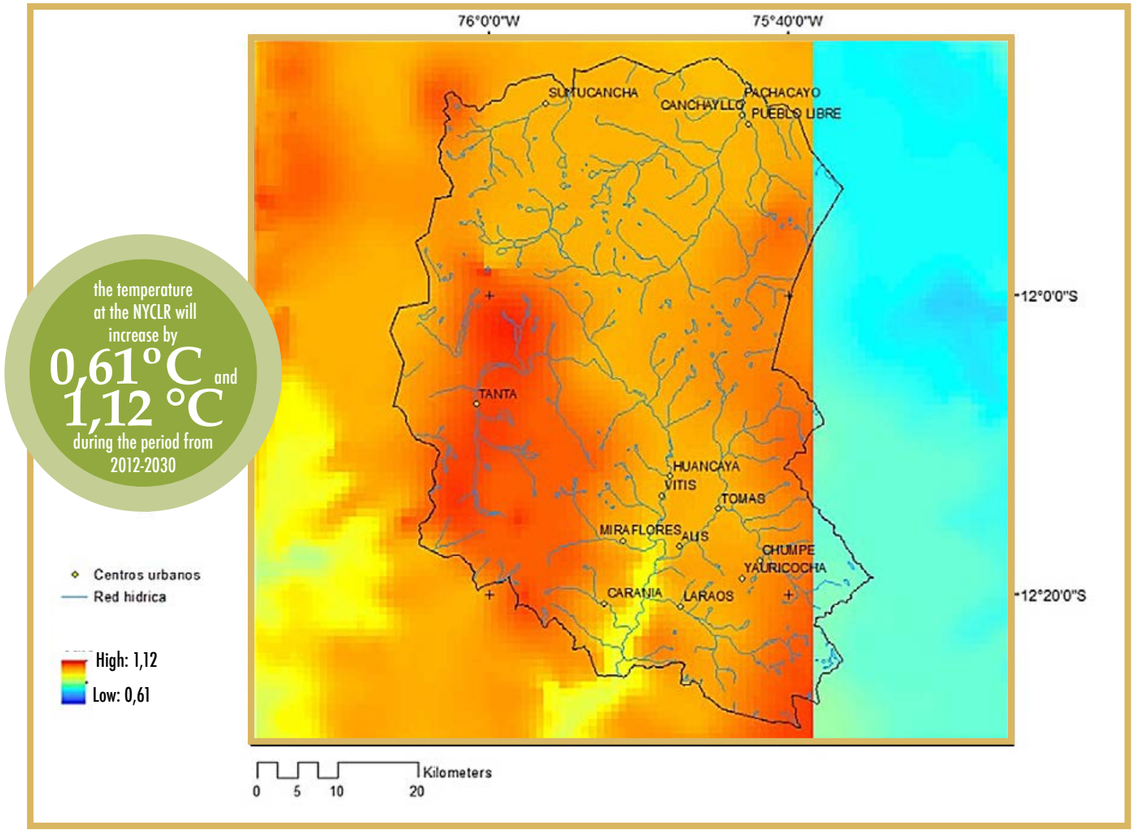
THE AVERAGE AIR TEMPERATURE DURING THE HISTORICAL PERIOD FROM 1950-2010 INCREASED BY +0,21°C and +0,32°C PER DECADE

The analysis of temperature changes in the short and mid-term at NYCLR is based on the study of the results of the simulation using a specific general circulation model (GCM) (the ECHAM4.5 model) and the analysis of trends observed in the historical series (1950-2010) of minimum temperatures, maximum temperatures and rainfall at three hydrometeorological monitoring stations installed near the Reserve (Lircay, Modelo and Marcapomacocha).

The analysis conclusions indicate that the average air temperature during the historical period from 1950-2010 increased by +0.21ºC and +0.32°C per decade under atmospheric pressures of 700 and 200 mb, respectively. The specific humidity increased by close to 11.54E-05 and +0.20E-05 grams of water vapor per kilogram of air per decade under atmospheric pressures of 700 and 200 mb, respectively. Finally the potential convective energy available increased by 14.54 joules per kilogram per decade. In addition, the study showed that the temperature at higher elevations of the Reserve has increased by 1.2ºC more than in lower regions.

Because of these results and their correction by elevation and by scenarios of greenhouse gas concentrations defined by the research group, it was possible to estimate changes climate conditions in the short (2011-2030) and mid-term (2046-2065). In general, estimates show that the temperature at the NYCLR will increase by between 0.61ºC and 1.12 °C during the period from 2012-2030 (fig. 7).

Figure 7. Average annual surface air temperature anomalies suggested by the results of the ECHAMM45.5 simulation model for the period 2011-2030 and for the scenario of GHG concentrations A1B.



Source: FDA, 2013.

3.2.3 VULNERABILITY OF THE MAIN ECOSYSTEM SERVICES

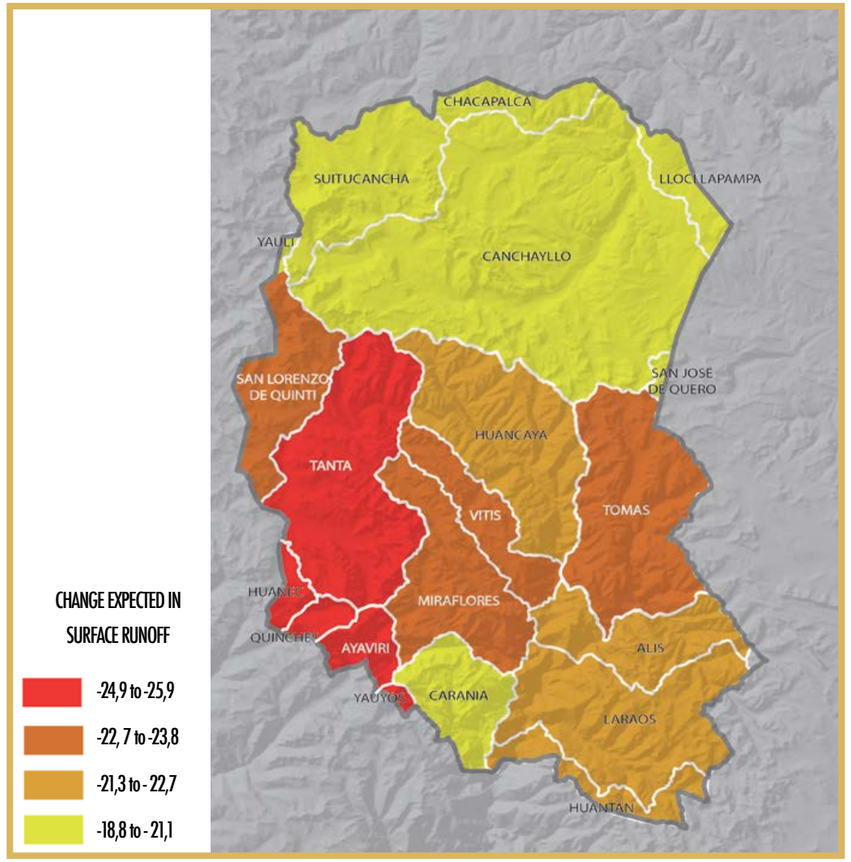
The study analyzed the following ecosystem services: supply and access to water, forage provisioning, plant-based fuel provisioning, animal fiber provisioning. The analysis of ecosystem services was made using the methodology indicated above (fig. 3). Considering that the demand for ecosystem services is calculated using socioeconomic data available for the district and in order to consider other socioeconomic variables, it was decided to present the results by district.

a SUPPLY AND ACCESS TO WATER

Taking into account the period from 2011-2030 and the scenario of GHG concentrations A1B, expectations are that the most critical changes in water supply (surface runoff) may occur in the upper drainage area of the Cañete river. At district level, the analysis concluded that reductions in runoff that have occurred in the eleven districts could range from -19.8 to -25.9 mm/year. According to simulation results, the Carania district will undergo the most moderate reduction while the Tanta district may have higher changes in runoff (fig. 8). These results are particularly important when we consider that Tanta is located in the upper catchment of the Cañete river basin and that possible changes in water supply in this district will have a significant impact on activities at downstream locations.

REDUCTIONS IN RUNOFF THAT HAVE OCCURRED IN THE ELEVEN DISTRICTS COULD RANGE FROM **-19.8 and -25.9** MM/YEAR.

Figure 8. Change expected in surface runoff (in mm/year) at district level, compared to the historical value for the 2011-2030 period for a scenario of GHGs concentrations A1B.



Source: FDA, 2013.

b FORAGE PROVISIONING

The analysis of forage provisioning compares the supply of natural grasses and cultivated grasses (alfalfa, ryegrass, clover, oats and feed barley) against livestock (sheep) demand taking into account the load capacity[5] of each district of the NYCLR. Using the above it was possible to identify when demand would exceed the load capacity of grasses using climate projections, in other words when they would reach their level of saturation.

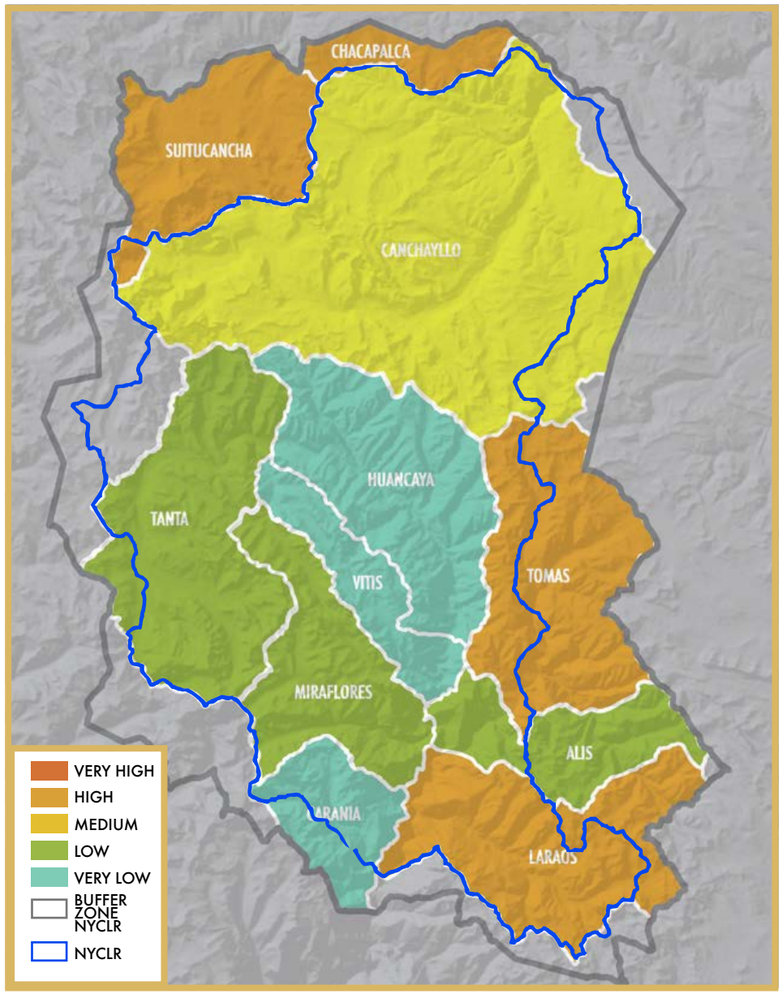
The analysis revealed that grasslands in the Cochas Pachacayo basin are already saturated (Fig. 9). This could be because the largest percentage of livestock is found in this zone (56% compared to 44% in Nor Yauyos, measured in units of sheep) and a lower percentage of grasslands (46% compared to 54% at Nor Yauyos). The impact of climate change will exacerbate this situation because it will decrease the supply of forage; therefore it is necessary to identify measures that will reverse this situation.

With regard to the Nor Yauyos basin, the analysis indicates that the impact of the load capacity of grasslands is not very significant. The assumption is that this could be a result of the landscape reserve status and that apparently there is more awareness among the population that natural grasslands should not be burned, a practice that was common in the region in the past. Likewise, there is surveillance by SERNANP park rangers and it seems that the population wants to conserve its natural resources. In addition, rural communities have positive attitudes towards conservation and are familiar with the regulations that prohibit practices that degrade grasslands.

THE COCHAS PACHACAYO BASIN ARE ALREADY SATURATED

5 The load capacity is the maximum size of the population that the environment can support indefinitely within a particular period, considering food, water, habitat and other necessary elements available in that environment.

Figure 9. Map of forage and grassland provisioning for livestock and its saturation level



Source: FDA, 2013.

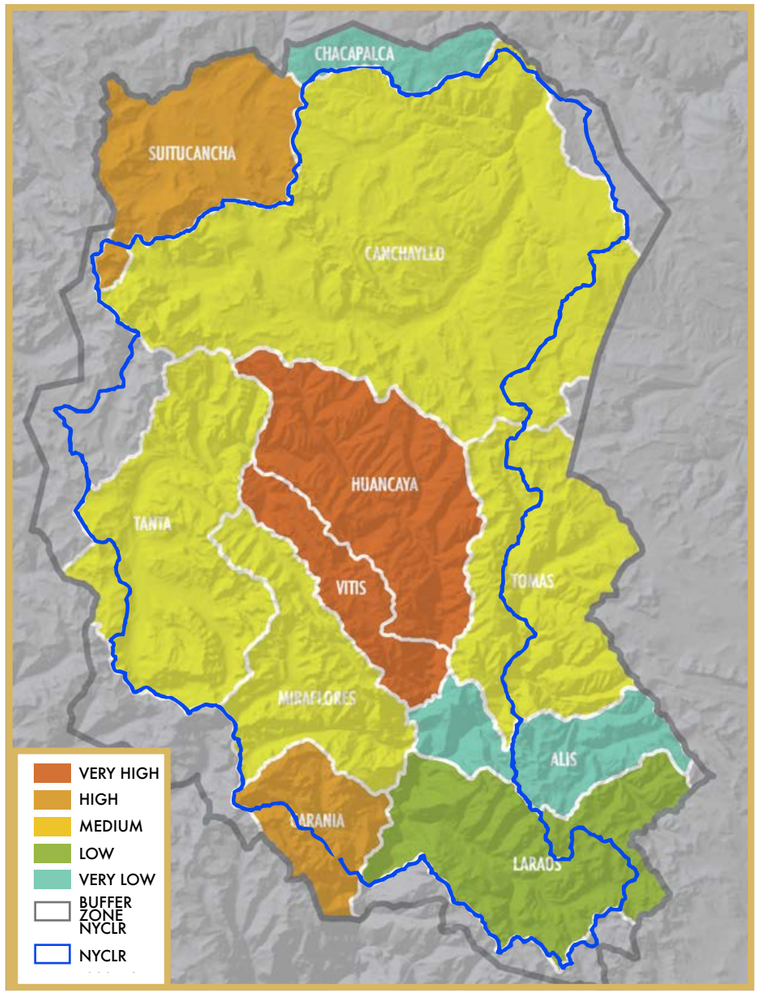
C PROVISIONING OF PLANT-BASED FUEL (FIREWOOD)

In order to determine whether the pressure exerted on the provisioning of plant-based fuel (firewood) has increased or decreased, the analysis compared the projected extension of firewood surface area (supply of plant-based fuel) current and future with the NYCLR population projection and the quantity of firewood used (in m3); in other words, the current and future demand for plant-based fuel.

The results reveal the existence of five general trends with regard to the pressure exerted on the use of this resource.

In some districts (Huancaya and Vitis) it will intensify significantly and therefore the demand for plant-based fuel will grow at a faster rate than supply -- the pressure will be very high (fig. 10). In other districts (Suitucancha and Carania) the variation in demand continues to be higher than supply, resulting in intensified pressure on the use of this resource (high pressure). A third group of districts (Canchayllo, Tanta, Miraflores and Tomas) will have medium pressure, because, according to the analysis, the projected surface extension of firewood (supply) current and future in these districts is greater than current and future demand for fuel, which indicates less pressure on this resource. In the Laraos district the pressure on the use of the resource is low, the increase in supply exceeds the increase in demand. Finally, the districts of Alis and Chacapalpa are districts with very low pressure because the increase in supply in the territory is greater than the demand.

Figure 9. Map of the pressure on plant-based fuel provisioning services.



Source: FDA, 2013.

d PROVISIONING OF ANIMAL FIBER

The supply and demand for vicugna animal fiber at NYCLR was estimated in order to analyze the pressure on this ecosystem service. First, the variation in area (hectares) suitable for production[6] of animal fiber (vicugna) was determined. Then the continuity of demand for animal fiber was examined. An important point is that vicugna fiber is mainly used for bartering and/or sale with other products such as fruits, vegetables and/or groceries originating from cities outside NYCLR. Consequently, the demand estimate was made for NYCLR as a whole and not by district.

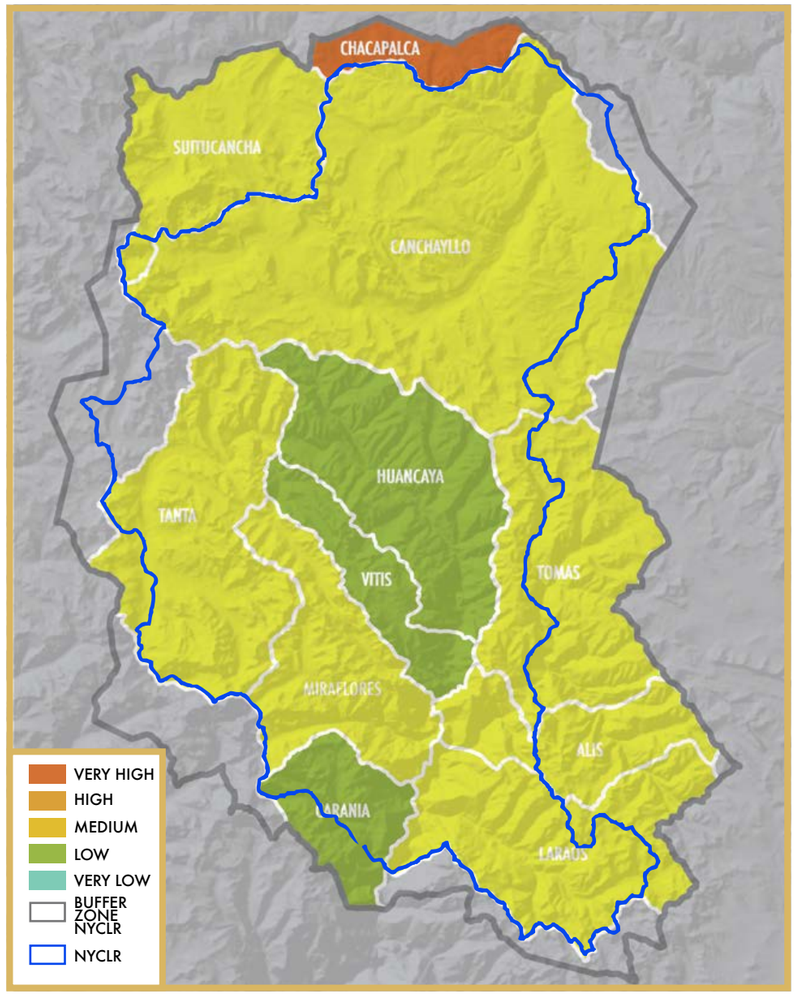
photo: Álvaro Beltrán - UNDP Peru

the surface area available for vicugna will decrease by 0.7% by 2030

For this ecosystem service, both the NYCLR demand and the surface area available for vicugna habitat (related to supply) will decrease by 0.7% by 2030.

Therefore, we can infer that the pressure on the use of animal fiber will be reduced in the future (fig. 10).

Figure 11. Map of the pressure on animal fiber provisioning services

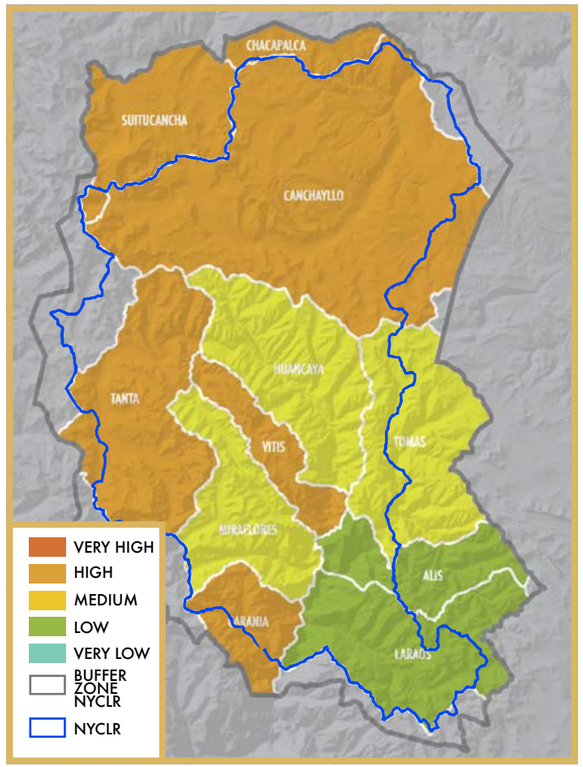


Source: FDA, 2013.

6 In the VIA, the productive aptitude for provisioning animal fiber was determined taking into account the current potential distribution of the species (vicugna vicugna) and the predominant plant cover of the species' habitat (grasslands and highland wetlands)

3.2.4 SOCIOECONOMIC SENSITIVITY

Figure 12. Map of Socioeconomic Sensitivity with the weighted socioeconomic index



Source: FDA, 2013.

a SOCIOECONOMIC SENSITIVITY INDEX

The socioeconomic vulnerability of NYCLR districts was calculated by building a weighted index based on three indicators (poverty, economically active population and malnutrition). The results were grouped into three levels of sensitivity (high, medium and low). Low sensitivity reflects a better situation than high sensitivity.

The Alis and Laraos districts were identified as the districts with the best socioeconomic conditions in the study region (fig. 11). Their access to the reserve, their elevation which is more viable for agro pastoral activities and their connectivity to communication routes can contribute to explaining this situation.

b PRESSURE ON AGRICULTURAL SURFACE AREA

The pressure on the use of the agricultural surface area is measured by using the dynamics of the growing surface area of agricultural crops (including cultivated grasses) in the NYCLR districts. The districts with the highest growth rate of planted agricultural surface aea (between 2001 and 2011) are considered more sensitive and vice versa.

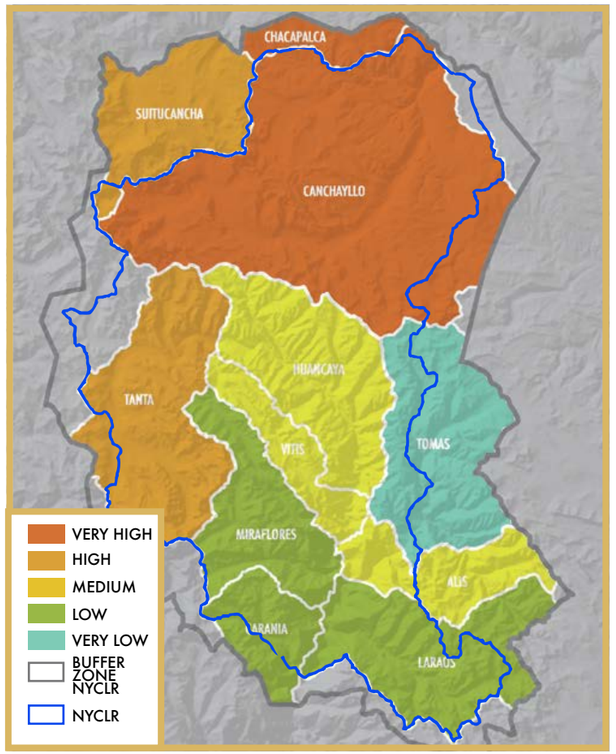
Positive pressure and the growing use of the agricultural surface area of the Canchayllo (4.4%), Chacapalpa (7.9%) and Suitucancha (3%) is a reflection of the conversion in the use of traditional crop areas towards improved forage (fig. 12). Given that in these areas, exclusively livestock breeding, the introduction of cultivated grasses is for feeding livestock (vicugna, sheep or alpaca) to obtain a better yield of meat and milk per animal, cultivated grasses such as rye grass, clover and alfalfa are replacing traditional crops such as potato, oca and mashua (edible tubers).

4.4% CANCHAYLLO

7.9% CHACAPALPA

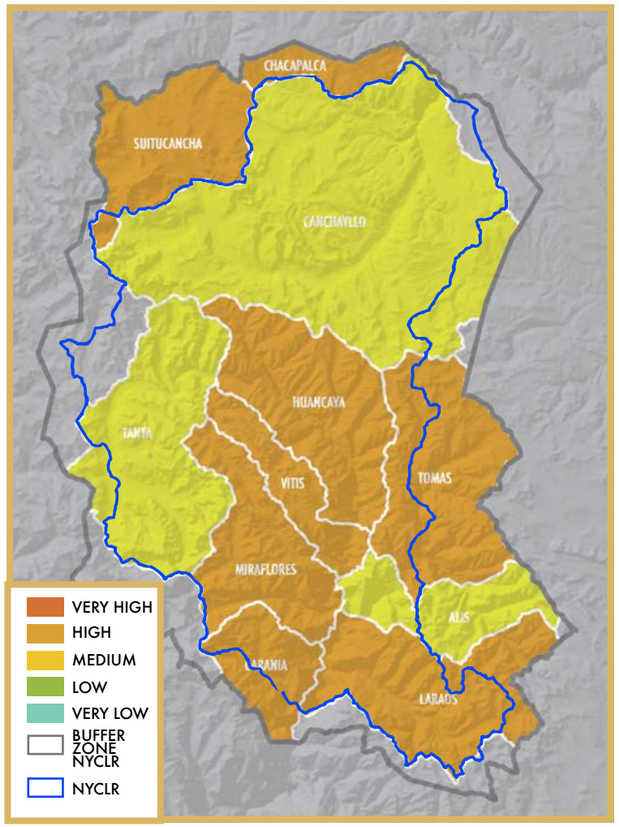
3.0% SUITUCANCHA

Figura 13. Sensitivity map of the pressure on the agricultural surface area.



Source: FDA, 2013.

Figura 14. Economic dependence on ecosystems: agricultural and livestock.



Source: FDA, 2013.

c ECONOMIC DEPENDENCE ON ECOSYSTEMS FOR AGRICULTURAL AND LIVESTOCK PURPOSES

Constructed based on information obtained from the 334 surveys conducted between June and July 2013. This indicator represents the percentage of the NYCLR population whose main source of income derives from agricultural and livestock activities. The higher the percentage, the higher the economic dependence on ecosystem services.

Once established, the results were grouped into levels of dependence: high and medium. The map (fig. 13) indicates a slight trend towards higher dependence in several districts in the Nor Yauyos Cochas basin compared to the Cochas Pachacayo basin.

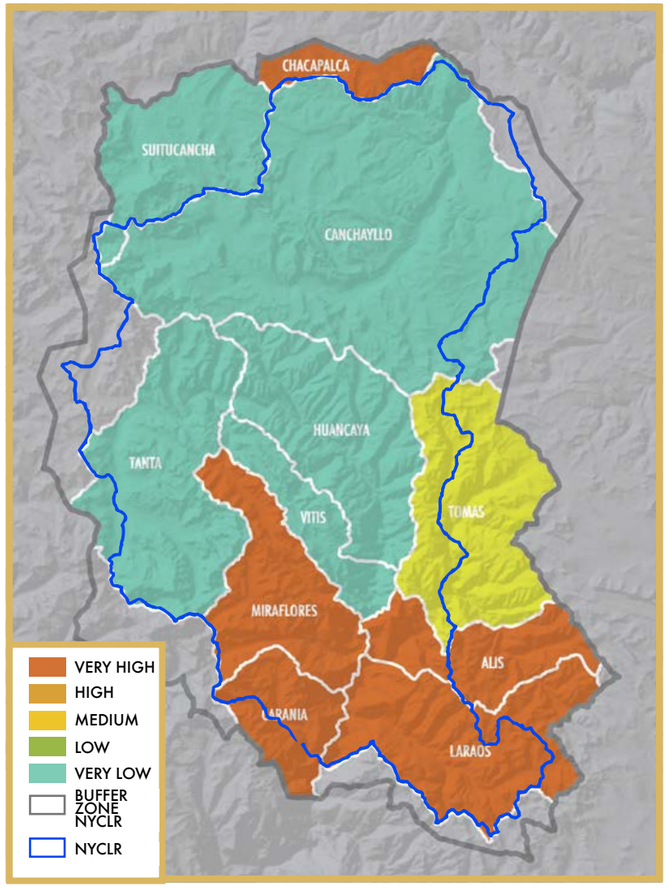
d HEALTH

The health service coverage indicator is constructed based on the number of medical personnel with general medical education for every one thousand inhabitants.

The lack of medical service coverage results in higher health sensitivity of the local population.

The districts were classified into three levels of deficiency of health services, as a function of this ratio: very high, medium and very low. From this analysis, we observed more deficient coverage in the Nor Yauyos Cochas basin in general, despite being at the entrance to the Reserve and having connectivity and tourist attractions (fig. 15).

Figure 15. Map of health service coverage deficiency.



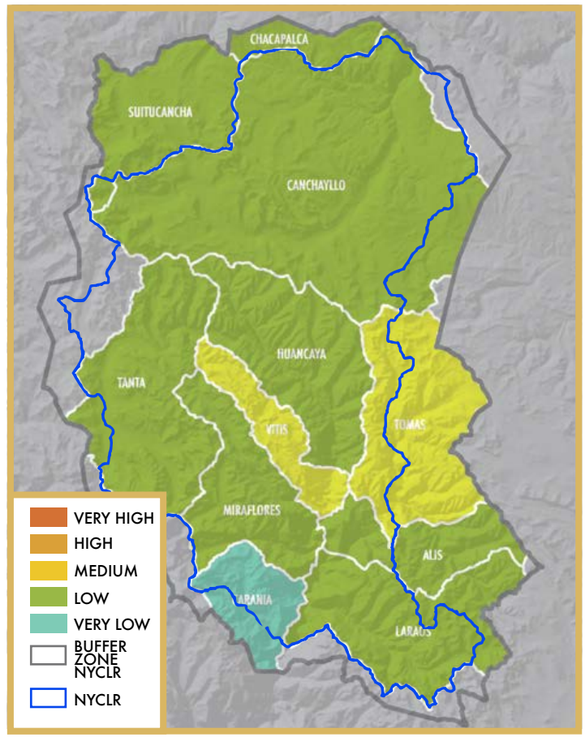
Source: FDA, 2013.

EDUCATION

Based on the results of the 334 interviews conducted, the level of family education was measured and the results were grouped into three levels: very low, low and medium level of family education.

In general, the families in the districts have a low level of family education (fig. 16).

Figure 16. Map of family education level in the area of study.



Source: FDA, 2013.

3.2.5 INTEGRATED VULNERABILITY RESULTS, BY DISTRICT

Table 3 summarizes the results presented above and offers and integrated overview of the socioeconomic sensitivity of each one of the districts studied.

Table 3. Socioeconomic Indicators and Indexes (2011-2030).

DISTRICT / INDICATORS AND INDEXES	Agricultural pressure on surface area	Economic dependence on ecosystems: agriculture and livestock	% EAP	% poor population	Malnutrition Rate (6-9 year olds)	Weighted: EAP, poverty and malnutrition	Health: doctors/1000 inhabitant	Family education
ALIS	-3.1%	60%	88%	24%	28%	3.8	0.0	45%
CARRANIA	-6.4%	79%	45%	38%	46%	1.8	0.0	28%
HUANCAYA	-2.4%	74%	53%	53%	29%	2.2	1.0	45%
LARAOS	-7.8%	64%	52%	30%	15%	3.2	0.0	49%
MIRAFLORES	-6.0%	71%	40%	22%	19%	2.8	0.0	43%
TANTA	0.0%	56%	33%	31%	53%	1.4	2.0	46%
TOMAS	-13%	74%	50%	34%	34%	2.4	0.9	51%
VITIS	-3.2%	61%	38%	49%	29%	1.8	1.9	51%
CANCHAYLLO	4.4%	43%	23%	41%	35%	1.2	1.1	48%
CHACAPALPA	7.9%	75%	25%	13%	44%	1.4	0.0	43%
SUITUCANCHA	3.0%	61%	41%	45%	37%	1.6	1.1	44%

Source: FDA, 2013.

GRADE OF SENSITIVITY: Very high | High | Medium | Low | Very low

In order to understand how these aspects interact in each district, an initial discussion was proposed on the strengths and weaknesses of the NYCLR districts in coping with climate change. Although preliminary, this discussion helps to identify some of the causal hypotheses that could later be addressed to improve local capabilities. To support this discussion, a radar graph for each district was prepared using numbers from one to five, with one being the value that indicates most weakness.

The following is an example of the discussion on three of the eleven districts studied. Canchayllo, Miraflores and Tanta.

CANCHAYLLO

41% OF POOR POPULATION

Canchaylló is a highly populated NYCLR district (1,774 persons) with a more urban housing distribution. It has a high percentage of poor population (41%), low EAP (23%), 35% child malnutrition, low level family secondary school education (48%). Its weighted socioeconomic index is the lowest in the NYCLR. However, Canchaylló has the third best index of medical service coverage in the NYCLR.

The entire Cochas Pachacayo basin is oversaturated with livestock with regard to grasslands available and Canchaylló has strong agricultural pressure, with evidence of a higher quantity of livestock vs. grasslands. One part of the Canchaylló population works in the mines, while the other depends on agro pastoral activities.

However, the majority of the population receives a salary from the Tupac Amaru Agricultural Society of Social Interest (SAIS), which has its own lands. Therefore, the district has the lowest level of economic dependence (43%) on ecosystems (agro pastoral) of the NYCLR districts.

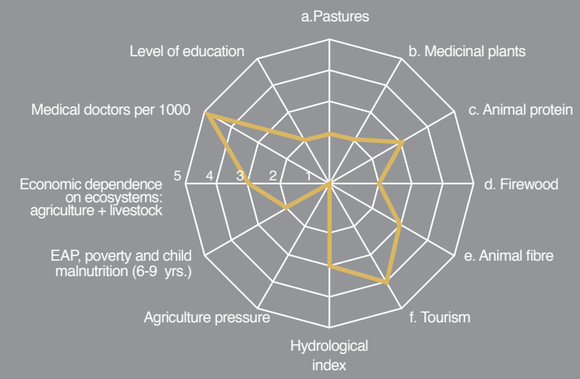


Figura 16. Radial graph on strengths and weaknesses for coping with climate change in Canchaylló. **Source:** FDA, 2013.

MIRAFLORES

71% OF INCOMES DERIVES FROM AGRO PASTORAL ACTIVITIES.

Miraflores has a high dependence on ecosystems (Level 2), because the source of income for 71% of its population derives mainly from agro pastoral activities. In terms of health service indicators, the district does not have one doctor per one thousand inhabitants and has a low level of family education (43% with completed secondary education).

According to the analysis, Miraflores is at a medium level regarding supply and demand projected as related to the load capacity of grasslands, medicinal plants, animal protein, plant-based fuel and animal fiber. With regard to supply and demand of tourism, Miraflores would not have much ability to support tourism, especially in terms of lodging. It would become quickly saturated, because it has a very low load capacity.

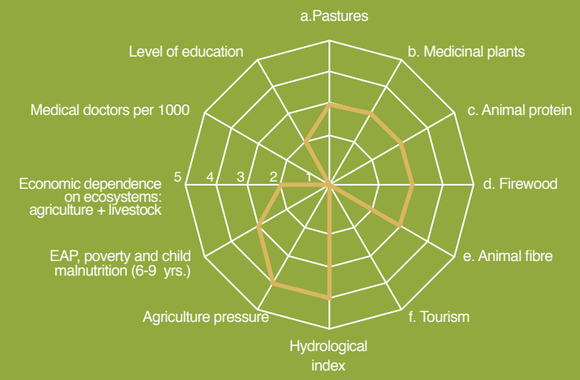


Figura 17. Radial graph on strengths and weaknesses for coping with climate change in Miraflores. Source**:** FDA, 2013.

TANTA

33% EAP

Water supply analyses indicate that the Tanta district would be more vulnerable to the threat of changes in surface runoff. Moreover, the load capacity of grasslands is expected to be saturated by 2021 given current climate trends without considering the impact of climate change, or in 2032 considering the impact of climate change. Following grassland and livestock trends, this situation denotes a low level of saturation of grassland load capacity. With regard to the ecosystem services analyzed, except in the case of animal protein and tourism (at level 1, the lowest), the supply has a good ratio compared to projected demand (medium level)

Tanta has the highest medical service coverage rate at NYCLR (2 for every 1000 inhabitants). However, although the district has a low level of poverty (31%), it has a reduced EAP (33%) and a high rate of child malnutrition (6-9 year olds), the worst in the NYCLR. Therefore, Tanta has a weighted socioeconomic index of 1.4 (level 2). Finally, the district has a low family education indicator (46%), with regard to completed secondary education.

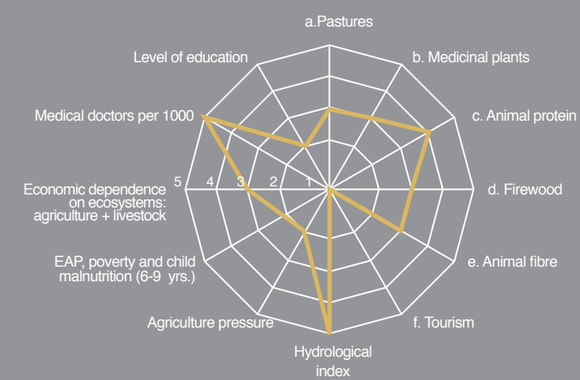


Figura 18. Radial graph on strengths and weaknesses for coping with climate change in Tanta. **Source**: FDA, 2013.

4 ADAPTATION MEASURES IN THE NYCLR: THE ROAD AHEAD

The vulnerability and impact study conducted within the context of the Mountain EbA project summarized in this document was proposed to provide the necessary scientific information for the identification and implementation of adaptation measures at NYCLR; not only for the population, but also for ecosystems and ecosystem services. Beyond suggesting the measures that could be implemented, the VIA also provides valuable clues to determine where to apply the proposed measures.

The final recommendations of the VIA in terms of adaptation measures (not necessarily all ecosystem-based but also conservation-based) encompassed very different areas (Table 3).

TABLE 3:

Recommendations from the VIA for climate change adaptation measures
* Livestock Organization and Grassland Monitoring
* Management of vicugna such as the added value to livestock raising
* Manufacturing hay as a food supplement for livestock
* Introduction of dormant alfalfa as a supplement to livestock activities
* Development of hunting activities (Controlled hunting of wild animals).
* Conservation of water sources;
* Payment Systems for environmental systems in basins;
* Improve the efficiency of irrigation Canals (Water Infrastructure);
* Implementation of living fences to protect crops;
* Installing an agricultural security system for local production;
* Establishing clear tourist load capacity limits.

Although all of the measures considered by the VIA are hypothetically viable within the parameters of the Mountain EbA, not all can be executed by the project because they may not be of interest to the local population, they are not related to the main NYCLR production activities or they are already being handled by other institutions. Another of the great challenges is the lack of information.

To ensure that the adaptation options implemented are the most pertinent, not only for the local population but also for NYCLR conservation studies and for the Mountain EbA project, measures have been identified and selected using the information provided from the Vulnerability and Impact Assessment, from bibliographic information and the opinions of experts and a process to identify robust measures [7]. The Mountain EbA project selected three measures for implementation at NYCLR as described in the following table:

MEASURES BY PRIORITY	PILOT SITE	BENEFITS		
		ECOSYSTEMS	ECOSYSTEMS SERVICES	POPULATION
• Vicuña management (in association with animal husbandry).	TANTA	• Reduces pressure on natural pastures, wetlands and alpine ecosystems favouring their recuperation.	• Enhances the production of animal fiber, scenic beauty and recreation.	• Creates employment opportunities derived from the commercialization of the fiber. • Boosts tourism activities.
• Community-based native grassland. • Improvement of ancestral hydrological infraestructure.	CANCHAYLLO	• Reduces the pressure on (over-grazed) grasslands and wetlands, favoring their recuperation. • Allows wetland and grassland restoration.	• Enhances agricultural production, production of fiber and animal protein. • Prevents soil erosion. • Contributes to hydrological regulation. • Hydrological regulation, fire prevention, minimum impact of extreme events and other ecosystem services, such as biodiversity conservation and enhancement of carbon storage in the preserved/restored grasslands.	• Improves animal yields and agricultural production. • Improves ancestral infrastructure. • Strengthened institutional arrangements and capacities for community management of water, grasslands and livestock. • Increased livestock productivity and quality through improved livestock distribution and grassland quality and the creation of natural troughs. • Higher resilience and adaptive capacity en both communities.
• Community-based native grassland. • Conservation and management of upper micro-watersheds, wetlands and water-courses. • Improvement of ancestral hydrological infraestructure.	MIRAFLORES			

Source: Mountain EbA project in Peru

These measures mainly benefit the wetlands and brushland / puna grasslands that constitute the most extensive ecosystem unit in the NYCLR and provide the largest quantity of ecosystem services for the population, because they provide sustenance for livestock, the main economic activity in the region.

{ 7 Robust measures are those that offer net environmental and social benefits – in some cases also economic – to ecosystems and the local populations no matter the future climate scenario. }

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photo: Mountain EbA project

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Appendix 1

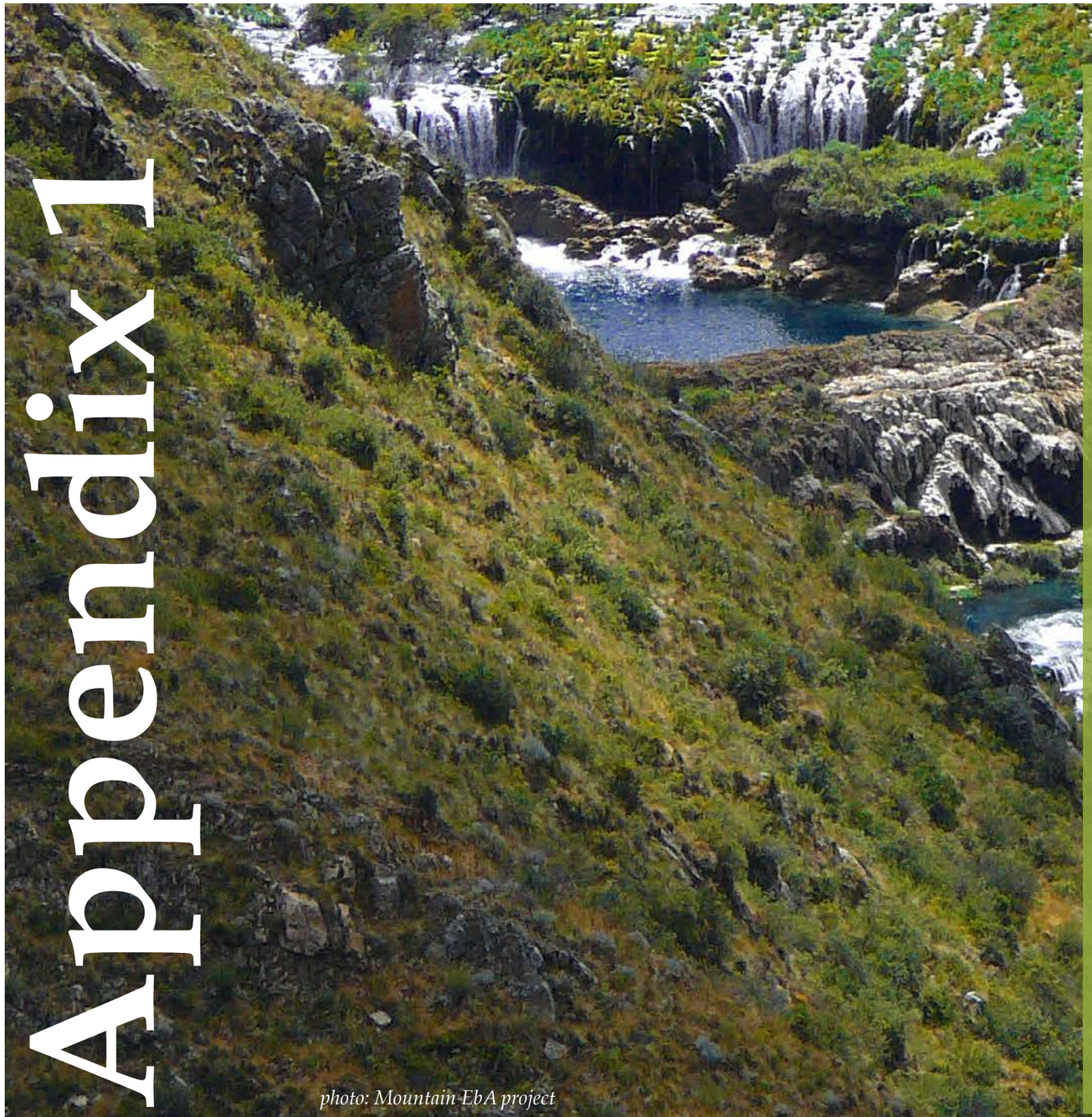

photo: Mountain EbA project

Appendix 1

"VULNERABILITY AND IMPACT ASSESSMENT OF CLIMATE CHANGE AT THE NOR YAUYOS COCHAS LANDSCAPE RESERVE AND BUFFER ZONES - VIA NYCLR".

Members of the Study Team on the "Vulnerability and Impact Assessment of Climate Change at the Nor Yauyos Cochas Landscape Reserve and Buffer Zones - VIA NYCLR".

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