Vulnerability Assessments for Ecosystem-based Adaptation: Lessons from the Nor Yauyos Cochas Landscape Reserve in Peru

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Abstract The development of Vulnerability Assessments (VA) to climate change is a rapidly evolving activity within the broader climate adaptation planning process. As such it is receiving significant attention from the communities of adaptation researchers and practitioners. It is uncommon to carry out more than one VA in the same place and at the same time thus this case study presents a unique opportunity to compare the application of three different Vulnerability Assessment approaches that were carried out simultaneously in the same location: the Nor Yauyos Cochas Landscape Reserve in Peru, during the period of 2012 through 2013. All three approaches shared the goal of identifying Ecosystem-based Adaptation (EbA) measures based on the ecological and social vulnerabilities the VAs helped to identify in the target area. Each approach, however, was different in terms of methodologies and conceptual foundation. The following case study describes the application of a participatory VA approach, a model-based VA approach and a deductive VA approach, using a set of descriptors in a custom designed matrix. We also present a narrative description of each approach to explain in more detail the process undertaken by each Vulnerability Assessment. Key lessons learned are that EbA measures require abundant information (pertaining to climate, ecosystems, biodiversity, land use practices, livelihoods, etc). As a result, interaction between scientific knowledge and traditional (local) knowledge is vital. Of importance, all three approaches rendered useful and pertinent results and surprisingly recommended very similar adaptation measures. Nevertheless, the participatory approach was the only one that did

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not require additional studies to implement measures following the Vulnerability Assessment. The three approaches also proved to be advantageous for application at different scales. While the participatory approach turned out to be most useful at the community level, the model-based approach and the deductive approach delivered information at a broader scope that served to better understand vulnerability for the entire ecosystem target area.

Keywords Ecosystem-based Adaptation (EbA) • Vulnerability Assessment • Peru

1 Introduction

Identifying current climate change adaptation measures is usually done through assessing vulnerability for a selected site. Yet, there are many different approaches to assess vulnerability, making it difficult to evaluate the approaches comparatively. Furthermore studies that examine approaches to Vulnerability Assessments exist, but these assessments are often undertaken at different sites (for an example see: Hammill et al. 2013). Vulnerability as a context-specific phenomenon makes it difficult to reach overarching conclusions on how the different approaches perform (Hammill et al. 2013; Munroe et al. 2012). Moreover, there are not many documented cases that allow for an examination of different approaches for selecting adaptation measures in the same site. Given that the three approaches examined in this case study vary in many aspects (see descriptions further below), we use a broad definition of VA to be able to encompass them: VA is a process that helps identify adaptation needs and options (adapted from PROVIA 2013) (Fig. 1).

Ecosystem-based Adaptation (EbA) is gaining traction as an approach that makes valuable contributions to and fills important gaps in broader climate change adaptation strategies (Travers et al. 2012; Munroe et al. 2012; Reid 2011; CBD 2009) and in the past few years there is a growing number of cases that show that EbA measures are being implemented across a wide range of ecosystems. Ecosystem-based Adaptation is defined by the Convention on Biological Diversity (CBD) as ***"the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change"*** (CDB 2009)**.** As further elaborated by Decision X/33 on Climate Change and Biodiversity, this definition also includes the ***"sustainable management, conservation and restoration of ecosystems, as part of an overall adaptation strategy that takes into account the multiple social, economic and cultural co-benefits for local communities"*** (CBD 2010)

Some EbA measures are based on traditional knowledge of local communities, while others are based on know-how from elsewhere and/or adapted to current environmental problems. The selection of which EbA measures to apply in a given place or time is shaped by the three aspects: the local context; how one frames the problem that needs to be addressed (a combination of defining the threats, hazards,

Fig. 1 The Nor Yauyos Cochas Landscape Reserve (RPNYC); located in the high and middle basin of the Cañete River and in the Cochas Pachacayo basin (photograph by Pablo Dourojeanni)

risk factors, sensitivity and adaptive capacity of the system under scrutiny) and how to go about identifying possible solutions (the assessment process itself) (GIZ 2014; Hammill et al. 2013). It is then interesting to pose the following question: Would the use of different approaches for assessing vulnerability, in a given place and time, arrive at different solutions? In this case study we have the unique opportunity to evaluate three different approaches that were applied simultaneously within the same study area, the Nor Yauyos Cochas Landscape Reserve in the Peruvian Andes.

2 Overview of Institutional Settings and Case Study Site

This case study derives from activities executed to date by the Ecosystem-based Adaptation (EbA) in Mountain Ecosystems Project. 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). In Peru, the Project is

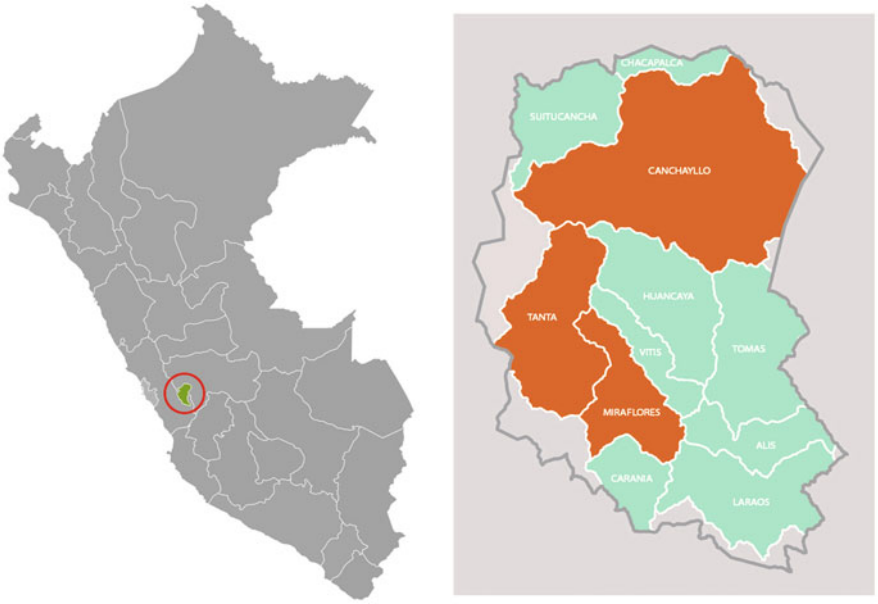

Fig. 2 Map of Peru and case study site showing the three districts where adaptations measures are being implemented

commissioned by the Ministry of Environment of Peru (MINAM for its Spanish acronym) and is implemented in the Nor Yauyos Cochas Landscape Reserve (NYCLR) 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).

The NYCLR is one of only two landscape Reserves in Peru (SERNANP 2014). Direct use of the natural resources by the local population is encouraged, but closely regulated by park authorities. The area holds great diversity of high Andean flora and fauna and is a source of many ecosystem services both for the local population as well as for populations located outside the Reserve (INRENA 2006). Water provision from the Reserve to downstream cities and highly productive agricultural valleys is a key conservation objective. It is estimated that more than 11 million Peruvians, including the inhabitants of Lima City downstream, depend on water that origins in this Reserve (Fig. 2).

It is widely accepted that current climate change impacts in the Andean mountains include changing rainfall patterns, glacier melt and reduction of downstream flows, increased temperatures, an increase in occurrence of frost and extreme weather events and the upward movement of flora and agriculture. In the future it is expected that these impacts will be exacerbated across the region (MINAM 2010). The three assessments showcased here focused on assessing climate vulnerability. Nevertheless other (local) drivers of ecosystem change were also explicitly taken into account (such as overgrazing, land use change, national and local policy).

The EbA Mountain project in Peru decided to undertake three approaches for assessing vulnerability in order to generate knowledge about ecosystem-based VA methodologies. UNEP undertook two parallel Vas (the model-based and deductive approaches) while the collaboration between UICN and TMI opted for the participatory approach. This provided the opportunity to assess vulnerability in three different ways within the same site (the NYCLR). Thus we avoided examining methods and results of VAs from different sites and different contexts, thereby allowing us to focus on studying the approaches themselves. The overall shared aim among the Vas was to identify EbA measures. Nevertheless, as an agreed implementation strategy between project partners, a "no-regrets measures" strategy was also conducted. These no regret measures were led by TMI and IUCN within the participatory approach and served as an entry point into communities with the explicit intention of being based on ecosystems.

To evaluate the approaches in a systematic way, a set of descriptors used for describing variables was created. In light of this evaluation, we propose an integrated VA approach that derives from the project experience in order for climate adaptation practitioners and government officials to learn from this experience.

3 Definition of Descriptors Used to Homologize Approaches

The designs of the three different Vulnerability Assessments respond to different conceptual approaches of how to identify adaptation measures, and are described as "deductive approach", "participatory approach" and "model-based approach". Through each approach, data was collected and analyzed. After completing the Vas, the project team identified lessons learned. Quantitative and qualitative data derived from the approaches were classified by a set of custom made descriptors to homologize the three different approaches, and were documented in a matrix as part of the case study. The descriptors included in the matrix are: scope, resolution, duration, expense, inputs (data and information requirements), outputs (kinds of results and recommendations of adaptation measures) and level of local participation in adaptation measure construction and selection (see Table 1). Definitions of descriptors are listed below.

Scope of VA area: refers to the geographical area covered by the VA. It can range from large to small, such as the entire project site (the NYCLR including its buffer zone), a watershed within the project site, an ecosystem, a district or a village. In this case study, the scope is measured in geographical units (square kilometers).

Resolution of VA: refers to the degree of detail of the inputs and outputs of the assessment. It can range from being a fine resolution where both input information and output information have great detail or a coarse resolution where outputs are coarse (even though inputs might have a fine resolution). Examples of fine and coarse resolution can be information on vulnerability at village level (fine

Table 1 Matrix of descriptors, attributes and units of measurements

Descriptor	Attribute	Unit of measurement	Value of attribute
Scope	Size of area covered by assessment	Square kilometer (Km^2)	Depends on the approach
Resolution	(input) resolution of source data and information	Relative (Fine or coarse)	Fine: use of Primary data (surveys, interviews, focal groups, field observations, participatory methods)
Input information			Coarse: secondary data (literature review or other sources of data) (Or a combination of both (primary and secondary data) (fine)
Resolution	(output) resolution of results and EbA measure recommendation	Relative (Fine or coarse)	Fine: village, community
Output information			Coarse: district, ecosystem, watershed or entire project site
Duration	Time spent conducting assessment	Months	User defined value
Expense	Resources spent doing assessment	US Dollars	User defined value
Inputs	Data and information required for assessment	Relative (low, medium, high, very high)	User defined value
Outputs (products and recommendations)	(products) types and number of different products	Count number and type	User defined value
	(recommendations) types and number of proposed EbA measures	Count number and type	As defined in the variable SCALE of output resolution information

Participation level	Local participation level	Local participation level according to forms of participation	Very low: Contractual participation form
			One social actor has sole decision-making power over most of the decisions taken during the process
			Low: Consultative participation form
			Most of the key decisions are made by one social actor, but emphasis is put on consultation and gathering information from others
			High: Collaborative participation form,
			Different actors collaborate and are put on a more equal footing, emphasizing linkage through an exchange of knowledge, different contributions and a sharing of decision-making power during the process
			Very High: Image Collegiate Participation
			Different actors work together as colleagues or partners. "Ownership" and responsibility are equally distributed among the partners, and decisions are made by agreement or consensus among all actors
			(Adapted from Vernooy (2005)
Beneficiaries of the information	Stakeholders directly interested in the results of assessment	# of institutions or stakeholders	User defined value
Following steps	Readiness for implementing EbA measures after end of assessment	List of steps and/or time in months to undertake those steps	User defined value

resolution) or at entire project site (coarse resolution). In this case study the resolution is measured twice, distinguishing between input and output information.

Duration of VA: refers to how long the VA took to reach final selection of proposed EbA measures. The beginning of the duration is set by the start of the assessment. The start of the assessment is the signature of the consultant contract of the team who leads the approach. The end of the duration of assessment is marked by the delivery of the final report with the proposed EbA measures to be implemented at project site. The duration of assessment is measured in time units of months.

Expense of VA: refers to how much it cost to conduct the assessment. The cost includes personnel who conduct the assessment, field activities associated with data collection and validation, data procurement and materials. The expense of the assessment is measured in currency units of US Dollars.

Inputs necessary for generating VA: refers to the amount of data and information needed to characterize the social and ecological system(s) under scrutiny. Inputs may vary from literature review, meteorological data, future climate scenarios and projections, census information, surveys, field observations, etc. By default any approach may use any given amount of data and information that is available or that it is possible to generate. Nevertheless, by design, the three approaches featured in this case study also have different demands of input information that is needed for generating results (outputs). Some are more information-demanding than others. To measure the inputs necessary for each of the assessments, we needed to categorize each approach and list the inputs needed for generating results (see section on description of approaches below). A scale of four classes was established to measure the amount of inputs necessary for generating the three assessments featured in this case study. The scale is divided into low, medium, high and very high demand of inputs.

Outputs generated by VA: refers to the two types of possible outputs that are of interest in an adaptation project. These refer to products that synthesize the Vulnerability Assessment and the final recommendations (EbA measures to be selected for implementation). The most common types of results can be a wide range of products, such as maps, reports, or indicator-based vulnerability scales. The final recommendations refer to the EbA measures that are proposed on the basis of the results of the assessment. As well, as explained above (see resolution of assessment), the output information resolution is an important aspect to be taken into account and is in direct relation with the EbA measure. For example, there is a difference in the degree of certainty in recommending an adaptation measure suited for one village and the same recommendation for the entire project site. This can also be viewed as a correlation between the variables of scope, resolution and output information. The design of each assessment has a different scope and resolution. The output information should, therefore, be in accordance with these variables.

Level of local participation during VA duration: refers to the degree of involvement the local beneficiaries of the proposed EbA measures have had in the development of the VA. This is in direct relation to the design of the assessment approach (deductive, participatory or model-based). It is measured in terms of local par-

ticipation level in the selection process. Local participation level is referred to as the degree of community control over the process, the stage of the process when local people participate, and the level of representation of different stakeholders and community groups in the process (Vernooy 2005). In this sense, key questions for analyzing level of local participation are: who controls and makes decisions, who undertakes activities, and who benefits from the results (Ibid.). There is usually an inverse correlation between the level of local participation with the scope of the assessment and a positive correlation with resolution of assessment. In other words, the greater the scope the lower level of local participation and the larger the resolution, the higher level of local participation is implied.

Beneficiaries of the information: refers to the stakeholders that have a direct interest in the results of the assessments. They can include local communities and project partners, as well as external organizations and public and private institutions.

Following steps: refers to the immediate actions that are required prior to the implementation of the EbA measures (under the premise that VAs should always lead towards implementation of EbA measures). This can be measured in two ways. The first is a list of steps that need to be taken, for example, further research or consultations; and second, in the amount of time that these steps would take to accomplish.

3.1 Matrix for the Descriptors and Units of Measurements

A matrix has been custom created for this case study to tabulate results of the variables used to evaluate the performance of the approaches used for the selection of EbA measures. In Table 1 there is an explanation of the attributes being evaluated, the scale used to value them and the units of measurements used for scoring.

Some of the attributes of the variables have a user-defined value in the sense that it is the user that defines the value according to their expected outcomes or context. For example, a time consuming and expensive Vulnerability Assessment can be valued low because it takes too much time to deliver results. On the other hand, if there are no time or budget constraints, a long and expensive Vulnerability Assessment can be valued highly in accordance with the number of outputs, scope and resolution of results.

4 Narrative Description of Assessments and Matrix of Descriptors

A narrative description of each of the three approaches is added in this section to present complementary information that is not captured by the descriptors. A recount of background information on the decision to choose a given approach, or the methodological process and information requirements has been added here to better understand each of the Vulnerability Assessments. At the end of this section we present the completed matrix in Table 2.

Table 2 Matrix of descriptors and their values according to approach taken for selecting EbA measures

Descriptor	Participatory approach	Model-based approach	Deductive approach
Scope	Canchayllo, area of 76.5 Km^2	All of the NYCLR. Including buffer area 3307 Km^2	All of the NYCLR. Including buffer area 3307 Km^2
	Miraflores, area of 202 Km^2		
Resolution	Both fine and coarse	Both fine and coarse	Coarse
Input information			
Resolution	Fine	Coarse	Coarse
Output information			
Duration	8	16	3–4 months (in a 12 month period)
Expense	80,000	130,000	50,000
Inputs	High	Very high	low
Outputs	Products generated:	4 reports including:	1 set of criteria
	2 memoirs of the IPRA	40+ maps; complete list of species; ecosystem distribution; species distribution; future climate change exposure scenarios; ecosystem services list and distribution; demand and supply of ecosystem services maps; sensitivity of population to climate change impacts and	3 versions of possible EbA measures
		11 radial diagrams depicting vulnerability (1 per district)	
	16 memoirs of field visits, meetings and others.		
	10 Technical reports		
	6 Maps		
Products	2 Documents with the detailed design of two no-regrets measures package (see description in recommendations).		

Outputs	(1) Community-based sustainable water management of upper river micro-basins	(1) Pasture management associated with wildlife management scheme	(1) Vicuña management
			(2) pasture management
Recommendations of EbA measures (no regret measures in the case of the participatory approach)	(2) Community-based sustainable communal native grassland management.	(2) water sources conservation and schemes for ecosystem payments	(3) conservation of watersheds and schemes for ecosystem payments
			(4) MAPs collection
		(3) Improvement and maintenance of the water infrastructure	(5) Agroforestry
		(4) sustainable tourism activities	
Local participation level	High.	Low.	Low to very low.
	Collaborative level of participation is reached. Local co-researchers are key members of the assessing team. EbA measures are selected and designed through an exchange of knowledge between local and external partners and a sharing of decision-making power during the process	Consultative level of participation due to the application of different tools for consulting and discussion of issues (interviews and focus groups)	Consultative level of participation to key informants at local level. More consultation was done at higher levels of government (regional, national)
Beneficiaries of the information	Local population at community level; park authorities; local authorities; SERNANP; EbA project organizations	SERNANP, park authorities,	SERNANP, park authorities, EbA Project organizations; MINAM
		EbA project organizations;	
		Local communities, MINAM	
Following steps	Capacity building at community level; implementation of EbA measures on the basis of specific technical studies that need to be developed	Use of the information coming from the study to identify specific ecosystem-based adaptation measures. This will imply a consultative process with the communities identified as most vulnerable.	Couples with the results of the VIA to pinpoint site location for intervention. Further detailed studies at site level needed for measure design and implementation

4.1 Participatory Approach: Vulnerability and Community Planning[1]

A "participatory approach" manages to assemble adaptation measures based on the many observations and opinions compiled from the local community in a process of extensive consultation in which local partners increase their decision-making power (see for example CRISTAL tool or CVCA tool). TMI, IUCN's implementing partner in the NYCLR, developed a methodological process to select, design and implement no-regrets measures in two pilot communities of the NYCLR. We used the following definition of no-regrets measures to guide our work: *"No-regrets measures maximizing positive and minimizing negative aspects of nature-based adaptation strategies and options. No-regrets actions include … measures taken by communities [and/or facilitated by organizations] which do not worsen vulnerabilities to climate change or which increase adaptive capacities and measures that will always have a positive impact on livelihoods and ecosystems regardless of how the climate changes"* (Raza et al. 2014).

Canchayllo and Miraflores communities, both located inside the NYCLR, were initially selected for assessment based on environmental, social, ecological, political and operational criteria (the selection process was done by the Mountain EbA project and the NYCLR Head and staff) (TMI 2013). In Canchayllo the main livelihood is cattle farming, although many families complement their income with other activities. The community of Miraflores, on the other hand, also depends on cattle farming; however agriculture is likewise an important livelihood strategy. There is a high level of out-migration and a low birth rate in Miraflores.

Field trips and workshops were carried out to identify vulnerabilities based on local perceptions, communities' needs and priorities, and generate ideas on how to address such vulnerabilities. Local communities and key stakeholders including the Reserve staff and district municipality authorities participated in such activities (Podvin et al. 2014).

An Integrated Participatory Rural Appraisal (IPRA) followed, where environmental and social impacts of pre-selected no-regrets measures were analyzed by a group of local stakeholders with experts' support, to make the final selection and design. Results of the IPRA were presented and validated by local stakeholders (and presented in the assemblies of both local communities), NYCL Reserve staff, and the EbA partners.

The methodological process that was carried out in Canchayllo and Miraflores took into account existing data and information, but was largely based on new information generated through the participatory process. As a result, two no-regrets measures were selected in each community. Canchayllo prioritized community-based native grassland management and improvement of ancestral hydrological infrastructure. Miraflores, on the other hand, selected community-based native grassland management as well, while also selecting conservation and management of upper micro-watersheds, wetlands and water courses.

[1] For a complete description of this approach refer to Podvin et al. 2014.

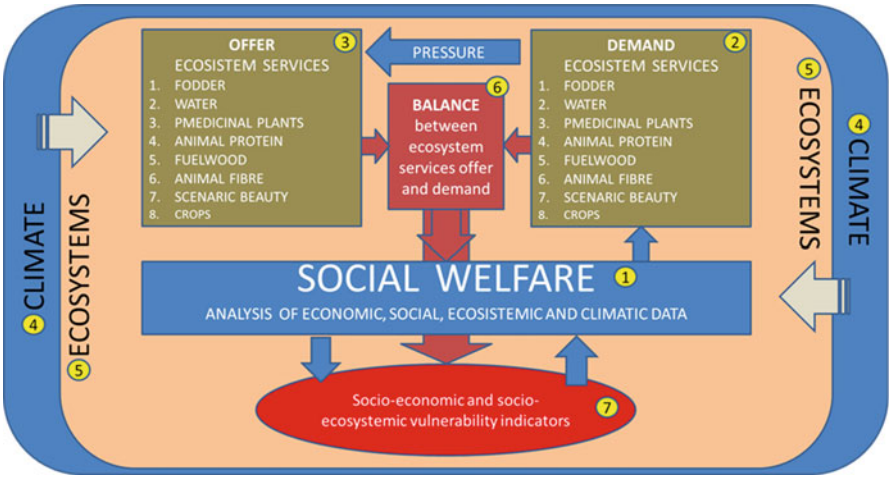

Fig. 3 Social welfare (*1*) depends on the economic activities in order to meet people livelihood. People activities (welfare) generate a demand for ecosystem services (*2*), and a pressure on the supply of ecosystem services (*3*). Supply of ecosystem services depends on both climate (*4*) and the existence of the ecosystems themselves (*5*). The interaction between demand (*2*) and supply (*3*) of ecosystem services generates a balance of supply and demand (*6*) of the ecosystem services which impacts on social welfare (*1*), which is also affected by the climate (*4*) and the presence of ecosystems (*5*). These interactions generate socio-economic and socio-ecosystemic vulnerability (*7*) which ultimately depends on social welfare (*1*)

4.2 Model-Based Approach: Vulnerability and Impact Assessment (VIA)[2]

A VA (FDA 2013), based on a set of statistical and spatial models for different aspects of the entire project site (the NYCLR) was developed and is here termed as the "model-based approach" (for example see Munroe et al. 2015). Data and information inputs were required to generate past, present and future climate scenarios, ecological processes, hydrology, economic processes, livelihoods and local people's perceptions.

The main goal of the "model-based approach" applied to the NYCLR and its buffer zone was to analyze the vulnerability to climate change of the territory of the Reserve and identify which areas would be most vulnerable to climate change, according to future emissions scenarios. It also resulted in a list of possible adaptation measures with indication of the districts where they could be implemented. This characterizes and differentiates the model-based approach from the other methods described in this chapter by the development of future climatic scenarios as one of the main methodological characteristics as well as by its focus on how the provision of ecosystem services and people's vulnerability would vary according to the climate scenarios. A conceptual scheme of the VIA is provided in Fig. 3.

[2] For a complete description of this approach refer to FDA, 2014 and Pablo Dourojeanni et al. 2014.

The study made use of several models to project future climate behavior, species distribution, as well as future ecosystem services provision. It required a number of data inputs from various sources (50-year records of climatic data on precipitation, temperature, numerical grids, Digital Elevation Models or DEMs, records of species richness and distribution, population censuses, agricultural census, interviews, surveys, focus groups). In addition, both primary and secondary sources were utilized and new information generated (such as the land cover map of the Reserve) and different methods for species and ecosystem modelling were applied. Lack of chronologically consistent data series (e.g. water quantity), as well as lack of available data at the proper scale (e.g. water quantity and quality, climate data) were among the main challenges encountered. The morphology of the terrain also represented a challenge both for the fieldwork and for the degree of uncertainty of the climate scenarios. It is notable that the scale of the inputs is very variable, from fine, in the case of data collected through surveys and interviews in the Reserve communities and other stakeholders, to coarse in the case of the climate data – downscaled later on. The scale of the results has generally been homogenized to the district level.

To develop such a study, the participation of an integrated and interdisciplinary group of specialized experts was needed in order to properly analyze all components that merged into the final results (see Fig. 1) and to develop the methodology used which considered changes in ecosystem services as one of the main elements. Consultations with external specialists were also occasionally required.

4.3 Deductive Approach: Literature Research and Expert Knowledge

Another VA, a "deductive approach", was conducted based on literature review, consultations with experts, field observations and consultations with local stakeholders. Results were reached using general rules (criteria) designed to delineate the boundaries of what could be possible EbA measures (Dourojeanni 2012a). These criteria worked as a rule-based envelope model into which information from literature and expert opinions was fed, and the output was a set of EbA measures that were based on the context of the entire NYCLR and watershed level (Dourojeanni 2012b). Conclusions (identified EbA measures) were only made as a reference to test the conclusions of the other approaches applied in the project.

The aim of this approach was to identify possible EbA measures that could be suitable to implement in the project site (the NYCLR), and therefore the first step was to define EbA. A set of criteria was derived from the literature and field visits were performed to gather information on site. A first set of 19 possible EbA measures (Dourojeanni 2012b) was discussed and prioritized into five options

(Dourojeanni 2013). These options were reviewed and further documented with the support of field visits and expert consultations.

It is worth noting that information generated through the model-based and the deductive approaches was used as inputs for the identification of a third intervention site (in addition to Miraflores and Canchayllo), namely the community of Tanta, as well as the EbA measures to be implemented there. As with Canchayllo, the community's main livelihood activity is livestock production. EbA measures selected for Tanta included community-based grassland management and domestic livestock husbandry, but also associated with management of vicuñas in the wild.

5 Lessons for Nor Yauyos Cochas Landscape Reserve and Beyond

The participatory methodologies applied in the planning, design, validation and implementation phases of the participatory approach have been key to deliver bottom-up activities that empower and enhance the involved local communities' ownership of project activities and results (TMI 2014). Even though the time extension (duration) of this approach has been shorter than the other two approaches, it has managed to produce a valuable amount of site-specific information (at community level). The added value of the participatory nature of this approach has been that this information has helped both communities and researchers reach a common understanding of local vulnerabilities to climate change and how they can be addressed. Also, in order to define the no-regrets measures, it was crucial to have a multidisciplinary team comprised of local researchers and external experts to analyze preselected no-regrets measures and their net potential social and environmental impacts. Another added value of the participatory approach was that at its conclusion, the adaptation measures were almost fully designed and only needed minor technical studies for the start of implementation, thus saving time from having to carry out further in depth studies. A key difference between the participatory approach and the other two approaches is that it focused its assessment at a very fine-scale—only two communities—and analyzed in the field pre-selected adaptation measures.

The model-based approach was a time-consuming, expensive and complex study. Nevertheless, the large amount of useful information that was produced rendered its execution valuable for understanding the complicated relations between supply and demand of ecosystem services in the entire project area (NYCLR), regardless of the uncertainty associated with modelling (resolution of data, amount of data and assumptions used in models). The model-based approach also made a complete review of existing statistical information on population and agriculture and compared it with primary data gathered through a survey. The compilation of all this information is highly important, not only for the selection and implementation of EbA measures. Park authorities and local communities will also use it to update local planning schemes for conservation and development and national authorities

will further expand their knowledge on how to conduct Vulnerability Assessments in protected areas.

The deductive approach only used existing information, expert consultations, field site visits and key interviews to produce a potential list of possible EbA measures. The main value of this approach was the conceptual exploration of EbA and the production of a general framework for classifying possible EbA activities regardless of the site (Dourojeanni 2012a). Nevertheless, the lack of involvement of the local population in the selection process of possible measures renders the exercise insufficiently grounded in the target territory and in a need for a second phase to design specific activities together with local communities.

The model-based approach demanded the largest amount of data, but also produced the largest amount of information for the entire project site (NYCLR). Nevertheless, as in the case of the deductive approach, the recommendations of EbA measures made by this approach were loosely grounded in the territory and required further design and consultation with local communities. Due to its participatory nature, the participatory approach resulted in recommendations that were highly grounded in the two local communities where the analysis was performed. However, the scope of the assessment was small and only rendered valuable information for the two selected communities. In contrast, the other two approaches produced information for the entire NYCLR which contributed to assessing and comparing vulnerability at a broader scope.

All three approaches used research, involving external (non-local) scientists to design a specific intervention at a selected site. The participatory approach did this through the IPRA and the other two approaches were led by an off-site scientist. This means that all approaches demanded a solid scientific basis for the design and implementation of EbA or no-regrets measures.

5.1 Towards an Integrated Approach

For future interventions, a combination of the three approaches for VA could be useful to reduce the amount of time, financial costs and effort involved in selecting and designing EbA or no-regrets measures. Once a set of criteria for identifying and classifying EbA measures (deductive approach) is created, the amount of time for pre-selecting possible measures has been reduced. Pre-selecting possible measures helps to narrow down plausible options (at community level or for a larger segment of territory), thus helping to allocate resources to the in-depth study of fewer subjects (as was the case of the participatory approach that also used a set of criteria for pre-selecting measures). As a next step to pre-select EbA measures, the development of an IPRA, as was conducted by the participatory approach, will help to develop together with the community the final selection and design of adaptation measures, while strengthening local capacities. Nevertheless, concerning the challenge of choosing where to perform (scope: what specific community or site at

broader scale), the implementation of measures, the VA is still reliant on a broader basis of information or on a finely defined project that targets a specific site.

Many of the specific methods for modeling and mapping ecosystem services applied in the model-based approach can be incorporated into the IPRA to help refine the identification of vulnerabilities of the population, ecosystems and ecosystem services. This is especially useful when the measures are already selected and the specific sites are determined, so that the research can have a great amount of detail (fine resolution).

6 Conclusion

The application of the three approaches described in this paper offer valuable lessons learned about how to design and conduct future Vulnerability Assessments for selecting measures in the context of Ecosystem-based Adaptation. These lessons led to the generation of several key recommendations to ensure the effectiveness and desired results of future Vulnerability Assessments.

Before initiating the design of an assessment, it is important to frame it appropriately, within the context of the overall objectives and desired outcomes of the given EBA initiative. This framing includes an early identification of hazards, the limits and units of analysis of the affected socio-ecological system, the specific purpose(s) of the assessment, available inputs (i.e. data, financial resources, technical capacities), and the target audience(s) of the outputs as well as other relevant stakeholders who should be engaged in the assessments development. In first completing this framing exercise, one can then determine, adjust and even package different methodologies to ensure the production of the desired outputs.

The ‘why’ of the assessment provides the foundation upon which to select and even integrate approaches. In the specific case of the Ecosystem-based Adaptation in Mountain Ecosystems project in Peru, two primary objectives shaped the multiple approaches to the assessment: (i) reduce the vulnerability of critical mountain ecosystems in Peru through Ecosystem-based Adaptation, and (ii) reduce the vulnerability to climate change of the local communities living within the Nor Yauyos Cochas Landscape Reserve. Both objectives required the engagement and in some cases active participation, of multiple stakeholders to ensure the effectiveness, legitimacy and credibility of the assessment results. Furthermore, both objectives demanded differentiated outputs from the assessment process in order for it to be relevant.

Therefore, stakeholder participation is critical at all stages of the assessment development. For example, the deductive approach, as described in this paper, engaged scientific experts, national and subnational authorities, and to a more limited extent, local actors. The participation of these multiple stakeholders served to gather the necessary information inputs, and also to periodically validate draft results. In the case of the participatory approach, the local communities were fundamental as co-researchers, providing their perceptions on risks, as well as needs,

priorities and deep knowledge that could guide the selection and design of the adaptation measures. Additionally, participation of local communities increased the likelihood of ownership and use of the information to decide on what, how and where adaptation measures should be implemented.

The decision about which approach to apply, or a combination of approaches, is dependent ultimately on the end uses or applications of the analysis that should be defined during the initial framing exercise. If the emphasis is on mobilizing local, community-level action, it is important to follow a methodology that facilitates active community participation in all stages of the analysis. However, if there is also an explicit objective to bring to scale the adaptation response, through policy, planning and accompanying financial mechanisms, it is important to ensure that stakeholders responsible for these processes at district and national levels are effectively engaged, in order to ensure their ownership of the results.

Given the EBA Mountain project's two-tier objectives stated above, it is in this light recommended that an integrated, blended approach to the assessment be employed. Community input to the participatory approach ensures social relevance and local ownership of the results, while the participation by policy-level decision makers in the deductive and model-based approaches ensures that results will have a certain level of ownership and credibility among these key stakeholders needed to inform policy and planning decisions at a larger systems-wide scale.

In order to maximize the benefits derived from applying multiple approaches, care should be taken to conceptualize, map and plan them under a single process. Doing so will allow that intermediate outputs be validated through the other approaches, in effect spurring a reiterative and adaptive learning process with the input of multiple methodologies, and the collective participation of diverse stakeholder groups. For example, local community engagement in the initial stages could then provide focus to the deductive approach, e.g. in identification of priority ecosystems and the services they provide, while local actors could be re-engaged to validate initial findings from the "top-down" assessments. The articulation of the bottom-up and deductive models will further ensure a more robust Vulnerability Assessment with a multidimensional and multilevel structure built with the iterative contributions of all key actors.

In both cases, communications and packaging of the results are key. While potentially technically similar in nature, the results need to be translated into the cultural and technical language of each key stakeholder group to facilitate the appropriation and application at the relevant scale.

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References

CBD (Secretariat of the Convention on Biological Diversity). (2009). *Connecting biodiversity and climate change mitigation and adaptation: Report of the second ad hoc technical expert group on biodiversity and climate change* (Montreal, technical series No. 41, p. 126). Montréal: Secretariat of the Convention on Biological Diversity.

CBD (Secretariat of the Convention on Biological Diversity). (2010). *COP 10 Decision, X/33*. http://www.cbd.int/decision/cop/?id=12299

Dourojeanni, P. (2012a). *Ejercicio de elaboración de criterios para la selección de medidas de adaptación basada en ecosistemas en la RPNYC, Perú*. Documento de trabajo interno.

Dourojeanni, P. (2012b). *Lista preliminar de posibles medidas de adaptación basada en ecosistemas para la RPNYC*. Documento de trabajo interno.

Dourojeanni, P. (2013). *Documentación de la lista corta de medidas de adaptación basada en ecosistemas para la RPNYC*. Documento trabajo interno.

Dourojeanni, P., Giada, S., & Leclerc, M. (2014). *Evaluación de Vulnerabilidad e Impacto del Cambio Climático en la Reserva Paisajísitca Nor Yauyos-Cochas y su Zona de Amortiguamiento: Resumen Técnico*.

FDA (Fundación para el Desarrollo Agrario). (2013). *Evaluación del Impacto y Vulnerabilidad del Cambio Climático de la Reserva Paisajística Nor Yauyos Cochas y áreas de amortiguamiento – VIA RPNYC*. Elaborado en el marco de la colaboración interinstitucional CDC-FEP-Universidad Nacional Agraria La Molina, Escuela de Ingeniería de Antioquía y IRI-EICES-Columbia University. Lima, PNUMA.

GIZ. (2014). *The vulnerability sourcebook concept and guidelines for standardized vulnerability assessments*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. https://gc21.giz.de/ibt/var/app/wp342deP/1443/wp-content/uploads/filebase/va/vulnerability-guides-manuals-reports/Vulnerability_Sourcebook_-_Guidelines_for_Assessments_-_GIZ_2014.pdf

Hammill, A., Bizikova, L., Dekens, J. & McCandless, M. (2013). *Comparative analysis of climate change vulnerability assessments: Lessons from Tunisia and Indonesia*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. https://gc21.giz.de/ibt/var/app/wp342deP/1443/wp-content/uploads/filebase/va/vulnerability-guides-manuals-reports/Comperative-analysis-of-climate-change-vulnerability-assessments.pdf

INRENA. (2006). *Reserva Paisajística Nor Yauyos Cochas, Plan Maestro 2006–2011*. Instituto Nacional de Recursos Naturales – INRENA Intendencia de Áreas Naturales Protegidas – IANP

MINAM. (2010). *Segunda Comunicación Nacional del Perú a la Convención Marco de las Naciones Unidas sobre Cambio Climático (SCNCC).*

Munroe, R., Dilys, R., Doswald, N., Spencer, T., Möller, I., Vira, B., Reid, H., Kontoleon, A., Giuliani, A., Castelli, I., & Stephens, J. (2012). *Review of the evidence base for ecosystem-based approaches for adaptation to climate change*. http://www.environmentalevidencejournal.org/content/pdf/2047-2382-1-13.pdf

Munroe, R., Hicks, C., Doswald, N., Bubb, P., Epple, C., Woroniecki, S., Bodin, B., & Osti, M. (2015). *Guidance on integrating ecosystem considerations into climate change vulnerability and impact assessments to inform ecosystem-based adaptation*. Cambridge: UNEP-WCMC.

Podvin, K., Cordero, D., & Gómez, A. (2014). Climate change adaptation in the peruvian andes: Implementing no-regrets measures in the Nor Yauyos-Cochas landscape reserve. In R. Murti & C. Buyck (Eds.), *Safe havens: Protected areas for disaster risk reduction and climate change adaptation*. Gland: IUCN.

PROVIA. (2013). *PROVIA guidance on assessing vulnerability, impacts and adaptation to climate change*. Consultation document, United Nations Environment Programme, Nairobi, Kenya. 198 p.

Raza, A., Barrow, E., Zapata, F., Cordero, D., Podvin, K., Kutegeka, S., Gafabusa, R., Khanal, R., & Adhikari, A. (2014). *Ecosystem based adaptation: Building on no regret adaptation measures*. Technical paper. 20th session of the Conference of the Parties to the UNFCCC and the 10th session of the Conference of the Parties to the Kyoto Protocol, Lima, Peru, 1–12 December 2014.

Reid, H. (2011). *Improving the evidence for ecosystem-based adaptation. Sustainable development opinion paper*. London: IIED.

SERNANP. (2014). Lista oficial de ANPs. http://www.sernanp.gob.pe/sernanp/archivos/biblioteca/mapas/ListaAnps_12112014.pdf

TMI (The Mountain Institute). (2013). *Memoria de la reunión de trabajo para selección de sitios del Proyecto EbA Montaña*. Internal report. 12 p.

TMI (The Mountain Institute). (2014). *The mountain institute report on action learning for mountain EbApProject, Perú/RPNYC*. First cycle of Action Learning. Internal Report. 10 p.

Travers, A., Elrick, C., Kay, R., & Vestergaard, O. (2012). *Ecosystem-based adaptation guidance: Moving from principles to practice*. UNEP Working document, April 2012.

Vernooy, R. (2005). The quality of participation: Critical reflections on decision making, context and goals. In J. Gonsalves, et al (Eds.), Participatory research and development for sustainable agriculture and natural resource management: A sourcebook. Volume 1: Understanding participatory research and development. Laguna/Ottawa: International Potato Center-Users' Perspectives With Agricultural Research and Development/International Development Research Centre.