UNEP-WCMC **technical report**

Guidance on Integrating Ecosystem Considerations into Climate Change Vulnerability and Impact Assessment to Inform Ecosystem-based Adaptation

UNEP WCMC

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The information shared in this document is an outcome of the *Ecosystem-based Adaptation in Mountain Ecosystems Project* focused on Nepal, Peru and Uganda where UNEP (UNEP-WCMC) in collaboration with partners IUCN and UNDP, undertook extensive work on Vulnerability and Impact Assessments (VIAs), to build a case for better understanding of climate resilience as it relates to mountain ecosystems. *Ecosystem-based Adaptation in Mountain Ecosystems* is supported by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety.

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Executive Summary

This Guidance provides information and advice on how to integrate consideration of ecosystems and their services into a climate change Vulnerability and Impact Assessment (VIA). It is informed by the experience of the *Ecosystem-based Adaptation in Mountain Ecosystems Project* focused on Nepal, Peru and Uganda where UNEP (UNEP-WCMC), in collaboration with partners IUCN and UNDP, undertook extensive work on VIAs to build a case for better understanding of climate resilience as it relates to mountain ecosystems. The work is supported by the Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety of the Federal Republic of Germany.

VIAs are conducted to inform the objectives, focus and content of adaptation interventions and strategies, and many approaches, tools and methods now exist to guide this process. However, despite this plethora of guidance, there are significant challenges to fully capturing the complexity of social-ecological systems and their vulnerabilities in VIAs.

This Guidance addresses these challenges and recognizes the importance of designing assessments of social vulnerability to climate change so that they take account of potential changes in the supply of and demand for ecosystem services (the benefits that people obtain from ecosystems) that support livelihoods, the well-being of societies and their adaptation strategies. Using the steps described can provide a strong basis for identifying options for ecosystem-based adaptation to climate change (EBA), as part of wider adaptation planning.

The target audience of this Guidance includes: climate change practitioners interested in a holistic approach to adaptation planning and exploring the applicability of EBA; policy-makers commissioning VIAs; and ecosystem-based management practitioners intending to integrate climate change into their initiatives. It is particularly aimed at practitioners who are already engaged in VIA approaches, but who need assistance in incorporating an understanding of the effects of climate change on ecosystem services, and subsequent impacts on people's livelihoods and well-being. Although VIAs can be conducted at various scales, this Guidance principally addresses conducting them at a sub-national scale, such as the community, watershed or regional level.

This Guidance takes the reader through steps that will support the integration of ecosystem considerations into holistic VIAs, describing **key questions** to be answered, outlining the **process** of carrying out the steps, identifying the **outputs** of each step, and referring to **other useful materials**. It also uses a fictional case study to illustrate the type of information that might be collected at each step. The steps have been designed to match with the types of steps that are commonly included in vulnerability assessment guidance, and may be thought of as part of an iterative rather than a linear process. These steps are:

1. **Define the scope:** determine for who and what the VIA is intended, as well as its geographical and temporal scope.
2. **Understand the context:** develop an understanding of the social-ecological system being studied, specifically its livelihood groups, the eocsystem services they depend on, and the ecosystems that supply these services.
3. **Assess current exposure and sensitivity:** identify the climatic parameters important for the supply of ecosystem services, assess the potential impacts of observed

variability and trends in these climatatic parameters on livelihood groups through changes in important ecosystem services.

4. **Assess current adaptive capacity and vulnerability:** identify the adaptive capacity of people in the livelihood groups to the potential impacts identified in Step 3.
5. **Assess future vulnerability:** develop future scenarios for climate and development, so that activities and outputs from Steps 3 and 4 can be revisited to assess future vulnerability to climate change.
6. **Consider next steps:** define the next steps for using the assessment results to inform adaptation planning, including validating and presenting the results, combining with other analyses, and identifying management options for maintaining or enhancing the supply of ecosystem services as part of reducing vulnerability to climate change.

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Part I Introduction

Adaptation strategies are generally based on a prior assessment of climate change impacts and vulnerability (Vulnerability and Impact Assessment; VIA), which informs the objectives, focus and content of adaptation interventions and the overall strategy.

Many approaches, tools and methods now exist for conducting VIAs, ranging from those that focus on the vulnerability of, and impacts on a local community or a particular species, to large-scale assessments of countries and regions. Multiple approaches may be combined to design and carry out an assessment and the particular techniques employed can vary from case to case.

Significant challenges remain, however, including:

1. Selecting indicators that can capture the complexity of a social-ecological system and its vulnerabilities;
2. Accessing the needed technical expertise from a range of disciplines;
3. Avoiding compartmentalization of different sections of a VIA and weaving together these components to construct a coherent approach[1].

This Guidance addresses these challenges and recognizes the importance of assessing the possible changes in the supply of ecosystem services (the benefits that people obtain from ecosystems) due to climate change, as these ecosystem services can support livelihoods, the well-being[2] of societies and their adaptation strategies. Examples of ecosystem services include the supply of physical goods (such as food, fuel and clean water); the regulation of floods, soil erosion, micro-climate and disease outbreaks; and non-material benefits such as the recreational and spiritual benefits of natural areas.

Like the people who utilize them, ecosystem services can be affected by changes in climatic parameters, and some, such as flood regulation, are particularly important for reducing people's vulnerability to climate change. Therefore, it is important that the role of ecosystem services is adequately assessed during a VIA.

Purpose

The purpose of this document is to provide guidance on how to integrate consideration of ecosystems and their services into a climate change VIA.

Following the steps described in this Guidance (see 'Guidance structure and overview' below) can provide a strong basis for identifying options for ecosystem-based adaptation for climate change (EBA), as part of wider adaptation planning.

More specifically, this Guidance helps to address the following questions:

- What is the relationship between ecosystems and livelihoods?
- Which ecosystems supply the ecosystem services that are most affected by climate change?

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[1] 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, Eschborn, March 2013.

[2] For the purposes of this document, well-being is defined as a state characterized by health, happiness and prosperity. The following key components are frequently cited as being essential to human well-being: the basic material requirements for a good life; freedom and choice; health; good social relations; and personal security (Millennium Ecosystem Assessment 2005).

- How will climate change affect ecosystems and their supply of services?
- What impacts do these climate-driven changes in ecosystem services have on livelihoods and well-being?

Scope

An assumption of this Guidance is that its users will already be working with established VIA methodologies and tools. This Guidance should be seen as complementary to these. It focuses on assessing the vulnerability of people to climate change impacts through changes to the supply of ecosystem services, and consequently, changes in people's livelihoods and well-being.

The content of the Guidance is informed by UNEP-WCMC's experience of supporting the VIA process under the flagship programme of UNEP, UNDP and IUCN: 'Ecosystem-based Adaptation – Adapting to climate change in mountain ecosystems', supported by the Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety of the Federal Republic of Germany, and carried out in collaboration with the Governments of Nepal, Peru and Uganda.

Scale

VIAs can be conducted at various scales (e.g. individual, household, community, city, regional, watershed, national). These scales may correspond to ecosystems or landscapes (e.g. a watershed) or to administrative units, depending on the adaptation planning process that the VIA is intended to inform. Although an assessment of vulnerability and impacts that incorporates ecosystem services should logically focus on an ecosystem or landscape, it is also important to recognize that policies, planning and data collection are often implemented at the level of administrative units. This Guidance principally addresses conducting VIAs at a subnational scale, such as the community, watershed and/or regional level.

Target audience

This Guidance is intended for:

- Climate change adaptation practitioners interested in adopting a holistic approach to adaptation planning, by adding consideration of ecosystems to a VIA that is already considering socio-economic factors;
- Those commissioning VIAs;
- Climate change adaptation practitioners interested in exploring the applicability of EBA as part of their climate change adaptation measures; and
- Ecosystem-based management practitioners intending to integrate climate change into their initiatives.

The Guidance is particularly aimed at practitioners who are already using or engaged in VIA approaches, but who need assistance in incorporating an understanding of the potential effects of climate change on ecosystem services, the subsequent impacts on people's livelihoods and well-being, and what this means for their overall vulnerability to climate change.

Overall it is assumed that the user of this Guidance will have at least a basic awareness of climate change.

Guidance structure and overview

This Guidance is not a technical field manual. It is written in a style designed to take the reader through steps that will support the integration of ecosystem considerations into holistic VIAs that examine not only ecological, but also socio-economic consequences of climate change. It describes **key questions** to be answered, outlines the **process** of how to carry out the steps, identifies the **outputs** of each step, and refers to how **other useful materials** (in Annex 1) can be used to support each step. It uses a fictional case study to illustrate the type of information that might be collected at each step.

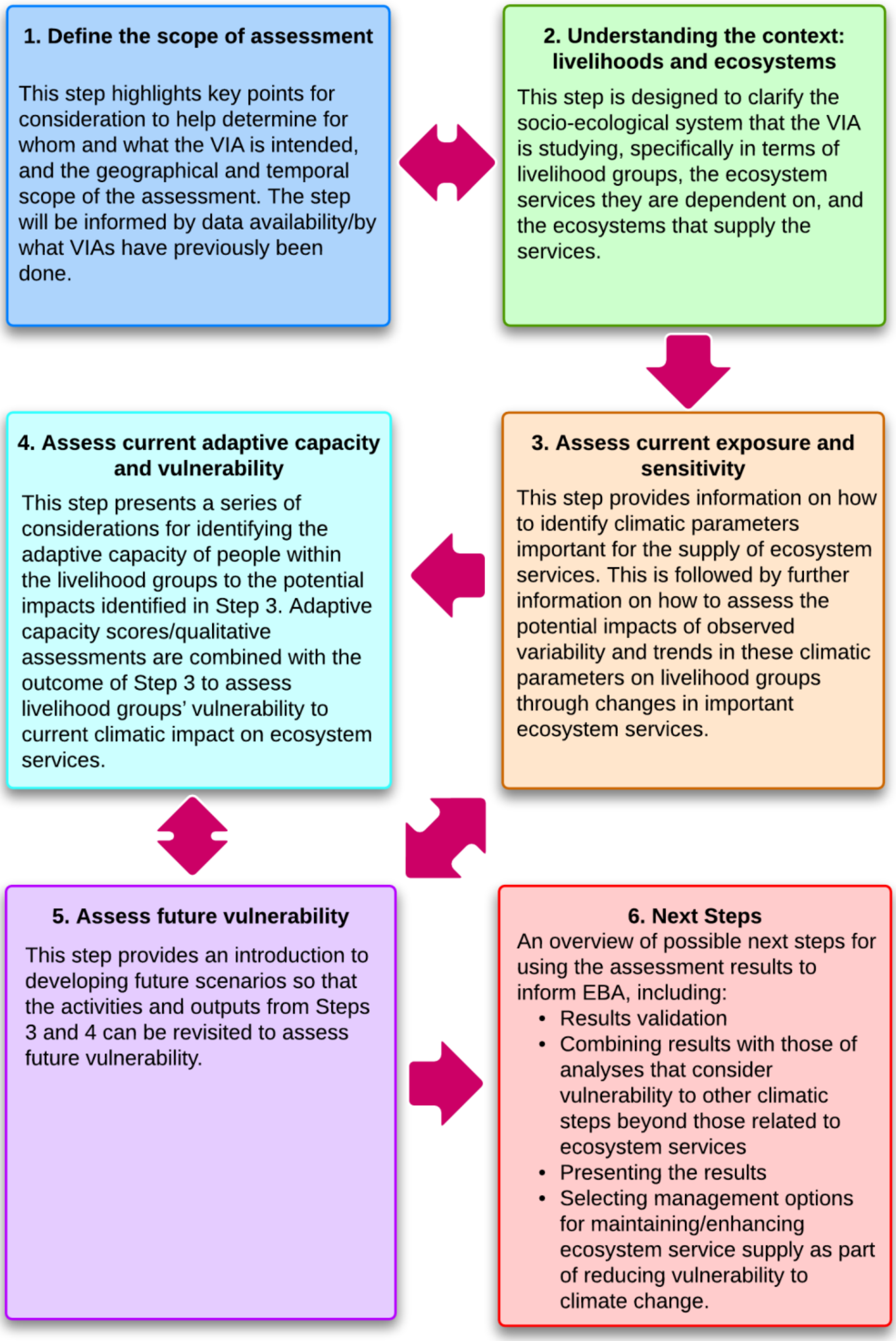
The Guidance is structured in a series of steps that are common to many types of vulnerability assessment guidance (e.g. the United Nations Development Programme Adaptation Policy Framework[3]):

1. Define the **scope**
2. Understand the **context**
3. Assess **current exposure and sensitivity**
4. Assess **current adaptive capacity and vulnerability**
5. Assess **future vulnerability**
6. Consider **next steps.**

Each of the steps captured in Figure 1 forms a section of this Guidance. It should be noted that the sequence of steps should not be thought of as a strictly linear process, but more an iterative one. The information developed under each activity may result in new insights that may require re-evaluation of earlier conclusions. Following the order of steps as they are presented here should nevertheless allow those conducting a VIA to focus their efforts efficiently and minimize repetition.

[3] Lim, B., Spanger-Siegfied, E. (2004). *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures.* UNDP. Cambridge University Press, Cambridge, UK.

Figure 1: Framework of Guidance steps



Fictional case study narrative: The Itayuni-Babarka mountain landscape

Who and where: the people and the land

The Itayuni-Babarka mountain landscape spans the high-altitude valley, rangelands and mountain peaks of a tropical country. The Itayuni, indigenous to the region, live in the steppes and heathland of the higher altitudes, and the surrounding peaks have been their sacred sites for centuries. The Itayuni people are traditionally herders, living in small groups of houses scattered across the rangeland. Although they rely mostly on raising cattle, some of their food also comes from small terraced plots of high-altitude tolerant crops. They also extract forest products from the alpine and cloud forests that cover the lower slopes.

Forty years ago, an ethnic group called the Babarka were displaced from ancestral lands and settled in the lower parts of the landscape to farm in the flat areas and rolling hills around the banks of the White River. Although the two communities have remained distinct, they have established close trade relations over time. The Itayuni merchants come down to sell crafts, clothing and other wool products, as well as medicinal and aromatic plants found in the forest and highlands, in exchange for food and some of the modern goods that reach Babarka. Itayuni women in particular gather medicinal plants that, once sold, provide them with essential cash income.

Changing conditions

In recent years, rainfall has become more unpredictable, coming later in the year than usual or in erratic patterns. The farmers in Babarka have coped by tapping into the reservoir of the small hydro-electric plant, though this has caused a reduction in capacity for electricity production. Water reserves are now at an all-time low, especially since sedimentation of the reservoir has reduced its capacity.

In the highlands, a prolonged drought caused fires that destroyed precious scrubland and even killed cattle. When rain finally arrived, it was so intense that some of the terraced fields collapsed and caused a landslide, blocking the road between the Itayuni settlements and Babarka. The White River has flooded in the past, but never as severely as recently, damaging farmland and causing cracks to the sole bridge across the river, which is a vital access point to the other side of the valley during the rainy season.

In addition to drought, strange out-of-season weather events such as wind and hail storms of unprecedented force have destroyed crops, caused miscarriages in livestock and killed wild birds. This comes on top of ever-smaller agricultural harvests in the valley, leading to some food shortages for these communities, whose isolation means that alternative (shop-bought) foodstuffs are hard to come by. Some youth in Babarka have started to work seasonally in the city, in the construction and low-skilled service sectors, coming back to the valley for the harvest season.

Resource use: cause or consequence?

The forests that once covered the mid-altitude slopes are shrinking and becoming fragmented, as wood is extracted for both timber and fuel. Individual quotas, developed in partnership with a local environmental NGO, have been allocated among the Itayuni; however, they are enforced leniently. People in Babarka are also extracting more timber every year, and flood damage has increased the demand for materials for reconstruction.

The Blue Lake, located halfway between the two communities, used to provide excellent fishing grounds for the Itayuni. But it has become murky and the fish are smaller and smaller as seasons pass. The price of crayfish has also gone up; crayfish traps left in the river are coming back empty, a change some blame on pollution. Last year, the small hydro-electric power plant had to be shut for a whole month to *replace the turbine. The engineers that came from the city said that the turbine had been damaged by the high concentration of sediment in the water.*

When cold spells occur in the highlands and the steppe becomes covered in frost, making foraging impossible for livestock, the Itayuni have to take their herds down to the valley. Lately, cold spells have occurred for longer periods, and, unexpectedly, during the growing season in the valley. Already faced with declining harvests, the people in Babarka are not so welcoming anymore to the Itayuni herds. Some have accused lone animals of destroying some of their crops, but the damaged leaves could well be due to outbreaks of insects at the end of the last rainy season. Nevertheless this has increased tensions between the communities, who have previously managed to co-exist reasonably well.

What does the future hold?

Ten years ago tourists started to visit the area. The beauty of the landscape, the pristine lake and the sacred mountains make it a prime trekking destination. Very few facilities are currently available, with only a few guesthouses in Babarka. Tourists usually hire an Itayuni guide to take them on treks around the area. The influx of money from tourism has allowed the community to hire a new teacher for the school in Babarka and reduce school fees. Some Itayuni families have started to send their children to the school in the hope that it will secure them a better future.

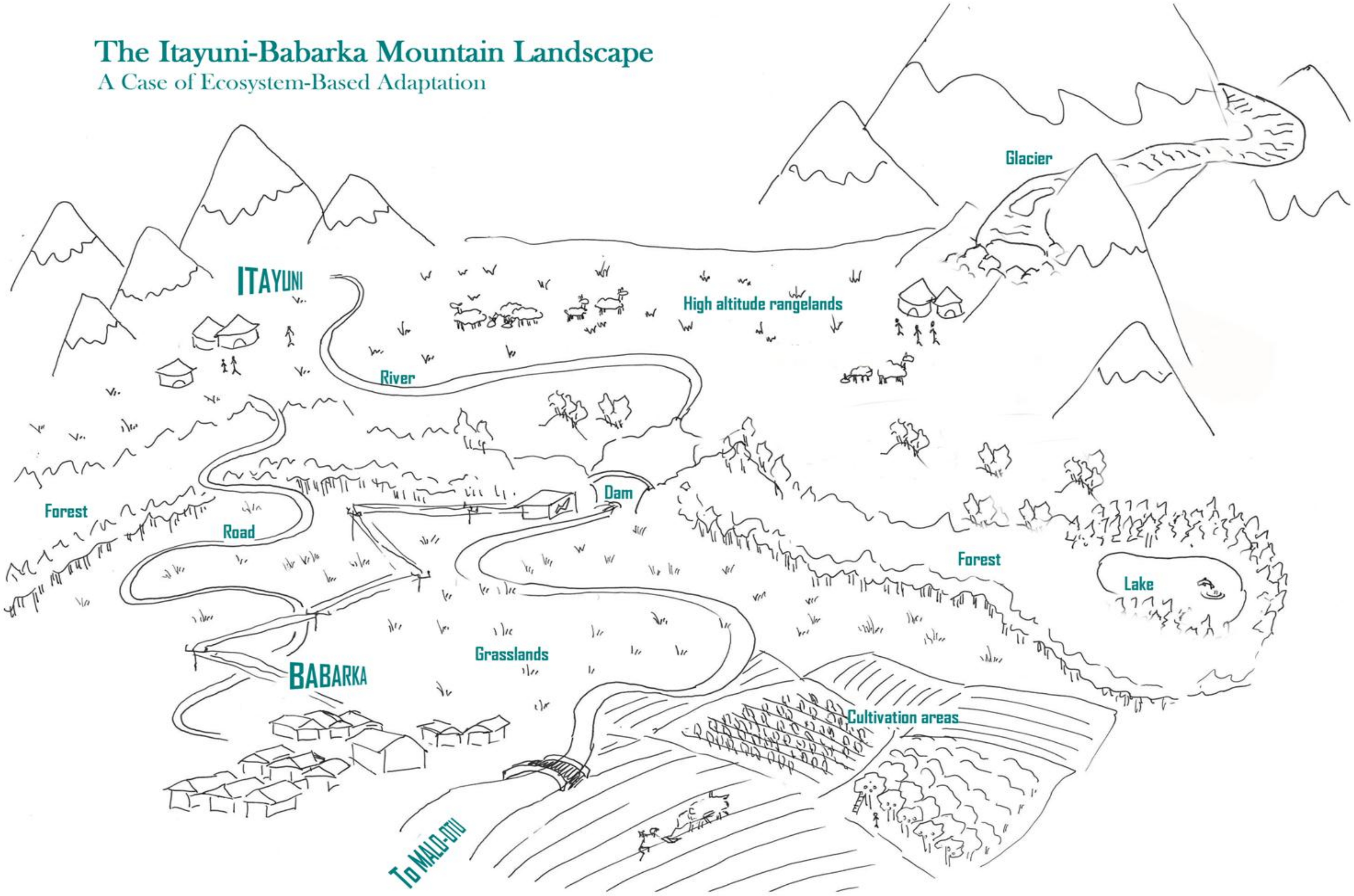
The local youth are discouraged by the lack of opportunities and the tough conditions, and are attracted to the big city. Many have left to work in the city in low-skilled jobs, whilst some have gone abroad. Recently, in the face of worsening economic conditions, even older Itayuni men have left to work in the city, and many never return, though they send remittances. The women left behind have found it harder than ever to cope with all the demands of making a living and raising a family.

Designating the Itayuni-Babarka landscape as a UNESCO World Heritage Site has been suggested as a method to increase tourist numbers. An application was developed in collaboration with communities, and is now in the hands of the provincial government. The communities recognize that if well managed, the UNESCO World Heritage Site could also provide increased funds to develop long-awaited infrastructure and services.

Planning Ahead

To try to avert a crisis, the governing councils of the Itayuni and Babarka communities have decided to meet and devise a strategy for the years to come. If the communities do not take action to adapt to the changing conditions, they are conscious that even their survival is at stake. Given the remoteness of the area, being largely self-reliant for food production is a necessity; but it is also an intrinsic part of the Itayuni and Babarka lifestyles. In past years, the communities have relied more on importing products from the lowlands, and this is draining their already meagre savings, and changing local culture. They worry that if their livelihoods become less and less viable, people will leave for Malo-Otu or other cities, and the communities may cease to exist. Both groups also want to preserve the character of the landscape and its natural beauty.

Figure 2: Fictional case study – The Itayuni-Babarka Mountain Landscape



Part II Key concepts

Ecosystem-based Adaptation (EBA)

EBA is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change. Examples of EBA include:

- Conservation, sustainable management and/or restoration of hill forests to stabilize slopes, intercept rainfall and prevent dry soils through transpiration, thus reducing the risks of shallow landslides associated with varying rainfall intensities and frequencies;
- Conservation, sustainable management and/or restoration of mangrove forests to reduce the impact of coastal flooding and erosion from storm surges linked to changing frequency and intensity of storms;
- Establishment of diverse agroforestry systems to provide flexible livelihood and income options to adapt to climatic variability, through the provision of climate-resilient tree and ground crops for human and animal consumption;
- Protecting natural breakwaters (e.g. coral reef conservation/restoration) to address sea-level rise induced coastal erosion.

Principles of EBA include:

- Resilient ecosystems and maintenance of ecosystem services, including those that reduce disaster risk, in the face of climate change, should be promoted;
- Multi-sectoral approaches should be promoted;
- The functional scale of ecosystems should be considered, recognizing that ecosystems have limits and are interconnected;
- Reduce the risk of maladaptation by considering biodiversity and ecosystem services in adaptation action design, and by developing sustainable monitoring and evaluation systems;
- Participatory approaches and decentralized, flexible management structures should be used to enable adaptive management;
- The best available science and local knowledge should be used, and knowledge generation and diffusion fostered. [4]

Ecosystems, their functioning and ecosystem services

Ecosystems provide **ecosystem services**, which, as outlined above, are needed by people in a variety of ways. Through the services they supply, ecosystems provide the basis for livelihoods and well-being, supporting food, water and energy security.

[4] For more information on proposed principles of EBA see: Travers, A., Elrick, C., Kay, R. Vestergaard, O. (2012) *Ecosystem-based adaptation guidance: Moving from principles to practice ('EBA Decision Support Framework')*. UNEP Working document, April 2012. UNEP, Nairobi, Kenya; Andrade, A., Córdoba, R., Dave, R., Girot, P., Herrera, F. B., Munroe, R.., Oglethorpe, J., Paaby, P., Pramova, E., Watson, E., Vergar, W. (2011) *Draft principles and guidelines for integrating ecosystem-based approaches to adaptation in project and policy design: a discussion document*. Technical Series No. 46. IUCN-CEM, CATIE, Turrialba, Costa Rica; Girot, P., Ehrhart, C., Oglethorpe, J. (2011) *Integrating Community and Ecosystem-Based Approaches in Climate Change Adaptation*. CARE, WWF, IUCN and IIED, Ecosystem & Livelihoods Adaptation Network; UNEP, UNDP, IUCN (2013) *Making the Case for Ecosystem-based Adaptation: Building Resilience to Climate Change.* UNON, Nairobi, Kenya; Naumann, S., McKenna, D., Munang, R., Andrews, J., Thiaw, I., Alverson, K., Mumba, M., Kavagi, L., Han, Z. (2013) *The social dimension of ecosystem-based adaptation*. UNEP Policy Series: Ecosystem Management No.12. UNEP, Nairobi, Kenya.

This means that the potential climate change impact on ecosystems and the consequences for human populations should be a fundamental consideration in climate change adaptation. In addition, ecosystems can provide regulating services that can reduce other impacts of climate change on people. Figure 3 below highlights some examples of different categories of ecosystem services (these are elaborated upon in Annex 2) and how ecosystem services relate to climate change adaptation. The supply of ecosystem services is determined by the functioning of the ecosystems that they are sourced from.

Ecosystem functioning can be defined as 'the flow of energy and materials through the arrangement of biotic and abiotic components of an ecosystem. It includes many ecosystem processes, such as primary production, trophic transfer from plants to animals, nutrient cycling, water dynamics and heat transfer'[5]. More simply, it is the outcome of the processes and interactions between all of the various components of the ecosystem, the flows of inputs to that ecosystem, and the structure of the ecosystem itself.

The supply of ecosystem services is reliant on this wide range of ecosystem components, processes and interactions, and the relative importance of these for the supply may vary. For example, provisioning ecosystem services (see Figure 3 and Annex 2) are normally linked to the presence of particular species or groups of species, as well as to the basic processes allowing these species to persist, such as nutrient cycling and soil formation. On the other hand, regulating services such as regulation of water flows or erosion control are often more dependent on structural characteristics of an ecosystem (e.g. vegetation cover and soil structure) and abiotic site parameters such as bedrock substrate and slope inclination, than on its precise species composition[6].

Given the importance of ecosystem services to livelihoods and well-being, and that the supply of ecosystem services is determined by ecosystem functioning, assessing the potential impacts of climate change on ecosystem functioning is an essential step in assessing societal vulnerability. Moreover, an understanding of this will help to inform how the ecosystem needs to be managed to mediate these potential impacts, and to maintain or enhance the supply of ecosystem services in the context of climate change.

This guidance identifies a number of characteristics of ecosystem functioning that are often particularly relevant for ecosystem service supply, such as ecosystem structure and the key ecological interactions and key species composition influencing that structure (see Annex 3)[7]. Focussing the assessment on these characteristics should enable the use of the Guidance with a variety of stakeholders with various levels of ecological understanding. It is intended that the Guidance will inspire further work on integrating assessments of the impact of climate change on ecosystem functioning (including, as necessary, any aspects of ecosystem functioning not covered by this Guidance) into climate change VIA practice to inform EBA actions.

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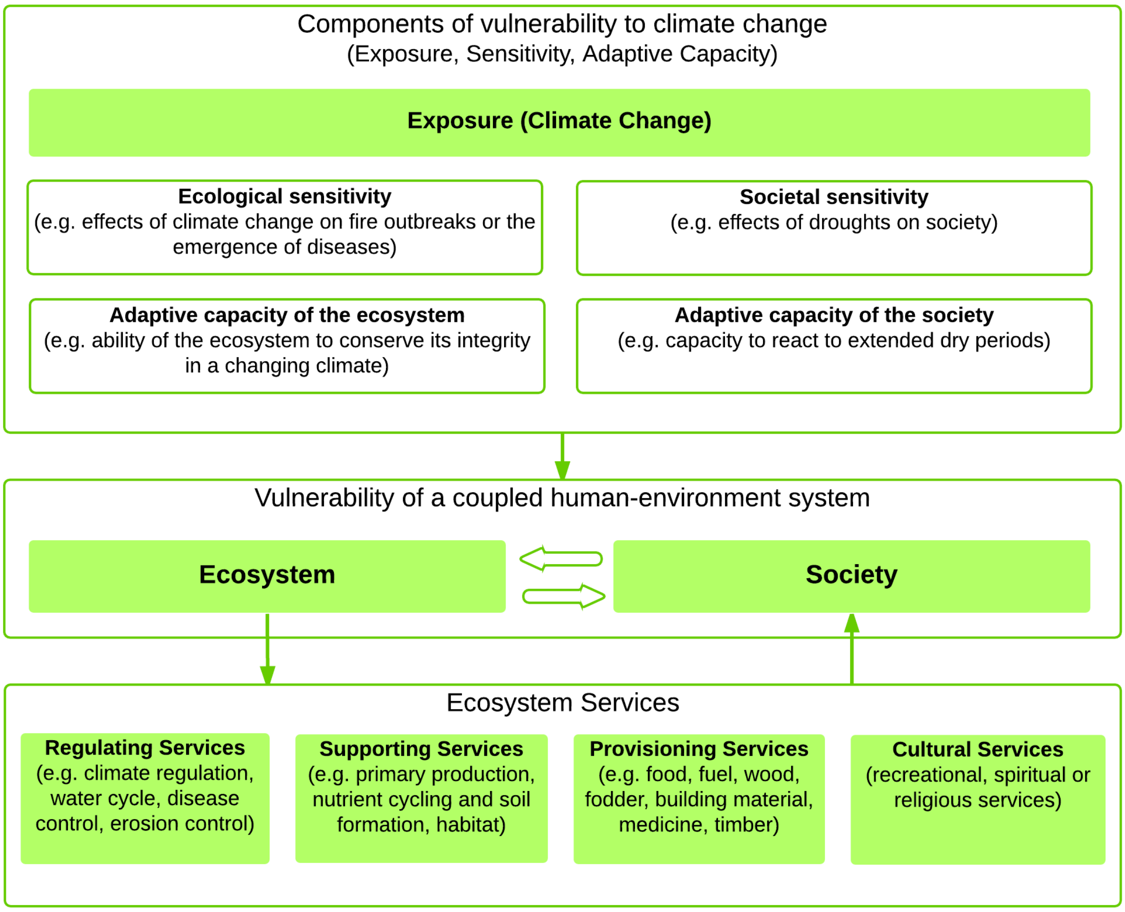
[5] Hicks, C., Woroniecki, S., Fancourt, M., Bieri, M., Garcia Robles, H., Trumper, K., Mant, R. (2014) *The relationship between biodiversity, carbon storage and the provision of other ecosystem services: Critical Review for the Forestry Component of the International Climate Fund.* UNEP-WCMC. Cambridge, UK.

[6] Epple, C., Dunning, E. (2014) *Ecosystem resilience to climate change: What is it and how can it be addressed in the context of climate change adaptation?* Technical report for the Mountain EbA Project. UNEP-WCMC, Cambridge, UK.

[7] These factors are also amenable to management and are likely to be influenced by climate change (unlike abiotic factors).

Figure 3: Conceptual Framework to guide assessing the vulnerability of coupled human-environment systems



Adapted from Hergarten, M. (2013) Forests and Climate Change Adaptation: A twofold approach. GIZ and ECO Consult

Socio-ecological systems

This Guidance has been designed for use in coupled human-environment systems, also called **socio-ecological systems** (Figure 3). A socio-ecological system is defined as a linked system of people and nature. Households, villages, larger settlements, and districts are nested within an ecosystem/ecosystems, which are connected to other ecosystems within a watershed or landscape. Societies manage ecosystems to benefit from and/or influence the supply of ecosystem services. For example, they may log and replant trees for timber, or clear forest and plant crops for food and cash income. Ecosystem services may also be affected by climate change, such as increasing temperature or decreasing rainfall, as well as other drivers of change, such as increasing demand from a growing population, or the effects of pollution. Determining the vulnerability of a socio-ecological system to changes in the supply of ecosystem services is thus an important component of determining its vulnerability to climate change.

Vulnerability

Vulnerability to climate change can be defined in a number of ways. For the purposes of this Guidance, it is defined 'as the degree to which a system [social, ecological or socio-ecological] is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of: i) the character, magnitude, and rate of climate variation to which a system is exposed, ii) its sensitivity, and iii) its adaptive capacity'[8]. **Sensitivity** is the degree to which a system is affected, either adversely or beneficially, by climate change, either directly or indirectly[9]. **Adaptive capacity** is the ability of a system to adjust to climate change, to moderate potential damage, to take advantage of opportunities, or to cope with the consequences[10].

The combination of **exposure** and **sensitivity** to climate change also determines the **potential** climate change **impact.** In the case of potential impacts resulting from changes in the supply of ecosystem services, the relationship can be described as follows:

Potential climate change **impact** on people	=	**Exposure** to climate variation that influences ecosystem services in the socio-ecological system	+	People's **sensitivity** to climate change through their reliance on ecosystem services that are sensitive to climate variation

The steps described in the following sections of this Guidance help to produce an assessment of vulnerability by logically identifying and combining these components using the following simplified relationship:

Climate change **vulnerability** of people	=	Potential climate change **impact** on people as a result of changes in ecosystem service supply	-	People's **adaptive capacity** to these climate impacts

[8] IPCC (2007) Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to* the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. [Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Avery, K.B., Tignor, M., Miller, H.L. (eds.)]. Cambridge University Press. Cambridge, UK and New York, NY, USA.

[9] *Ibid.*

[10] *Ibid.*

Differential vulnerability

People within socio-ecological systems can experience different levels of vulnerability, which is often referred to as differential vulnerability. For example, demographic factors (such as age, gender, education and place of residence), socio-economic factors (such as poverty), and other relevant factors (such as access to natural resources, food security and social networks) affect the components (i.e. exposure, sensitivity and adaptive capacity) and degree of vulnerability of individuals and groups. Unequal power relations between different groups in society may cause inequalities in the distribution of rights, roles, opportunities, power and access to and control over resources, leading to different degrees of vulnerability. Evidence from the field indicates that such inequalities generally increase many people's vulnerability to harmful climate change impacts, while limiting their options for coping strategies and adaptation.

In an ecosystem services context, for example, gender differences in access to and use of ecosystem services, such as medicinal plants or clean water, can affect the extent to which women, girls, men, and boys are affected by changes in the socio-ecological system caused by climate change. Relations within these groups can further affect vulnerabilities and should therefore also be considered.

VIAs need to be context-appropriate and inclusive of the poorest and most vulnerable groups in order to guard against the perpetuation of social inequalities [11]. Further, effective and long-term adaptation depends on a strong understanding of community structures and the different vulnerabilities, capacities and assets of groups within society.

Those conducting VIAs should consider the concept of differential vulnerability in their VIA design and approaches (see Box 1).

Box 1: Considering differential vulnerability in a VIA

It is important to understand and plan for addressing differential vulnerability at an early stage and throughout a VIA process. Without this sensitivity to the needs and vulnerabilities of different groups, practitioners will likely miss key information, including links between livelihoods and ecosystems that affect particular groups.

When conducting a VIA, having different stakeholder groups define the study area (Steps 1, 2) is a useful first step. This helps to increase interest and buy-in from the participants and ensures that the boundaries of the socio-ecological system to be studied are relevant to the communities themselves. Also, be aware that the system of interest may differ for particular groups. For example, women may include larger landscapes or alternative ecosystems because they value access to freshwater or firewood. This may reflect different priorities from men in some settings.

The research team may be able to identify the main stakeholder groups during the preparatory stages of a VIA (Steps 1.2, 2.1). However, more direct assessment methods (e.g. stakeholder mapping, Step 1.2) may be necessary to fully understand the variation in perceptions, interests, roles and rights across the community (including between and within obvious sub-groups, such as different genders). Explaining the results of these stakeholder mapping exercises to the community will also help to foster

[11] Rossing, T., Otzelberger, A., Girot, P. (2014) *Scaling-up the use of tools for community-based adaptation: Issues and challenges.* In Ayers, J., Schipper, L. F.,Reid, H., Huq, S., Rahman, A. (eds.), *Community-Based Adaptation to Climate Change: Scaling it Up.* Routledge, Oxford, UK.

transparency. The process may help the team to develop basic hypotheses about critical livelihood-ecosystem links, dependencies and drivers of change.

Due to time or financial constraints, it may be necessary to prioritize information-gathering and assessment on vulnerability of particular sub-groups (to complement the classification of livelihood groups), rather than attempting to capture all the variation that exists within the socio-ecological system. Criteria for selecting these groups include: groups likely to be most vulnerable; groups with the largest number of people; groups whose use of ecosystem services is likely to differ most from those already captured; or groups that have been pre-designated as priorities (e.g. women or indigenous people, who may or may not be the most vulnerable).

Be conscious of the different sub-groups and their relationships with each other when undertaking vulnerability assessments. Participatory exercises should try to ensure an appropriate balance between stakeholder groups. Furthermore, it helps to be conscious of the roles (and the flexibility of these roles) played by different groups, and to ensure that assessment activities take this into account (e.g. women tending fields at a particular time of day). The study team will decide when to bring stakeholder groups together, and when to focus on particular groups or even individuals. Care should be taken that all stakeholder groups understand the process by which information is being collected.

Other technical terms used in this Guidance document are explained in Annex 4.

Part III A step-wise approach to VIA

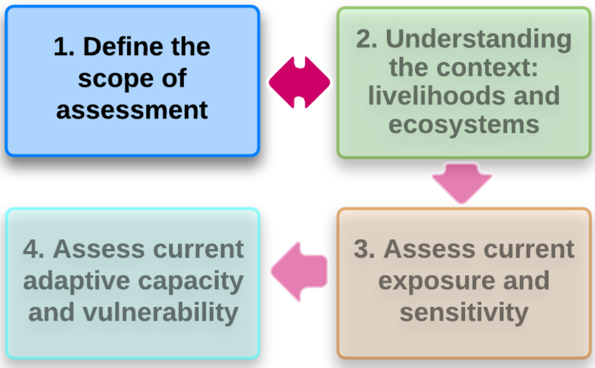
Step 1. Defining the scope of the assessment

Key questions

For which people and over what area will the VIA be conducted?

Over what timeframe will information be gathered?

What is the adaptation vision of the people covered by the VIA?



This step defines the scope of the assessment, in terms of geographical area, timeframe and who/what it is for. These boundaries are required at the beginning of the assessment to determine the scope and focus of the data needed. For example, you may decide to focus only on a particular set of stakeholders, or to concentrate on a particular sector important for local livelihoods. Although the scope is likely to be refined in light of later steps in this Guidance, an initial definition is necessary to ensure the work is appropriately targeted and suited to the information and resources available. The fact that you may not yet know the links between livelihoods and ecosystems, or whose adaptive capacity you will focus on is addressed by revisiting Step 1 after Step 2 is completed in order to determine the final scope of the assessment. Many of the activities described in Step 1 will be covered by established VIA methodologies and tools. This Guidance focuses on highlighting where additional consideration of ecosystems can be made in these activities.

Table 1: Process for Step 1

Activity	Outputs
1.1 Set an initial scope	Clear intended use of VIA information Terms of Reference for the VIA Terms of Reference for VIA team
1.2 Conduct background research	Map of project site Stakeholder map/list of relevant stakeholders Clear timeframe for analysis of past data and projections List of information sources or directory of meta-data List of relevant projects to engage with to access relevant information
1.3 Create/identify an adaptation vision	Clear linkages between VIA scope and adaptation vision
1.4 Determine final scope for VIA	VIA scope description (summarizing the above outputs)

Guidance

1.1 Set an initial scope

First consider what resources are available for the study, and what processes it is meant to inform. This will give an idea of an appropriate timeframe for conducting the study, the number of people involved, and what activities can be done to gather information, as well as the potential for holding workshops, hiring specialists, acquiring data and the depth of analyses.

Building a multi-disciplinary, multi-sectoral VIA team is advised, given the diverse nature of socio-ecological systems. For a team that balances social as well as ecological knowledge, experts such as economists, sociologists, ecologists, human and physical geographers, hydrologists, political scientists and climate change experts should be involved, as well as local 'experts', such as representatives from community-based organizations[12]. However, there are likely to be limitations in capacity and access to numerous kinds of expertise. It may also be expensive to hire the number of individuals needed to cover the desired fields of expertise. Explore alternative means to ensure that environmental, social, economic and political dimensions are covered by the VIA, such as collaborating with local organizations with better access to these kinds of information and expertise. Knowing the capacity of the VIA team enables identification of any extra knowledge or skills that may be required. CARE's Climate Vulnerability Capacity Analysis (CVCA)[13] provides a list of key skills and experience that are useful for a team conducting a VIA. Clarify roles and responsibilities from the start.

Using insight from the VIA team and other contacts, identify potential key groups of stakeholders to participate in the process and discuss with them their interest. Add to this list through conducting stakeholder mapping exercises.

As the context becomes better understood (Step 2) this list can be added to further.

At participatory stakeholder workshops, discuss the intended use of the VIA,

[12] However it is worth bearing in mind that the bigger the 'expert' the more their views may be emphasized at the expense of the knowledge and confidence of the communities involved. Both conventional 'expertise' and local knowledge should be valued and dealt with in similar ways.

[13] CARE (2009) *Climate vulnerability and capacity analysis: Handbook.* Retrieved 13/03/2014 <http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf>

including in relation to ecosystems, their services and management. The intended use of the information eventually generated can be thought of in terms of the following[14]:

- **The process that it will inform:** Is the assessment going to serve a particular project (e.g. an EBA project)? Or a regional or national adaptation programme to prioritize certain areas for EBA projects, or a local/regional/national strategy or policy that will integrate EBA?
- **The information it will provide:** Will the study lead to a better understanding of the way the system works, in terms of its constituent social and ecological components and their interactions? Or will it identify vulnerable 'hotspots' for further detailed analysis, raise awareness of the problems causing vulnerability, inform plans and decisions to reduce vulnerability, and/or compare and prioritize between vulnerable social-ecological systems or locations?

Following this, discuss the target groups or sectors, scale and timeframe of the VIA.

Be pragmatic; the scope cannot be finalized until the context is understood (Step 2). However, there is a need to define some aspects of the assessment scope in order to start the process, i.e. whom to work with, and what information to gather. Other factors influencing scope include:

- **Stakeholders' concerns**
- **Project/donor considerations**
- **Scale of analysis:** When considering socio-ecological systems, the scale may be defined as a geopolitical unit, in order to link to the appropriate management unit for undertaking adaptation action (e.g. village, district, region, or a similar unit), defined by the eventual users of the assessment. Alternatively, it may be defined by the natural boundaries of the ecosystem in question, such as a watershed. However, many assessments will need to combine these units or elements of them. The political unit will most likely be the level at which adaptation planning and statistical analysis are done or at which policies and institutions are established. Ecosystem and political boundaries rarely overlap completely, but they are not mutually exclusive. For example, if the VIA is to focus on a watershed, include all political units that overlap that watershed in the analysis. Similarly, if restricted to a political unit, examine the full extent of the ecosystems important to livelihoods and well-being within that unit; this may highlight the role of transboundary ecosystems and their services.
- **Assessment focus:** This may be defined in terms of the particular communities, stakeholders, sectors and livelihoods whose vulnerability will be assessed. Defining the focus of the VIA helps to further refine the geographical limits of the assessment. For example, there may be a need to consider spatial links between ecosystems that provide services for the livelihoods considered, such as upstream/downstream relations or links between different seasonal feeding grounds of domestic or wild

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[14] 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, Eschborn, March 2013.

animals. A stakeholder map can be a starting point for listing the main social groups and their livelihoods and deciding which of these to focus on for the assessment.

- **Timeframe:** Over what period should past climate trends be analysed and over what future period should vulnerability be assessed? These are often referred to as 'time slices', and may depend on what periods can supply reliable climate data, as well as the length of time needed to provide evidence of climate trends (e.g. 30-40 years). What is the most appropriate timeframe for the VIA to make sure it is suitable for the intended use? Will the assessment feed into an adaptation strategy or a development strategy that covers a certain time horizon (e.g. a mid-term or long-term strategy)? How do the communities involved in the assessment consider time – what is culturally appropriate? In what timeframe can you make reasonably sound assumptions and projections about climatic change and socio-economic development?

Other factors to consider:

- **Information base**: How much data is available and on what? What scale does it relate to? Will you need to retrieve primary information? Is the information suitable for use in vulnerability mapping? How far does the relevant information go back into the past? What projections are available?
- **Scientific integrity**: The scale should be large enough to capture interactions between ecosystems that contribute to the supply of ecosystem services, or, if using primary research, to host enough information points to be statistically significant.
- **Other assessments/projects**: It may make sense to adopt a similar scope to other VIAs undertaken in the area, in order to build upon their information base.
- **Access to information, to the project area, to stakeholders, etc.**

Fictional case study: EBA in the Itayuni-Babarka mountain landscape

Stakeholder groups

Two main groups can be clearly distinguished in this case: the Itayuni community in the uplands and Babarka village in the valley. Because the activities of each group influence, and are influenced by, the ecosystems they both depend on, it makes sense to include them together rather than independently. However, they are distinct and not always coordinated in their management of the environment, and they are affected by and respond to environmental change in different ways. For example, the two groups implement different quotas for wood extraction.

Another key aspect is the interaction between these two societal groups, in terms of their potential to collaborate to ensure a balanced and equitable use of ecological resources, but also the potential for conflicts if there is increased competition for dwindling resources. Adaptation strategies will have to tackle the challenge of how to provide sufficient resources for both groups.

Geographic boundary

The relevant ecosystems to be considered when defining the scope of the vulnerability assessment include not only the productive areas (farmland, pastures) and those that provide direct services (forests, lake and river), but also those that are indirectly involved in the productivity of the system, such as the mountain snow caps and glacier. The latter are important because of: their influence over hydrological flows; the unpredictable effects that they could trigger under changed conditions (glacier lake outburst floods); and their existence value (Itayuni sacred sites on the mountain slopes).

The presence of a city downstream is another element to take into account. The city of Malo-Otu is too far away to be considered as a component of the socio-ecological system. However, in devising the adaptation strategy, it will be necessary to bear in mind potential negative and positive effects on elements external to the system, and their potential to influence aspects of the socio-ecological system. For example, in line with a rights-based approach the strategy will have to ensure that the quantity and quality of freshwater available to downstream users remains acceptable. Without such considerations, an adaptation strategy can be undermined.

1.2 Conduct background research

Data availability is a very important consideration, as it will influence the approach and methods used for the VIA, as well as its scale and detail. The VIA team should also consider whether they will reply on existing secondary data or whether they have the resources to collect primary data.

As a starting point, review national and/or regional climate change adaptation plans/programme/strategies and national communications to the United Nations Framework Convention on Climate Change. These can provide insight into approaches (already undertaken or completed) for conducting VIAs and/or the type and quality of information available.

Collating a directory of available information (including details on dataset scale and ownership) is an important step to ensure that relevant information that has already been gathered and processed is being used, rather than the VIA process wasting valuable resources on undertaking new research.

1.3 Create/identify an adaptation vision

Identify any climate change adaptation vision that the stakeholders had previously developed or contributed to. This helps to refine the VIA scope by enabling the assessment to be targeted at informing adaptation options that have already been identified.

For example, if stakeholders were interested in promoting river restoration or integrated coastal management as part of EBA interventions, the VIA should help to inform where to implement these actions, and confirm that they may help to reduce vulnerability.

Linking the VIA to existing plans or visions needs to be balanced against a possible need to provide information that can help stakeholders to consider adaptation options that they have not thought about before.

Figure 4 below shows an image of a climate change adaptation vision developed for the Sanzara landscape in Uganda. It includes the fear of what might happen if adaptation options are not considered, as well as a vision of what EBA approaches could support.

Extreme care must be taken to avoid the dominance of visions developed by powerful groups, at the expense of the rights and views of marginalized groups within the socio-ecological system.

It is also important to be transparent and open at this stage regarding what can and cannot be accomplished within the assessment and why. This will help to communicate results and avoid unrealistic expectations.

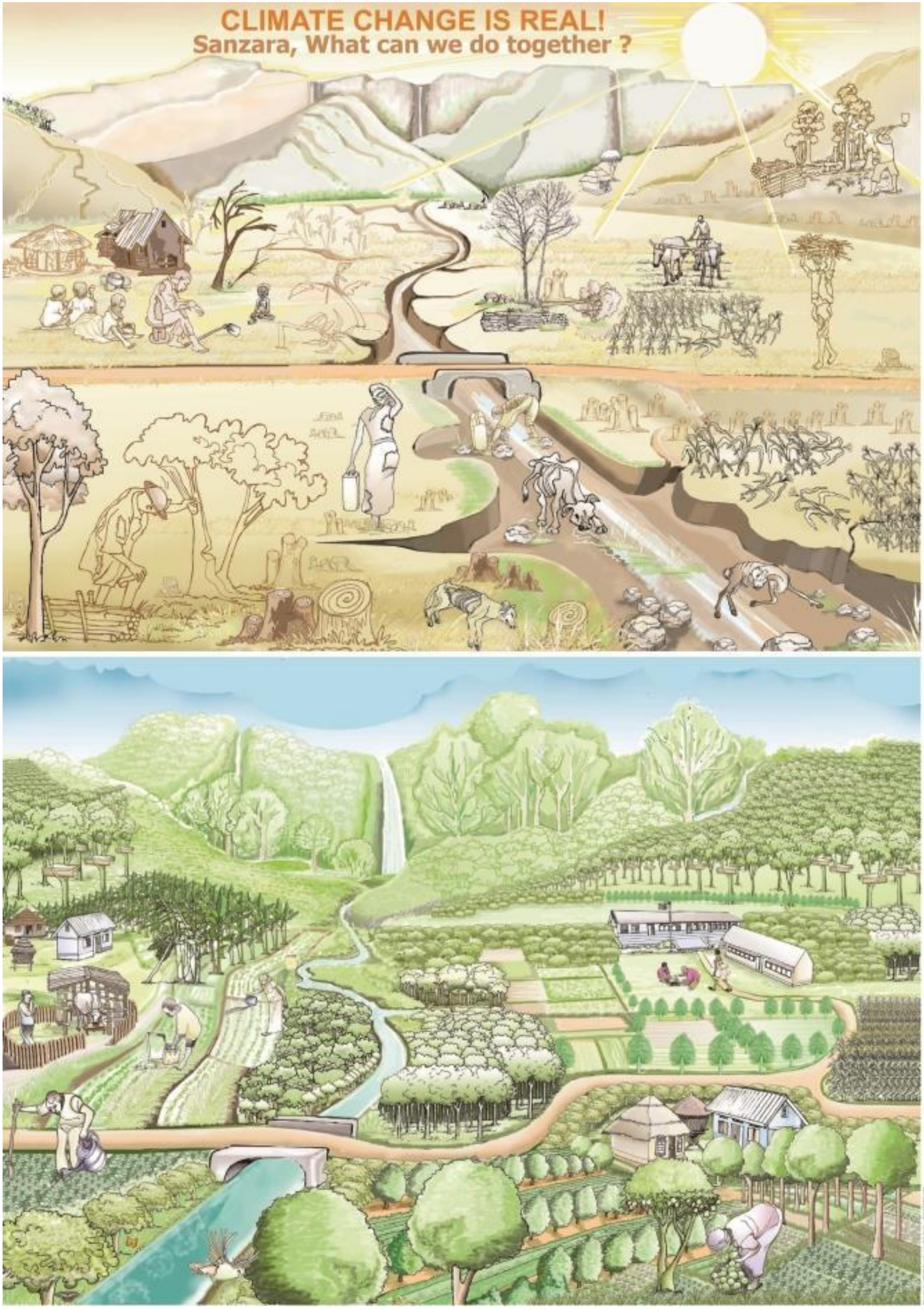
A number of participatory exercises for developing visions that are not resource intensive are available in the UNEP-WCMC *Adaptation and Resilience Planning for Communities and Protected Area Management* manual (in press); please see Annex 1 for further information.

This vision may need to be refined after Step 2 is completed.

Figure 4: An adaptation vision for Sanzara, Uganda

An example from the joint UNEP-UNDP-IUCN project 'Ecosystem-based Adaptation – Adapting to climate change in mountain ecosystems'.

The first picture shows a vision of the landscape negatively impacted by climate change, whilst the second picture shows a vision created by stakeholders of what they would like their landscape to look like.



Fictional case study: EBA in the Itayuni-Babarka mountain landscape

Data availability

The provincial government has census data for Babarka for the past 30 years, but data are almost non-existent for the more rural and remote community of Itayuni. Basic climate data, such as monthly average temperatures and rainfall, are also available for the past 20-30 years, although the record is patchy from the more remote weather stations. Agricultural data are scarce but remotely sensed data (i.e. data derived from satellites) that could be used to assess land use change are available over the past ten years. In view of the livelihood activities of the community, land use is an important component of the analysis. Based on this, a 20 year time slice into the past will be used to build the assessment of socio-economic, climatic and ecological trends in the landscape.

After consultation with the community, the assessment team also decided that 2035 is the right time horizon for analysing future vulnerability and developing a strategy. This reflects the community perspective of the number of years in a generation.

Adaptation vision

The following are the well-being or development aspirations that the communities wish to preserve or improve. Identified through consultation workshops with key stakeholder groups, including women and young people in both the Itayuni and Babarka communities, these reflect a vision for their communities in the future period of 2035. They will help define the scope of the VIA:

- Self-reliance for food production
- Means to avoid hunger during food shortages (such as cash reserves)
- Natural beauty of the landscape
- Ability to visit sacred sites
- Distinct communities living without conflict
- Better education levels
- Employment opportunities for youth
- Livelihood diversification and support for women
- Diversification of revenues through eco-tourism
- Reduced risks from natural hazards

1.4 Finalise the scope of the VIA

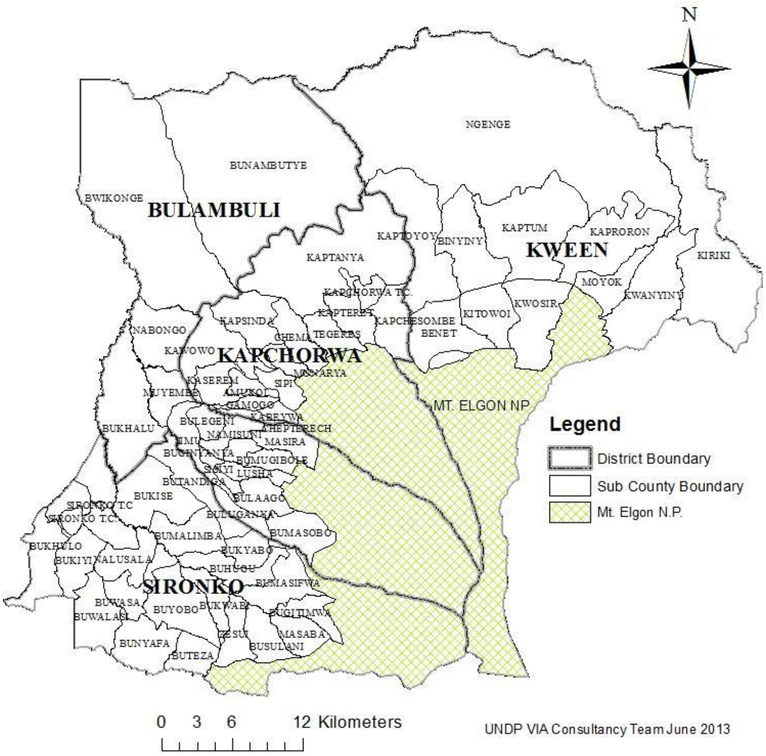
Combined with the outputs of Step 1, the outputs of Step 2 described in the following chapter (which encompass developing a profile of the socio-ecological system) will provide the information needed to finalize the scope of the VIA. Box 2 below provides an example of setting the scope for a VIA in Uganda.

Box 2: Setting the scope of a VIA: Mt Elgon, Uganda

An example from the joint UNEP-UNDP-IUCN project 'Ecosystem-based Adaptation – Adapting to climate change in mountain ecosystems'.

Geographical territory

The Mount Elgon ecosystem spans a wide geographical area and many administrative units. Defining the geographical boundaries of the VIA (to inform EBA implementation) in this case involved delineating and describing the exact geographical and administrative area to which the study would apply. Several components informed this process, including previous studies, which provided an account of the geophysical and socio-economic environment; and stakeholder consultations, which generated consensus on the practicable boundaries and explored the likelihood of significant spill-over effects to and from neighbouring districts. Based on this information, it was then agreed that the VIA would cover the four districts of Kween, Kapchorwa (Sebei) Sironko and Bulambuli (Bugisu) (see administrative map below).



Map: Administrative boundaries in Kween, Kapchorwa, Bulambuli and Sironko districts

Source: Ecosystem Based Adaptation in Mountain Elgon Ecosystem: Vulnerability Impact Assessment for the Mt Elgon Ecosystem, Dec. 2013

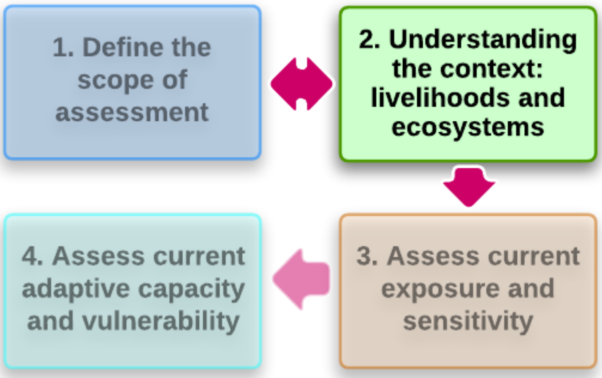
Timeframe

A review of archives, expert opinions and community consultations helped to achieve consensus on the appropriate timeframe of the VIA. The aim was to identify a practical timeframe for analysis of historical events, as well as projected future scenarios in the Mt Elgon ecosystem. The capacity of key informants to recall past historical events was noted to diminish when referring to periods before the 1980s. Most historical analyses were therefore limited to a 30-year period extending from the early 1980s to the present. The projection of future scenarios was based on a similar duration (30 years), as this provided an opportunity to align interventions with national development planning frameworks, especially Uganda's Vision 2040.

Step 2. Understanding the context: livelihoods and ecosystems

Key questions

What are the key livelihood activities in the socio-ecological system?



Who are the key livelihood groups?

How are ecosystem services important for livelihoods?

Which other ecosystem services are important for the well-being of communities and individuals?

The aim of this step is to understand how ecosystems and the services they supply are part of, or support, people's livelihoods and well-being. This will help to develop a profile of the socio-ecological system that the VIA is studying, and it provides both a context and a focus for Steps 3, 4 and 5 (which will assess the current and future vulnerability of the socio-ecological system).

Table 2: Process for Step 2

Activity	Outputs
2.1 Identify, in consultation with stakeholders, the livelihood groups on which the assessment will focus	List of livelihood strategies List of livelihood groups (including approximate numbers in each)
2.2 Identify relevant ecosystem services used by livelihood groups	Lists of the ecosystem services and their relative importance for each livelihood group
2.3 Identify the ecosystems that supply the important ecosystem services	List and maps of the ecosystems that supply these services for each livelihood group For each ecosystem service, a description of its supply status and trends
2.4 Produce a historic profile of the socio-ecological system	Timeline of socio-ecological system noting climatic variability, gradual change/trends and extreme events Based on this information, a revised list of ecosystem services, their relative importance, and the ecosystems that supply them for each livelihood group, along with descriptions of the status and trends in supply.
2.5 Further refine the results of Step 1	VIA scope description

Guidance

2.1 Identify, in consultation with stakeholders, the livelihood groups on which the assessment will focus

This step identifies which groups in the assessment area benefit from which ecosystem services, through an analysis of the roles of the services in supporting livelihoods and well-being. Completing Step 1 will have resulted in a list of the main stakeholders, but this will now need to be further refined to identify the ways that different stakeholders obtain their livelihoods. The assessment and potential EBA interventions may need to be tailored specifically for each of the main livelihood groups. The assessment team will need to produce a list of the main livelihood strategies to identify the livelihood groups. For an example, see those listed in the case study below.

Of course, there will be some households or even individuals that practice a combination of these livelihood strategies, some of which may rely on or affect ecosystem services more than others. For example, a household may be primarily involved in farming but also engage in seasonal construction work and collect wild food from the forest. In most cases, the assessment focus will be on the principal livelihood strategies, rather than supplementary sources. However, it is important to recognize that supplementary livelihood sources can supply vital income or resources during uncertain times. For example the food provided by a forest may be important in periods when farming is difficult.

Depending on the number of participants and assessment sites, this process may be lengthy. There are many ways of classifying livelihood strategies and livelihood groups, but for the purpose of a rapid assessment it may be sufficient to use the classifications in current government surveys and statistics. However, keep in mind that existing classifications may not be optimal for analysing natural resource dependent livelihoods, as these are often part of the informal economy.

If the assessment area is large, it may not be possible to assess every group in every location separately. In this case, consider conducting the assessment for groups of people with similar livelihood strategies living in similar environmental settings (e.g. livestock herders utilizing summer high altitude pastures), and then using these representative results as an indicator of the livelihoods of other similar areas.

For each livelihood group, determine the approximate number of people in the group to inform the assessment of the importance of different ecosystem services in the VIA area. However, also recognize that some livelihoods that are only practiced by a few individuals may be disproportionally impacted by climate change, and so may need to be included in the assessment (see Box 1 on differential vulnerability).

It is also likely that some ecosystem services will be relevant to people's well-being across livelihood groups, e.g. the provision of medicinal plants or the protection of a settlement from flooding. Care should be taken not to overlook these services in the assessment.

Fictional case study: EBA in the Itayuni-Babarka mountain landscape

Livelihood strategies

In identifying important livelihood strategies, the team determines that for an upland Itayuni community in the Itayuni-Babarka mountain landscape, the important strategies are:

- livestock farming
- crop farming (maize and some coffee)
- extractive use of natural resources from the forest (e.g. timber and non-timber forest product harvesting)
- seasonal wage employment
- trade

Of these livelihood strategies, most households are primarily engaged in livestock and crop farming, supplemented by gathering products from the forest for subsistence uses, trade of livestock and handicrafts, and some seasonal wage labour. Several families are heavily involved in trade, to the extent that it forms their main source of livelihood.

Livelihood groups

For the same community, the team thus identifies the following main livelihood groups:

- Livestock farmers, in the upland pastures
- Crop farmers, in the upland terraces
- Traders/merchants

2.2 Identify relevant ecosystem services used by livelihood groups

For each livelihood group, identify the categories of information specified in Table 3. The activities suggested for generating this information are not resource-intensive, but considerable time may be required for interpreting the results.

Table 3: Methods for identifying priority ecosystem services and trends in their supply and use

Information category	Method
1. Ecosystem services that livelihood groups benefit from	Use the list of ecosystem services in Annex 2 as a starting point to identify potentially relevant ecosystem services for each livelihood group.
2. Importance of these ecosystem services	Categorize each ecosystem service as essential, important, slightly important or unimportant. Discard unimportant ecosystem services.
3. Trends in ecosystem service supply and use	For each ecosystem service, seek evidence of trends in their supply and use, and the reasons for any change.

2.2.1 Ecosystem services that livelihood groups benefit from

The list of ecosystem services provided in Annex 2 is a starting point to identify and list important ecosystem services for each livelihood group. Other classifications and categorizations of ecosystem services may also be used, especially to incorporate local and indigenous interpretations.

Undertake appropriate consideration of regulating ecosystem services, in part by discussing what assets and infrastructure are important to livelihoods and well-being. Ecosystems can play a vital role in regulating the levels of hazards such as floods, mudslides and wind, and therefore changes to ecosystems can have impacts on assets/infrastructure such as crops, bridges, roads, houses, sewerage systems, community buildings, and electricity transmission. On slopes, the rates of absorption and discharge of rainwater can be significantly altered by the type of vegetation and soil cover. Where wetlands are present in valley bottoms and lowlands, the rates of water infiltration and discharge, and therefore regulation of flooding and water storage for times of drought, can also be greatly influenced by the vegetation structure of the wetlands.

Identify all assets/infrastructure (or as much as resources allow) that have in the past been affected by climatic hazards, or are potentially at increased risk from these hazards. Record the frequency of past hazards. Developing a historical timeline (Step 2.4) may support this process. This could also be conducted through a participatory hazard mapping exercise (see Annex 1). The role of ecosystems in regulating these hazards can then be discussed and identified.

Alternatively, if participants are struggling with the concept of ecosystem services, conduct a resource mapping exercise[15] to construct an overview of the natural resources available. Construct a map illustrating the main natural and physical resources of the site. Discuss how participants use the resources mapped (links to ecosystem services can be made by the facilitator) and how they benefit from them, including in relation to identified livelihood strategies. This map can also incorporate important assets/infrastructure as described above to help visualize how regulating ecosystem services can regulate impacts on assets/infrastructure.

For each livelihood group, it is necessary to identify how each ecosystem service supports different aspects of their livelihoods and well-being. For example, certain ecosystem services may play a vital role in supporting a group's main livelihood strategy (such as water supply for agriculture), while other ecosystem services may be used most during times of agricultural stress (such as fish from the river for food), or for recreational or spiritual reasons (such as a sacred forest). These only need to be a general description at this stage.

2.2.2 Importance of the identified ecosystem services

For each livelihood group, categorise the perceived importance of the identified ecosystem services as essential, important, or slightly important (e.g. perhaps only occasionally important). The reason for the rating of importance should be given in just a few words, such as 'required for house building'. Assess the importance of the ecosystem service in terms of its current usage and supply (availability) to the group (see Step 2.2.3 'Trends in ecosystem service supply and use' below). The facilitator

[15] For more information on resource mapping, see: ENDA/SEI Adaptation Toolkit in Annex 1.

should also keep a note of those ecosystem services not classified as essential, important or slightly important. These could be useful to return to if considering the possibility of alternative livelihood strategies when designing/planning EBA measures (see 'Next Steps' section). For example, the participants may only consider some services as 'not important' because they have not considered using them in an alternative way.

Focus group discussions or household questionnaires may be used to elicit information on the importance of ecosystem services to different livelihood groups. Consider other factors in this process, such as the relative wealth or gender of the different groups or households involved in the study, as this may affect how important certain ecosystem services are to them and how they perceive their supply. Different stakeholders will have different perspectives on the value of specific ecosystem services, and thus an appropriate balance may need to be struck when prioritizing the importance of ecosystem services. This information will be important in understanding and taking account of differential vulnerability in the VIA process, e.g. when determining current vulnerability (Step 4.2).

To identify the differences between ecosystem services deemed important by stakeholders, the following activities may prove useful. The selection of the study area with the participation of the stakeholders, and the ensuing time spent in the community, should have already provided preliminary insight into key vulnerability aspects for different groups. Now, based on continued dialogue and working with rudimentary hypotheses, a more systematic process such as 'participatory rural appraisal' can help to further develop understanding of which ecosystem services are important to each group. Consider conducting these exercises with each selected stakeholder group in turn, to ensure that the perceptions of these groups are included.

Narrative-based activities such as storylines help to elucidate why particular ecosystem services are important to particular groups, and to provide information on trends in ecosystem service supply and demand (Step 2.2.3). This can also highlight the drivers which affect changes to these services, whether they are environmental or social in origin (e.g. changing land rights, access to ecosystems, or increased crop damage from wild animals), and this information will be useful for the development of scenarios for Step 5.1. As familiarity with the study area increases, inquiries can focus on which environmental and non-environmental stresses (and potentially interactions between stresses) pose a risk of harm to particular stakeholders and the ecosystem services on which they depend. This can also inform the development of a profile of the socio-ecological system (Step 2).

2.2.3 Trends in ecosystem service supply and use

For each ecosystem service, seek evidence of trends in their supply and use, and the reasons for any change. At this stage of the assessment, it is sufficient to simply categorize trends as rapidly or slowly increasing or decreasing, or as stable. Record the time period on which this categorization is based, such as "over the last 5 years".

Also document the reason/s behind any trends in ecosystem service supply. These should identify any changes in the functioning of the ecosystem, and any changes in the access of the group to the ecosystem service or in how the ecosystem service is used. The information on ecosystem functioning and access to ecosystem services will also inform the assessment of people's current and future adaptive capacity in Steps 3 and 4.

The facilitator and working groups can draw upon scientific information in order to compare local perceptions of change with observed trends, especially as participants may not be aware of trends across the entire study area. The VIA team may need to introduce scientific information to the community for discussion.

2.3 Identify the ecosystems that supply important ecosystem services

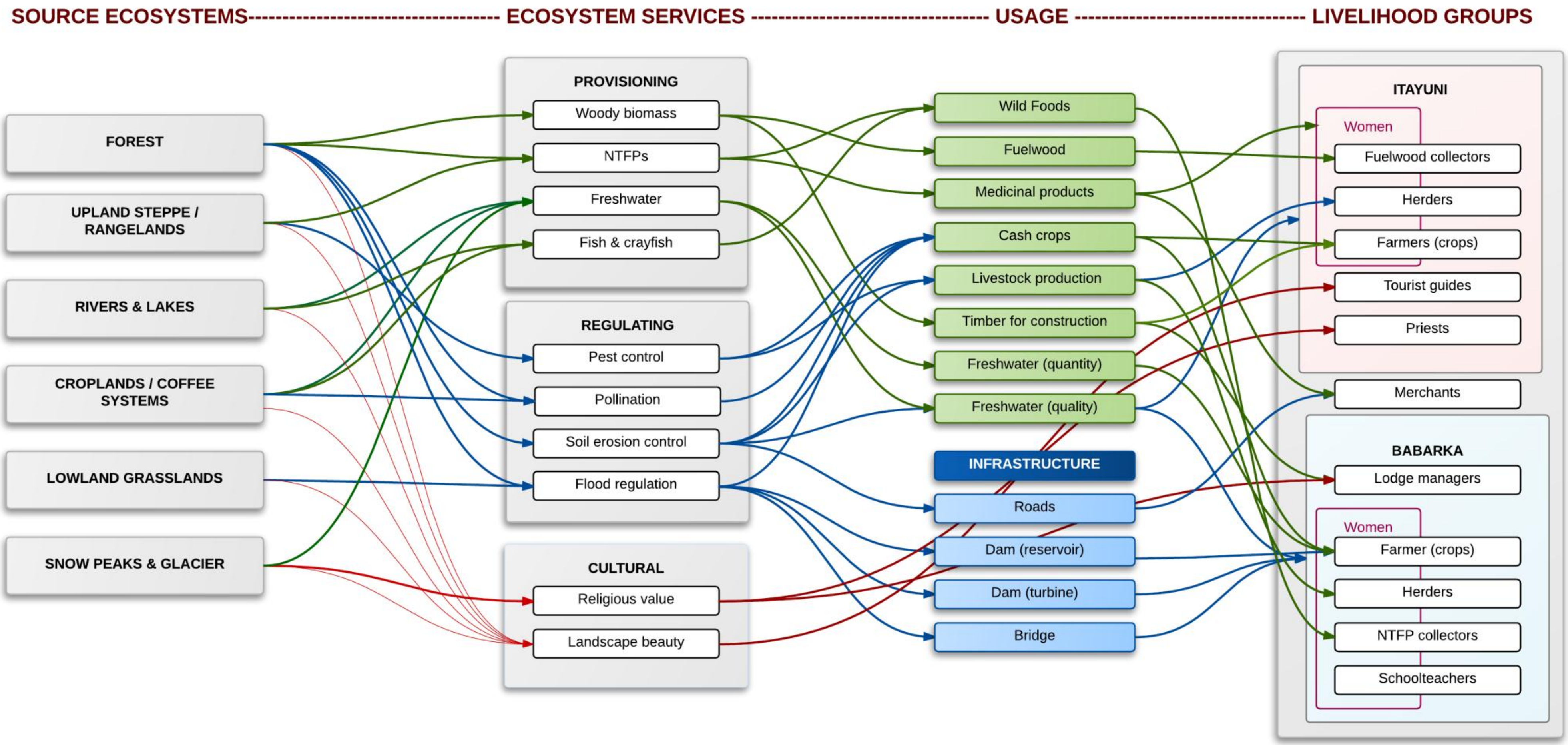
Since climate change affects the supply of ecosystem services through its impacts on ecosystems, the assessment needs to identify the ecosystems that supply each important ecosystem service (i.e. those classified as essential, important, or slightly important). The description of ecosystem types may use existing land use or cover categories. Specify not only the ecosystem type, such as forest or farmland, but also the name of the locality or area where the ecosystem services come from.

The main aim is to understand the relations between each ecosystem type and locality and the supply of ecosystem services. The identification of ecosystems should be iterative as participants may not immediately recognise the full range of ecosystems (and therefore ecosystem services) relevant to the services that they have classified as important. For example, in relation to honey production, they may not immediately recognise the importance of ecosystems located away from the hives, such as high altitude meadows, which may be key for honey bees foraging.

Using a more graphical representation in the form of a flowchart (see Figure 5 for an example), building on the ecosystem services identified in the previous step and linking them to particular livelihood groups, their usage and the 'source' ecosystem, can help gather the information during a focus group/expert interview. Due to the time required to gather the information, and produce such a figure, prioritize those ecosystems classified as essential and important, and leave out those deemed slightly important.

Once the sources of the ecosystem services (the ecosystem/s) have been identified, record information (e.g. in a manner similar to that in the case study below) on: the ecosystems and their localities; the ecosystem services provided by each ecosystem; trends in the supply of these ecosystem services; and which livelihood groups use the ecosystem services, and how. Hand-drawn maps, made with the community, can demonstrate the spatial connections between the services and the livelihood beneficiaries, as well as demonstrating the amount of knowledge generated by the stakeholders thus far in the process.

Figure 5: Example flow chart showing 'source ecosystem', 'ecosystem services', 'usage', and 'livelihood groups' in the Itayuni-Babarka landscape (Fictional case study)



Fictional case study: EBA in the Itayuni-Babarka Mountain Landscape

Locality: Village of Babarka

Livelihood group: Maize and coffee farmers

Number in livelihood group: 300

Table 4: Example summary for a single livelihood group of the importance, sources and trends of ecosystem services (ES) (Fictional case study)

ES (and ES type)	Importance of these ES to them and why (usage)	Sources of the ES	Trends of the ES per household and reasons given
Maize and beans food crops PROVISIONING	**Essential,** for food	Farmland in the Babarka Valley	Declining production last 10 years - low soil fertility, increasing pests, storms.
Coffee beans PROVISIONING	**Essential,** primary income	Farmland in the Babarka Valley and on low slopes	Declining production last 5 years – no fertilizers, drought.
Cattle, chickens PROVISIONING	**Essential,** for food and sale in times of need	Pasture in the Babarka grasslands and Itayuni rangelands	Declining cattle numbers over past 5 years (richer farmers more likely to have cattle) – drought. Increasing no. of chickens and other poultry – less affected by drought.
Regulation of water flows REGULATING	**Essential**, for drinking, cleaning	White River, Blue Lake, Peak Glacier, White River I dam, and springs and stream in the Jade forest	Stable quantity, but declining quality (see below) – not reliant on rainfall only for water supply.
Erosion control REGULATING	**Important**, to maintain water supply and quality, farmland, and hydropower supply	Jade Forest, farmland, cropland vegetation	Declining, with increased sediment in streams last 10 years – increased storms, less forest.
Pollination REGULATING	**Essential,** for coffee production	Jade Forest on lower slopes and Babarka valley farmland, insects	Evidence of decreased pollinator populations last 3 years – reason uncertain.
Timber PROVISIONING	**Important,** for building materials, supplementary income	Jade Forest, especially around Blue Lake and White River I dam	Declining over the past 5 years – less supply from forests but also less demand as people in Babarka switch to other materials.
Fuelwood PROVISIONING	**Important for fuel supply**	Jade Forest, especially close to Itayuni settlements and Babarka town	Same as timber, declining in last 5 years – demand decreasing as some richer households switch to alternative fuel sources. Poorer households more likely to use fuelwood.

2.4 Produce a historic profile of the socio-ecological system

Developing historic profiles or timelines with the stakeholders identified in Steps 1 and 2.1 is a useful step for generating the following information and insights:

- **The occurrence of past climate hazards, and their interaction with ecosystem services (which may be beneficial or negative)**
  - Supports gathering exposure information for Step 3.1.3 (e.g. local indicators of observed changes in climate: agro-ecological zones moving, loss of species, changes in phenology);
  - Supports gathering ecosystem resilience information (for Step 3.2) (related to its current state);
  - Provides information on non-climatic disturbances (addressing these may reduce the sensitivity of the socio-ecological system – Step 3.2.1);
  - Provides insight into vulnerable infrastructure and its relationships with regulating ecosystem services (Step 2.2).
- **Which climate hazards and/or climatic parameters to focus on in assessing vulnerability**
  - Informs Step 3, including the selection of climatic parameters important to ecosystem services and therefore livelihoods and well-being (Step 3.1)
- **Past coping (see below) and adaptation efforts – what worked and what didn't, what was problematic, different coping strategies of different groups (e.g. women and men) – and linkages to ecosystem services**
  - Provides additional information on the importance of certain ecosystem services to different livelihood groups, and informs consideration of adaptive capacity in Steps 3 and 4.
- **Major political and socio-economic events**
  - Highlights important trends and their drivers, which may relate to the supply and use of ecosystem services;
  - Informs consideration of adaptive capacity in Steps 3 and 4.
- **Perception of risk amongst stakeholders – including the extent of risk analysis, planning and investment for the future that has taken place in the socio-ecological system**
  - Helps to determine sensitivity and adaptive capacity (for Step 3.2.1-3.2.2 and Step 4).
- **Indications of stakeholder aspirations**
  - Informs Step 1.3, the identification or creation of an adaptation vision.

N.B. Coping is different to adaptation, but can inform adaptation strategies. Coping is short-term, oriented towards survival, not continuous, motivated by crisis, and reactive. Adaptation is longer-term, continuous, combines old and new strategies and knowledge, and uses resources efficiently and sustainably. *CARE (2009)* Climate vulnerability and capacity analysis: Handbook. *Retrieved 13/03/2014* <http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf>

This process can also enhance knowledge sharing by helping young people to learn from the past.

Depending on the scale of the socio-ecological system being assessed (initially defined in Step 1, informed by Step 2), more than one profile may need to be produced for each geopolitical unit or subsystem. Assessors can then combine and compare these to build a profile for a larger socio-ecological system. Alternatively, they can create a profile with representatives of stakeholders that have an overview of the larger socio-ecological system.

Several tools are available to support the development of historical timelines. For assessments at the local level (e.g. community scale), we recommend approaches outlined in CARE's Climate Vulnerability and Capacity Assessment Tool (see Annex 1). For larger-scale assessments, other approaches may be needed (the PROVIA Guidance lists methods for larger-scale assessments; see Annex 1).

In using these tools pay particular attention to information relevant to ecosystem services, including when asking the following or similar questions during any facilitated discussions, noting any changes in ecosystem service supply and use, and any coping and/or adaptation strategies related to ecosystem services:

- Are there any trends or changes in frequency of these events over time?
- What was done to cope with these events?
- What worked to cope with the events?
- What didn't work to cope with the events?
- Did different groups cope with the events in different ways? Why?
- Were there any efforts that actually increased the negative impact?
- Have the coping efforts changed based on the changing frequency and intensity of events?
- If trends have been noted, what have been the adaptation strategies?
- What events do you expect will occur in the future? When?
- Does this perception of future events affect your plans for the future?

Using the historical timeline (see Tables 5 and 6 for examples) and the record of discussion, revisit Step 2.2 and re-categorize as necessary the importance of ecosystem services based on any new information on:

- Trends in ecosystem service supply
- Vulnerable infrastructure
- Ecosystem services used in coping strategies
- Ecosystem services used in past adaptation
- Ecosystems that supplied these services

2.5 Further refine the results of Step 1 for the VIA scope

Revisit the results of Step 1 to refine the definition of the VIA scope with the outputs of Step 2. For example, discussions may have shown that a particular ecosystem upstream from the originally envisaged study area provides essential ecosystem services for livelihood groups, necessitating an extension of the geographical scope of the VIA.

Fictional case study: EBA in the Itayuni-Babarka Mountain Landscape

Table 5: Example historical timeline – Itayuni community responses (Fictional case study)

Historical timeline – Itayuni community responses	
Year	**Event**
2008 – dry season	Prolonged drought caused fires; new volunteer fire brigade suggested but lack of time and resources.
2008 – wet season	Extreme rainfall – terraces collapsed. Attempted to rebuild but fewer men around for labour and old knowledge is being lost.
2009	Hail storms.
2009	More merchants start travelling to larger market in Malo-Otu. Women traders note that trading is more difficult now than before, due to longer distances, child care, and safety concerns.
2010	Intense rainfall – landslide blocked road between Babarka and another village. Villagers and government helped to clear and restore road. Some villagers blame poor maintenance of terraces and loss of nearby forest for making landslide worse.
2011	Storm stopped the pilgrimage to the summit of Itayuni.
2012	New school opened; not all children can afford to attend.
2012	Frost in highlands during growing season; lower crop yield and less pasture for grazing.

Table 6: Example historical timeline – Babarka community responses (Fictional case study)

Historical timeline – Babarka community responses	
Year	**Event**
2008-2012	Rainfall later in year and erratic, causing loss of some crops.
2009	Hail storms destroyed crops and killed animals.
2010	Heavy rain, with flooding in Babarka – houses collapsed and many rebuilt with forest timber. No help from government. Some landslides in hills but impact small.
2010	School notices about classes shrinking as more youth working seasonally in city.
2011	Crops destroyed by Itayuni herds and insects; farmers' group made complaint to mayor.

Focus group discussions with the Itayuni community and with residents of Babarka highlight that the different communities are experiencing some climate events or trends in different ways, and have been responding differently. For example, both communities note the extreme rainfall of 2010. In the uplands, the primary impact identified was landslides, including one that blocked the road, a key link to the valley below, while in Babarka, the main impact identified was flooding and subsequent damage to houses.

Both communities responded to the impacts of the event directly, working to restore infrastructure, although the government did help in the case of clearing the road. Many houses in Babarka were rebuilt using timber from the forest, the case for both richer and poorer households, as timber is easily accessible and free. The regulating and provisioning ecosystem services of the forest play a role in both mitigating against flood damage and landslides, as well as in supporting coping strategies (e.g. timber for rebuilding).

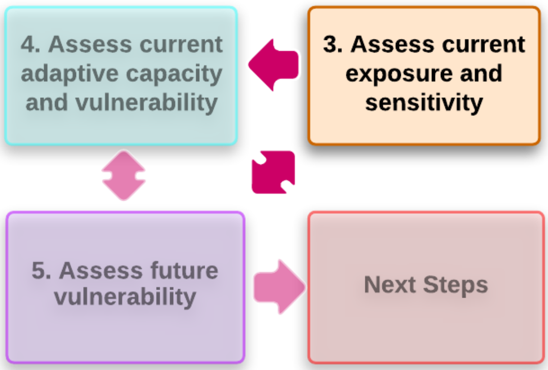
In both communities, people fear that there will be more flooding and landslides in the future. Different access to resources and coping strategies were also noted between women and men, and richer and poorer groups; for example, women tend to have more responsibility for child care, limiting some of the strategies open to them.

Step 3. Assess current exposure and sensitivity

Key questions

Which climatic parameters are the most significant for the supply of important ecosystem services?

What is the potential impact of observed variability and trends in climatic parameters on the supply of ecosystem services and therefore on people's livelihoods and well-being?



The previous step identified important ecosystem services for livelihood groups, the current trends in their supply, and their source ecosystems. The aim of the next two Steps is to determine the current vulnerability of people to changes in ecosystem service supply as a consequence of observed climatic variability and trends. The present step identifies the potential climate impacts on people by assessing their exposure and sensitivity to climate-induced changes in important ecosystem services.

Process

The purpose of the following steps is to determine classifications (high, medium, low) for the first two components of vulnerability, exposure and sensitivity, which together constitute potential impact.

The process outlined here predominantly follows a qualitative approach, comparing exposure and sensitivity across different livelihood groups and across different parts of the study area. Where appropriate information is available a quantitative indicator or modelling approach to assess each key factor may give a more scientifically rigorous (but resource intensive) classification. Such classifications are useful for mapping vulnerability (Box 3 below provides an example of vulnerability mapping based on an indicator approach from Nepal).

Table 7: Process for Step 3

Activity	Outputs
3.1 Identify climatic parameters important for ecosystem services	Description of characteristics of ecosystem structure, key ecological interactions and species composition that are important for the supply of ecosystem service Table of information on climatic parameters
3.2 Assess the potential impacts on livelihood groups of observed variability and trends in climatic parameters through changes in important ecosystem services	Factors of resilience agreed and noted Table of ecosystem characteristics, their relation to the supply of ecosystem services and resilience to climatic factors Record of discussion with participants on ecosystem resilience Table of resilience scores/values/ categorization and justification Table of categories of exposure, resilience and vulnerability (exposure and ecosystem resilience combined) of ecosystem characteristics to summarize current climatic vulnerability of ecosystem service supply Table of categories of potential impact on livelihood groups of observed variability and trends in climatic parameters and resulting changes in ecosystem services supply

Box 3: Mapping vulnerability in a mountain socio-ecological system in Nepal

Nepal is one of the three pilot countries for the joint project 'Ecosystem-based Adaptation – Adapting to climate change in mountain ecosystems'. The Mountain EBA team in Nepal conducted a VIA for the Panchase ecosystem area in 2013. Covering a complex socio-ecological system of mountains, farmlands, protected forest, water bodies and towns and villages, the Panchase study offers an opportunity to better understand the potential impacts of climate change and drivers of vulnerability in Nepal's mid-hills region.

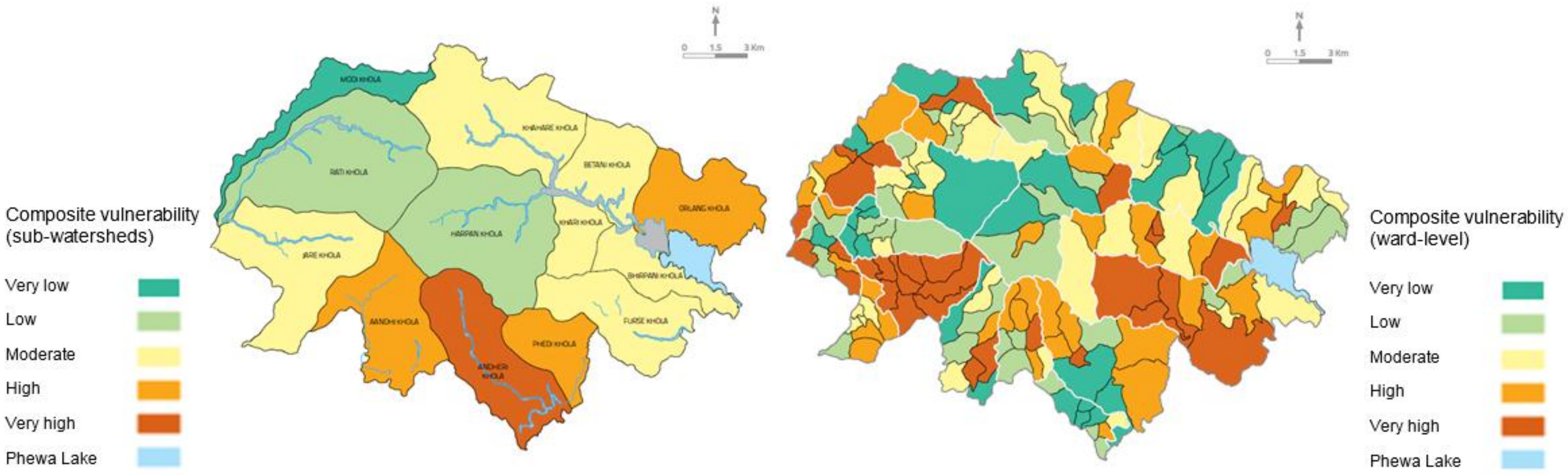
The VIA team, led by the Institute for Social and Environmental Transition (ISET-Nepal), chose an indicator-based approach to determine vulnerability across the Village Development Committee areas, watersheds and sub-watersheds of Panchase. After conducting field research and dialogues with communities in the area, each geographical sub-unit was assigned values against 32 indicators related to exposure, sensitivity and adaptive capacity to determine current and future vulnerability to climate change. Some examples of the indicators are as follows:

Exposure: flood affected households, forest fire affected area

Sensitivity: population density, households reliant on ecosystem for livelihoods

Adaptive capacity: access to finance, traditional networks, road density

The results were then mapped to indicate which areas were the most and least vulnerable overall, while additional maps were prepared to show specific indicators of vulnerability, such as landslide risk. The map below, for example, shows the current composite vulnerability of Panchase's sub-watersheds (left) and ward-level vulnerability to climate-related disasters (right).



Source: Dixit, A. (2014) Climate change vulnerabilities and ecosystem-based adaptation: Atlas of Panchase Mountain Ecological Region, Nepal. ISET-Nepal: Kathmandu, Nepal.

Guidance

3.1 Identify climatic parameters important for ecosystem services

The supply of each ecosystem service is determined by ecosystem functioning (see Step 2). This step involves identifying the characteristics of ecosystem functioning that are relevant for specific ecosystem services, and then identifying the climatic parameters that influence this functioning. Information on these climatic parameters is obtained using the results of Step 2.4 (historic profile of the socio-ecological system), supplemented with data from other sources.

For some ecosystems, climatic parameters that are significant for the supply of services are well known. For example, this is particularly true of agricultural systems. If the climatic parameters are already well known, then Steps 3.1.1-3.1.2 can be skipped and the team may proceed directly to Step 3.1.3.

3.1.1 Identify key characteristics of ecosystem functioning for ecosystem service supply

Despite the complexity of ecosystems, it is normally relatively straightforward to understand and assess their functioning for VIA purposes. The ways in which an ecosystem functions to supply a particular ecosystem service can often be quickly and fruitfully described in terms of ecosystem structure, key ecological interactions, and key species composition. The following analytical steps can be used to identify the most relevant characteristics of an ecosystem with regard to its capacity to provide the desired service(s). In practice, the level of detail at which each step is undertaken will be determined by the resources and data available to the VIA team. Often, informed judgement may be sufficient as the basis for a rough initial assessment.

The analytical steps are:

- Using the information from Step 2.3 on source ecosystems, briefly describe the current vegetation structure and soil structure of the ecosystem that supplies the ecosystem service. In some cases the structure of the food web may also be significant. Annex 3 provides more detail on the key elements in determining ecosystem functioning.
- Identify any key ecological interactions that are important for ecosystem structure and the supply of the ecosystem service. Some types of ecological interactions between individual organisms are of mutual benefit, such as pollination and seed dispersal by insects and vertebrates, or symbioses between trees and *mycorrhyzal* fungi which help the trees in extracting minerals from the ground. Other ecological interactions such as predation, herbivory, and parasitism are harmful to some species, but may have important consequences at the ecosystem level. For instance, large-bodied predators and herbivores have many effects on the structure and composition of food webs and vegetation. The actions of humans, particularly in the case of resource use, also constitute an important ecological interaction. Their behaviour is a fundamental driver of the flows of ecosystem services (see Box 4 below for examples).
- Where applicable, identify the key species necessary for the supply of the ecosystem service (i.e. the composition of the ecosystem in terms of key species). Note that some ecosystem services such as the provision of medicinal plants are closely linked to the presence of specific species, while others such as fodder production for grazing

animals may be less dependent on species composition, and it may not be possible to name specific species whose presence is crucial for service supply.

Fictional case study: EBA in the Itayuni-Babarka Mountain Landscape

Example descriptions of the characteristics of ecosystem structure, key ecological interactions and species composition to supply important ecosystem services from the forest adjacent to a Babarka farming settlement.

Table 8: Example descriptions of the characteristics of ecosystem structure, key ecological interactions and species composition to supply important ecosystem services from the forest adjacent to a Babarka farming settlement (Fictional case study)

Provisioning ecosystem services

Vegetation layers structure	Soil structure	Food web structure	Key ecological interactions and species composition
Timber – from wild trees in the forest			
Essential characteristics			
Tree species composition simplified so that timber species predominate.	Sub-soil penetrated by tree roots for water infiltration and mineral cycling.	Plants as described in vegetation layers structure. Populations of herbivorous insects regulated by insectivorous birds and mammals.	Tree species harvested for timber. Insectivorous birds regulate populations of herbivorous insects.
Desirable characteristics			
Some mature and decaying trees remain as seed sources and as habitat for insectivorous and pollinating birds and bats; shrub layer thin; herb layer covering soil and abundance of dead plant matter for soil formation.	Deep organic soil layer.	Abundant decomposers in the soil. Presence of vertebrate predators that regulate populations of tree seed predators and crop herbivores.	Soil decomposers. Pollinating insects required by timber tree species.
Fuelwood			
Essential characteristics			
Tree species composition simplified for preferred fuelwood species, otherwise as for timber ES.	Sub-soil penetrated by tree roots for water infiltration and mineral cycling.	Plants as described in vegetation layers structure. Populations of herbivorous insects regulated by insectivorous birds and mammals.	Tree species used as fuelwood. Insectivorous birds to regulate populations of herbivorous insects.
Desirable characteristics			
Some mature and decaying trees remain as seed sources and as habitat for insectivorous and pollinating birds and bats; herb layer covering soil and abundance of dead plant matter for soil formation.	Deep organic soil layer.	Abundant decomposers in the soil. Presence of vertebrate predators that regulate populations of tree seed predators and crop herbivores.	Soil decomposers. Pollinating insects required by fuelwood species.
Freshwater			
Essential characteristics			
Herb layer covering soil to reduce erosion.	Sub-soil penetrated by tree roots for water infiltration and mineral cycling.	Plants as described in vegetation layers structure.	
Desirable characteristics			
Mature trees with deep roots to assist water infiltration.	Deep organic soil layer.	Abundant decomposers in the soil to maintain a porous organic layer.	Trees and herbs that provide soil cover and deep roots.

3.1.2 Identify the climatic parameters that influence ecosystem functioning

The results of Step 3.1.1 will have identified the characteristics of ecosystem functioning that supplies the ecosystem service. For each ecosystem service, supply will be influenced by the effect of the climate on the ecosystem structure, ecological interactions and species composition. Identify the climatic parameters that are likely to be critical in determining the supply of the ecosystem services. These could include:

- Daily maximum temperature
- Daily minimum temperature
- Extent and frequency of high or low temperature extremes
- Occurrence and seasonal distribution of frost
- Daily, weekly or monthly precipitation totals
- Daily, weekly or monthly maximum precipitation
- Daily, weekly or monthly minimum precipitation
- Length of dry spells / rainy season
- No. of days precipitation (< *x* mm)

Remember that there are a number of changes in the climate system that ecosystems will be exposed to. It is important to consider the changing frequency and intensity of events and variability (e.g. the difference between the minimum and maximum daily rainfall amounts throughout the year), as well as trends.

Box 4 provides an example of determining the desired ecosystem functioning for the supply of ecosystem services and the climatic parameters that influence ecosystem functioning.

Box 4: Determining characteristics of ecosystem structure and processes for the supply of important ecosystem services - example from the Mountain EBA Project in Peru

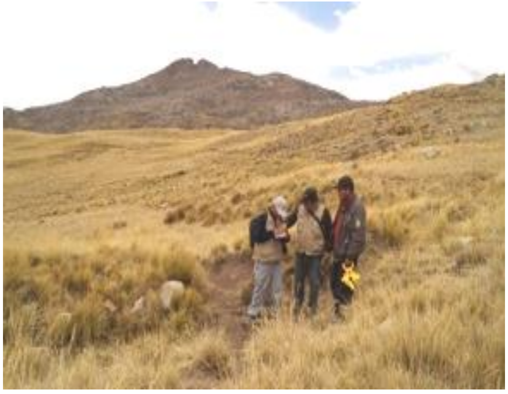


Photo: Participatory Rural Diagnosis (Source: The Mountain Institute)

Peru is one of the three pilot countries for the joint project 'Ecosystem-based Adaptation – Adapting to climate change in mountain ecosystems'. The Peru Mountain EBA project is working with the community of Canchayllo in the Landscape Reserve Nor Yauyos Cochas, in the Lima Region.

In 2013, The Mountain Institute conducted a participatory rural diagnosis with the community of Canchayllo to discuss natural resources and development challenges in the context of climate change. This process identified that the principal ecosystem services for the livelihoods of the people in the area are those supporting the production of livestock in the high altitude natural pastures, including production of forage and supply of drinking water.

As well as cattle and sheep, the pastures support wild populations of vicuña, which can be managed for their high value wool. The Mountain EBA Project and community of Canchallyo are planning EBA activities to improve the management of livestock grazing, pasture condition and the channelled flow of water for livestock to drink.

A project workshop in 2013 produced a broad description of the desired ecosystem structure and key ecological interactions and species composition for the supply of pasture and water, as part of identifying project impact indicators. It was found that the descriptions were very similar for both the supply of pasture and water. Table 9 below shows the initial descriptions of the ecosystem structure for these ecosystem services.

Table 9: Desired ecosystem structure for the ecosystem services of 'supply of forage (natural pastures)' and 'supply of water' from the high-altitude pastures of Canchayllo, Peru

Ecosystem structure		
Vegetation structure	Soil structure	Food web
Dense coverage of natural grasses. Homogeneous vertical structure of low height natural grasses.	Adequate level of organic material and microorganisms. Arable layer of at least 10 cm.	Abundant availability of grass for domestic and wild animals. Quantity of herbivorous animals in accordance with the carrying capacity. High population and diversity of decomposers (e.g. worms and beetles) in the soil.

These descriptions enabled identification of the **ecological interactions** for the supply of the following ecosystem services:

- **Herbivory** by the domestic cattle and sheep and the wild vicuñas of the natural grassland, as this strongly influences the species diversity of the pasture, the vegetation cover of the soil, the compaction of the soil, and the availability of animal dung for the biological soil community.
- **Decomposition of animal dung and dead grass matter** provides nutrients for growth of the pasture for the livestock, and increases the soil organic matter and structure and so improves the soil properties for infiltration and retention of water.
- The **key species composition** is the presence of grass species for livestock, the domestic and wild livestock, and the populations of decomposers.

Climatic parameters that are likely to be important in influencing the functioning of the ecosystem to supply these ecosystem services were then identified.

Table 10: Climatic parameters important in ecosystem functioning in high-altitude pastures of Canchayllo, Peru

How climate affects ecosystem structure and grazing ecological interaction	Climatic parameter	Information required on climatic parameter – change in:
Soil moisture determines pasture growth	Average temperature increasing (say something about precipitation as well?)	Soil moisture levels (not a climatic parameter)
Extreme low temperatures cause high mortality in livestock	Low temperature periods (prolonged frosts)	Number of days with maximum temperature below zero degrees Centigrade
Livestock and pasture are harmed by extremely high rainfall or prolonged dry periods Extended dry periods can result in bare ground and compaction, reducing the infiltration of rainwater into the soil The rate of runoff will be increased by high rainfall events	Irregular precipitation (extreme events) Increased variation in the timing of the seasons	Number of continuous days with rainfall Number of continuous days with no rainfall Quantity of maximum daily rainfall Soil moisture levels Sediment content in streams and rivers (not a climatic parameter)

This exercise can typically (dependent on the number of priority ecosystem services, participants and facilitators) be completed over the course of a 2 day workshop per community if priority ecosystem services and source ecosystems have been identified.

3.1.3 Gather information on climatic parameters to assess the exposure of ecosystems

Information on climatic parameters should be obtained (note sources mentioned in Step 2.4) from sources such as meteorological stations or government agencies to identify observed variability and trends in these parameters. Guidance on how to gather such information is covered by established VIA methodologies and tools, e.g. some free sources of macro-level information are listed in Annex 1.

Categorize the exposure of ecosystems across the study area to variation and/or trends in the climatic parameters as low, medium or high, based on the information gathered on the character, magnitude, and rate of climate variation to date. For example, exposure to dry, hot conditions may be high if the data shows increasing numbers of hot days, reduced rainfall and an increased risk of drought.

3.2 Assess the potential impacts on livelihood groups of observed variability and trends in climatic parameters through changes in important ecosystem services

3.2.1 Identify the factors determining the resilience of the supply of important ecosystem services to observed variability and trends in climatic parameters

How strongly ecosystem functioning will be affected by variability and trends in specific climatic parameters depends not only on exposure, but also on the ecosystem's resilience to changes in this parameter[16]. The resilience of an ecosystem to a specific type of changes can be determined by inherent ('natural') characteristics of the system as well as by its current condition or level of degradation. For example, an ecosystem made up of sclerophyllous shrubs may be naturally more resilient to an increase in the length of dry periods than a plant community dominated by tender-leaved herbs. At the same time, soil degradation through overgrazing is likely to reduce the resilience of both ecosystems as compared to their undisturbed, 'natural' state.

A first source of information on the resilience of ecosystem service supply to changes in the key climatic parameters can be the observed impacts of past climatic variability and trends (see Step 2.4). For example, interviews with stakeholders in the project area may reveal that some forest types have been affected less than others by past drought events.

It may also be possible to draw on published literature about the relationship between climatic parameters and the ecosystem characteristics relevant for service provision, such as the rate of biomass production or species composition. For example, there may be studies that have examined the impact of differences in average temperature or temperature extremes on fodder production in grasslands, or studies that have assessed the climatic factors that limit the distribution of key species.

In some cases, scientific knowledge may also be available on how anthropogenic pressures such as deforestation, overgrazing or drainage of wetlands affect ecosystem resilience to climatic events.

Where there is not enough information on the relationship between the condition of ecosystems and their resilience to climatic parameters, it may be possible to draw on some general rules of thumb, which are described below.[17]. These rules have been drawn from a wide range of observations on the resilience of ecosystems to natural and anthropogenic stressors. While none of the rules can claim universal validity, and there are documented exceptions to each of them, there is evidence to support their broad applicability in the context of resilience to climate variability and change[18].

[16] The term resilience is widely used to describe the ability of a social or ecological system to maintain basic structural and functional characteristics over time despite external pressures. In the context of vulnerability analyses, 'resilience' can be thought of as covering both 'sensitivity' (i.e. low sensitivity implies high resilience) and 'adaptive capacity' (i.e. high adaptive capacity implies high resilience). When looking at the vulnerability of ecosystems and their services, use of the term 'resilience' instead of 'sensitivity' and 'adaptive capacity' can simplify matters, as distinguishing between sensitivity and adaptive capacity is particularly difficult in ecological systems in comparison to social systems.
[17] Epple, C., Dunning, E. (2014) *Ecosystem resilience to climate change: What is it and how can it be addressed in the context of climate change adaptation?* Technical report for the Mountain EbA Project. UNEP-WCMC, Cambridge. UK.
[18] *Ibid.*

Degradation/disturbance history – if an ecosystem exhibits signs of degradation and/or disturbance (e.g. impacts from high livestock densities, overharvesting, pollution or human-induced wildfires, such as reduced vegetation cover or absence of sensitive species), then it may have lower resilience to a wide range of climate change impacts. When using information on the frequency of disturbance, there is a need to consider whether the disturbances are actually causing degradation or whether they are part of a natural disturbance regime to which the ecosystem is adapted.

Levels of biodiversity – low or reduced levels of species, genetic, structural and functional diversity in the ecosystem can contribute to lower resilience to climate change. In particular, diversity may be a useful predictor of the ability of an ecosystem to recover from disturbance (one component of resilience). Note that some types of ecosystems are naturally more diverse than others, so comparisons should only be made between ecosystems of the same type.

Fragmentation – fragmentation of an ecosystem may reduce its resilience. The negative effects of fragmentation on the ability to recover from disturbance are likely to be most pronounced in ecosystems that are heavily reliant on recolonisation as a means of recovery. By contrast, ecosystems in which a large share of the species has disturbance-resistant life stages, e.g. seeds or eggs, may be less affected. The effects of fragmentation on resilience are likely to be highest in ecosystems that, in an intact state, have a high capacity to regulate their own microclimate and soil conditions, such as forests or peatlands.

'**Naturalness**' (in species composition and provenance) – if the ecosystem is made up of naturally growing species, as opposed to planted species, then this may indicate higher resilience to some climate-related stressors. This is particularly true if the stressors are similar to those already occurring under the current climatic regime. Note, however, that the resilience of planted vegetation depends on the species selected, and that planting a mix of carefully chosen species with a high suitability under the range of expected future climatic conditions can be part of an adaptation strategy.

If it is clear from Step 3.1.1 that important ecosystem services are linked to the presence of a particular species or combinations of species, then it is also worth considering whether these species have traits that make them sensitive to climate change (see Box 5 for examples).

Following the review of available sources of information on the resilience of ecosystem service supply, a decision can be made as to which of the factors influencing resilience will be used to categorize the ecosystem services in the study area. Where possible, concrete evidence from the study region or from comparable sites should be preferred to the general perceptions. If perceptions are the only available option, a combination of common sense and an understanding of the ecology of the target ecosystems should be applied to select the ones that are most appropriate for the analysis.

Box 5: Traits that contribute to species' sensitivity to climate change

- Specialised habitat and/or microhabitat requirements
- Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle
- Dependence on specific environmental triggers or cues that are likely to be disrupted by climate change
- Dependence on interspecific interactions that are likely to be disrupted by climate change
- Poor ability to disperse to or colonise a new or more suitable range

Source: Foden, W., Mace, G., Vié, J.-C., Angulo, A., Butchart, S., DeVantier, L., Dublin, H., Gutsche, A., Stuart, S. and Turak, E. (2008) Species susceptibility to climate change impacts. In: J.-C. Vié, C. Hilton-Taylor and S.N. Stuart (eds). The 2008 Review of The IUCN Red List of Threatened Species. IUCN Gland, Switzerland.

3.2.2 Discuss the descriptions of the characteristics of ecosystem functioning that determine the supply of important ecosystem services (from Step 3.1.1) considering factors influencing ecosystem resilience. Assess the resilience of the supply of important ecosystem services to observed variability and trends in climatic parameters

This step can draw on information captured in Step 2, as well as additional information sources identified in Step 3.2.1. For example, if the level of degradation or the disturbance history of ecosystems is to be used as an indication of resilience, information from the historical profile produced in Step 2.4 may prove to be useful.

Capture the discussions on each factor influencing ecosystem resilience (see Table 11), recognising the relationships between the factors (e.g. degradation and fragmentation may be correlated). Each factor can be given an initial classification (low, medium, high), based on the extent to which the ecosystem supplying the important ecosystem service demonstrates the factor in comparison with other ecosystems. This can then be used to inform Step 3.2.3.

Table 11: Example classification of the resilience of key characteristics of ecosystem functioning (for timber production) to observed variability and trends in climatic parameters (Fictional case study)

Climatic parameter: Heavy storm events (leading to tree damage)									
Characteristics of ecosystem functioning					**Factors influencing resilience**				
Ecosystem service	Vegetation layers structure	Soil structure	Food web structure	Species composition	Slope exposure? (factor identified through stakeholder discussions)	Degradation / disturbance history?	Level of biodiversity?	Fragmentation?	'Naturalness'?
Timber – from wild trees in the forest	Tree species composition simplified so that timber species predominate, but some mature and decaying trees remain as seed sources and as habitat for insectivorous and pollinating birds and bats; shrub layer thin; herb layer covering soil and abundance of dead plant matter for soil formation. **This characteristic is very likely to be affected by storm events.**	Deep organic soil layer, and sub soil penetrated by tree roots for water infiltration and mineral cycling. **This characteristic is less likely to be affected by storms, as the tree species present in the area are deep-rooting and more susceptible to stem breakage than to uprooting.**	Abundant decomposers in the soil; plants as described in vegetation layers structure; populations of herbivorous insects regulated by insectivorous birds and mammals; presence of vertebrate predators to regulate populations of tree seed predators and crop herbivores. **This characteristic may be affected by storm events, as the increased amount of injured trees may lead to a spike in populations of tree pests.**	Tree species harvested for timber. Soil decomposers. Pollinating insects required by timber tree species. Insectivorous birds to regulate populations of herbivorous insects. **This characteristic is likely to be affected by storms, as several valuable timber species in the area are particularly susceptible to wind throw and are also slow growing, so they may be outcompeted by other species if disturbances become more frequent.**	Experience from past storm events has shown that forests on the dry northern, eastern and western slopes are usually less affected than those on southern slopes and on the wide, flat bottom of the main valley. This is attributed to the slower growth and deeper root systems of trees that need to cope with the drier conditions on these slopes, as compared to the fast-growing species on southern slopes and in the floodplain. **Resilience factor = low for forests on southern slopes and in the main valley, high for northern, eastern and western slopes and the smaller valleys.**	Forests across most of the area show few signs of degradation, except through fuelwood collection near settlements, and selective logging in low-mid slopes has led to lower canopy cover and some soil damage. **Resilience factor = high for most of the area, medium near settlements**	Forests across most of the area show natural levels of diversity, but some areas have an impoverished tree layer due to selective logging of the most valuable species. More diverse forests have higher levels of productivity and may still contain target species. **Resilience factor = high for most of the area, medium near settlements**	Selective logging has avoided fragmentation. **Resilience factor = high throughout the area**	Predominately native species, some planted, non-native tree species (mainly near settlements). **Resilience factor = high for most of the area, medium near settlements**

3.2.3 Assess linkages between current climatic variability and trends and ecosystem service supply by combining the assessments of resilience of ecosystem service supply and exposure to observed variability and trends in climatic parameters

As outlined in Part II, the vulnerability of ecosystem services to climate change can be assessed from the combination of exposure and resilience, keeping in mind that ecosystem resilience integrates both aspects of sensitivity and adaptive capacity (see 3.2.1). It may not be valid to try and combine quantitative measures of exposure and resilience into a quantified vulnerability score, unless the available data on ecosystem response to climatic factors is exceptionally good. At a preliminary scoping stage it may be enough to categorize the vulnerability of ecosystem services as low, medium or high. To aid such a categorization, a reference table of how the exposure and resilience scores could be combined is provided below (see Table 12). For each ecosystem service the results of Steps 3.1 and 3.2.1-3.2.2 are utilized to estimate the current vulnerability to the observed variability and trends in climatic parameters.

Table 12: Reference table of combinations of exposure and resilience categorisation

Exposure – whether and to what degree ecosystem service is exposed to observed variability and trends in climatic parameters	Resilience of the supply of important ecosystem services to observed variability and trends in climatic parameters	Vulnerability of ecosystem service supply to observed variability and trends in climatic parameters (combination of exposure & resilience)
High	Low	High
Medium	Low	High
Low	Low	Medium
High	Medium	Medium
Medium	Medium	Medium
Low	Medium	Low
High	High	Low
Medium	High	Low
Low	High	Low

3.2.4 Assess the potential impact on livelihood groups of observed variability and trends in climatic parameters and the resulting changes in ecosystem services supply

For each livelihood group and ecosystem service (identified in Steps 2.1 and 2.2), assess the current potential climatic impact on livelihood groups through changes in ecosystem service supply, applying the concepts outlined in Part II (whereby potential impact is a function of exposure and sensitivity). The climatic vulnerability of ecosystem service supply as identified in step 3.2.3 provides an indication of the degree to which people are exposed to potential climate change impacts resulting from changes in the supply of ecosystem services. At the same time, the importance of the ecosystem service to the livelihood groups gives an idea of the livelihood group's sensitivity to such impacts[19]. Classify potential impact as high, medium or low, using the combinations of scores presented in Table 13.

Table 13: Reference table of combinations of current climatic vulnerability of ecosystem service supply and ecosystem service importance, to assess potential impact on livelihood group

Current climatic vulnerability of ecosystem service supply	Importance of the ecosystem service to the livelihood group	Potential impact on livelihood group of changes in ecosystem service
High	Essential	High
Medium	Essential	High
Low	Essential	Medium
High	Important	High
Medium	Important	High
Low	Important	Medium
High	Slightly important	Medium
Medium	Slightly important	Low
Low	Slightly important	Low

[19] Depending on the type of climatic impacts considered, the sensitivity to climate change of people will depend on a wide range of factors including: infrastructure (e.g. share of population with access to sanitation and clean water sources); housing conditions (e.g. proportion of population living in semi-solid and fragile dwellings, or percentage of business assets on floodplains); nutrition (e.g. share of population undernourished); dependency (e.g. share of those classed as young and old in relation to working population); poverty; distribution of capitals/assets; and reliance on ecosystem services likely to be impacted by climate change. The latter is the factor that is most relevant to the types of impacts considered in the present document. Factors determining sensitivity can be identified through reflecting on who was impacted by past events and why some groups were impacted more than others (as identified in Step 2.4) and by referring to guidance beyond the scope of this present document (see annex 1).

Fictional case study: EBA in the Itayuni-Babarka Mountain Landscape

Table 14: Example assessment of current potential climatic impact on people resulting from changes in two ecosystem services important to farmers in a Babarka settlement (Fictional case study)

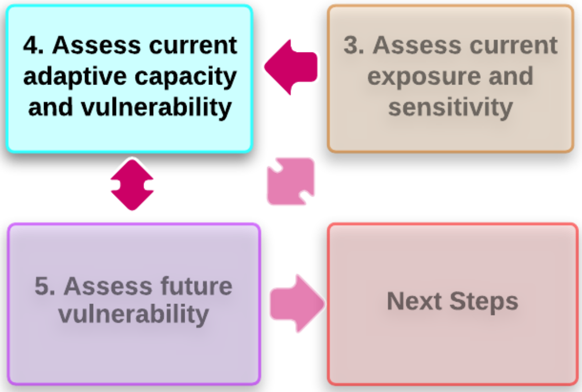
Essential/important ecosystem service	Climatic parameter	Exposure level	Resilience score	Vulnerability of ecosystem service supply	Importance of the ecosystem service to the livelihood group	Potential impact on livelihood group of changes in ecosystem service
Timber – from wild trees in the forest (Provisioning service)	Heavy rainfall (above 50 mm/hour)	High *(Trend of increasing heavy rainfall incidents; large area exposed)*	High to Medium *(Seedlings /saplings likely to be damaged. Relevant resilience factors: reduced biodiversity, high disturbance)*	Medium to Low	Important	Medium
	Strong winds (above 75 mph)	Medium *(Storms increasing in frequency; but some trees protected from winds due to topography)*	Low *(Felling and damage to some trees, much of the forest located in moist areas where trees develop shallow root systems. Relevant resilience factors: unfavourable distribution; reduced biodiversity, high disturbance)*	High	Essential	High
Flood regulation of wetland (Regulating service)	Dry/hot spells (longer than 1 month without significant rainfall)	High *(Trend of increased temperature, longer dry spells)*	Low *(Increased evaporation in dry season; build up of dead plant matter reduces* flood buffering *capacity) Relevant resilience factors: disturbance)*	High	Important	High

Step 4. Assess current adaptive capacity and vulnerability

Key questions

What is the adaptive capacity of people to the potential impacts on their livelihoods?

What is the current vulnerability of people to changes in important ecosystem services from observed variability and trends in climatic parameters?



The previous step identified the current climatic vulnerability of the supply of ecosystem services and, based on this, the potential impact of changes in these services on people's livelihoods and well-being. The purpose of this step is to identify the adaptive capacity of people, in order to combine this with the assessment of potential impact to indicate the vulnerable livelihood groups within the socio-ecological system.

Process

The following steps focus on identifying the capital bases and related processes that influence people's capacity to formulate and implement coping strategies and adapt to changes in the ecosystem services that support their livelihoods and well-being. These activities are shown below.

As in Step 3, for each sub-step, key factors for consideration are provided to inspire discussion in identifying the drivers of vulnerability, which are necessary to inform the selection of adaptation options. Although this predominantly follows a qualitative approach, if sources of information are available that allow a quantitative indicator-based or modelling approach to assess each key factor, then these may give a more scientifically rigorous classification. Such classifications are useful for mapping vulnerability (Box 5 provides an example of vulnerability mapping from Nepal based on an approach that use quantitative indicators).

Table 15: Process for Step 4

Activity	Outputs
4.1 Determine the adaptive capacity of livelihood groups to identified potential impacts	Records of discussions with stakeholder groups Venn diagram Table of classification (and justification) of adaptive capacity
4.2 Assess livelihood group's current vulnerability to climatic impact through changes in ecosystem services	Current vulnerability table

Guidance

4.1 Determine the adaptive capacity of livelihood groups in relation to identified potential impacts

There are many factors and measures of adaptive capacity to climate change and many tools to guide assessments of adaptive capacity. A suggested framework is the Africa Climate Change Resilience Alliance's Local Adaptive Capacity Framework[20]. This framework relates to the Sustainable Livelihoods Framework[21] as it considers capital bases (or asset types) and highlights the importance of assessing how transforming social structures and processes influences the capitals that people can access. It is informed by Jones, Ludi, & Levine's framework for analysing adaptive capacity at the local level[22], and their theory of five factors of high adaptive capacity:

Capital base – availability and combination of appropriate human, social, financial, physical, and natural capital (or assets) to best prepare the socio-ecological system to respond to a changing climate.

Institutions and entitlements – existence of an appropriate and evolving institutional environment that allows fair access and entitlement to key capitals/assets, and active participation by all groups in the planning and decision-making process.

Knowledge and information – the socio-ecological system has the ability to collect, analyse and disseminate knowledge and information in support of adaptation activities.

Innovation – the socio-ecological system creates an enabling environment to foster innovation, experimentation and the ability to explore niche solutions in order to take advantage of new opportunities.

Flexible forward-looking decision-making and governance – the socio-ecological system is able to anticipate, incorporate and respond to changes with regards to its governance structures and future planning.

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[20] Africa Climate Change Resilience Alliance (no date) *Consultation Document: The ACCRA Local Adaptive Capacity Framework (LAC).* Retrieved 03/03/2014 <http://community.eldis.org/.59d669a7/LACFconsult.pdf>

[21] DFID (1999) Sustainable Livelihood Framework and Guidance sheets. Retrieved 03/03/2014 <http://www.eldis.org/vfile/upload/1/document/0901/section1.pdf> <http://www.eldis.org/vfile/upload/1/document/0901/section2.pdf>

[22] Jones, L., Ludi, E., Levine, S. (2010) Towards a characterisation of adaptive capacity: a framework for analysing adaptive capacity at the local level. Background Note, Overseas Development Institute, London, UK. Retrieved 03/03/2014 <http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/6353.pdf>

4.1.1 Identify the adaptive capacity factors that influence the ability of the livelihood groups to adapt the aspects of their livelihoods that depend on the ecosystem services

Hold facilitated discussions using the questions, information and activities listed below, to identify which factors influence the ability of the livelihood groups to adapt those livelihoods that depend on the ecosystem services considered in Step 3.2. Consider those ecosystem services for which the potential impact on livelihood groups of changes caused by climate variability and trends has been rated high and medium, as described in Step 3.2.4.

Remember to consider the differential factors of adaptive capacity experienced by various individuals/groups within the livelihood groups, such as men and women, girls and boys, and different ethnic groups. Record the discussions, perhaps in a table similar to Table 16 presented below.

Two areas for discussion are profiled below, as well as an activity that can help draw out results for this step. The terms/concepts used below should be discussed in locally appropriate terms.

a. Discussing 'capital base'

Raise the following discussion questions about the groups' capital base:

- Which capitals are important for allowing an adjustment in livelihoods that adapts to current climatic impacts?
- Does the livelihood group have access to these capitals?
- Does the access to these capitals differ for different people within the wider group?

During the discussion, consider the linkages between each of the capitals and ecosystem services:

Natural capital

Stocks from which ecosystem services flow, e.g. forest cover. This category of capital obviously overlaps to a great extent with the concept and categories of ecosystem services.

Physical capital

Physical capital comprises the basic infrastructure and goods needed to support livelihoods. The location and functioning of some infrastructure can directly be affected by ecosystem services, e.g. the regulating ecosystem services of flood regulation and erosion control.

Social capital

In the context of the sustainable livelihoods framework, social capital means the social resources that support people in pursuit of their livelihood objectives. Social networks, groups and relationships can also be related to cultural ecosystem services, such as religious and cultural practices involving the natural environment, and wild plants and animals.

Human capital

Human capital represents the skills, knowledge, ability to labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives. At a household level, human capital is a factor of the amount and quality of labour available; this varies according to household size, skill levels, leadership potential, health status, etc.

The availability of provisioning ecosystem services such as food, clean water and medicinal plants will directly influence people's health. Regulating ecosystem services such as regulation of floods and soil erosion, water purification, and regulation of diseases, will also affect people's health and livelihood options. Cultural ecosystem services are also a major contribution to human capital, improving mental health, and considering the skills, knowledge and satisfaction from livelihoods that depend on the natural environment.

Financial capital

Financial capital denotes the financial resources that people use to achieve their livelihood objectives. This capital can be increased from the sale of crops, livestock, fish, timber and other provisioning ecosystem services. There may be income from 'payments for ecosystem services', which are usually regulating services such as climate regulation and regulation of water flows and quality. Incomes may also depend on livelihoods based on cultural ecosystem services, such as ecotourism.

b. Discussing 'Institutions and Entitlements', 'Knowledge and Information', 'Innovation' and 'Flexible Forward-thinking Decision Making and Governance'

Discussion questions on these factors of adaptive capacity include:

- Has each livelihood group experienced reduced/increased access to the source ecosystem of the important ecosystem services?
- Are there local norms or rules that regulate access to natural resources or water points, and are these being followed?[23]
- Is each livelihood group provided with knowledge and information on climatic trends? What about information on potential impacts, coping options and adaptation strategies? How is this information being used?
- Using the historical timeline from Step 2.4, did each livelihood group adopt alternative livelihoods after past climatic hazards? How willing were they to do this? How beneficial was the adoption of alternative livelihoods?
- Do government/local agencies provide support to communities to adapt to climate change? Is there an adaptation strategy (local, district or national) that recognizes each livelihood group and important ecosystem services? How useful is the support/strategy (e.g. has it resulted in any positive/negative effects?)?
- Which institutions and governance systems influence access to, management of, and information on, capitals that would enable an adjustment in livelihoods in order to adapt to current climatic impacts? To what degree can local communities influence these?
- What capitals do these institutions possess?
- Do people within each livelihood group experience knowledge, support, institutions and governance systems in different ways?

Ensure the availability of team-members with social science and facilitation experience for these sessions, in order to alleviate the potential complexity of these discussion questions through careful translation into plain language. If this can be achieved, these discussion questions should not demand too much time to cover.

[23] Africa Climate Change Resilience Alliance (no date) *Consultation Document: The ACCRA Local Adaptive Capacity Framework (LAC).* Retrieved 03/03/2014 <http://community.eldis.org/.59d669a7/LACFconsult.pdf>

c. *Activity: Drawing a Venn diagram*

A Venn diagram-type exercise (see Figure 6) can be very useful to gather information on 'capitals' and links to ecosystem services. There are numerous resources to support Venn diagram exercises. This section of the Guidance has been inspired by CARE's Community Vulnerability Capacity Assessment Tool[24]. The advantage of the Venn diagram is that it requires very few resources. Venn diagrams are used by many organizations because they feature the use of symbols, which are easily understandable, and because they can be drawn in almost any way, including using natural materials.

To start, the facilitator asks participants which organizations, institutions and groups[25] influence the following:

- Access to important ecosystem services
- Management of important ecosystems to supply services
- Information availability on important ecosystem services and climate

All the institutions, organizations, and groups that are mentioned should be noted.

Draw a big circle to represent the socio-ecological system, a livelihood group or a subset of a livelihood group. Those institutions, organizations, or groups with the largest agreed influence across the three categories should be drawn as larger circles (names can be provided or alternatively symbols can be used), and those with less influence drawn as smaller circles. For those institutions, organizations, and groups that have relationships/overlaps, link their circles and mark information flows. Also indicate conflicts, power relations and the success of rule enforcement.

After discussing the analytical questions below, participants show the degree of contact, co-operation, and/or influence that they have between themselves and those institutions by the distance between the circles. Institutions which participants do not have much contact with should be far away from their own circle (i.e. the big yellow circle in Figure 6); institutions that are in close contact with the participants, and with whom they cooperate most, should be inside their own circle.

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[24] CARE (2009) *Climate vulnerability and capacity analysis: Handbook.* Retrieved 03/03/2014 <http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf>

[25] It is important to remember that this includes groups and organizations that generate both formal institutions (i.e. with codified rules such as laws and rights) and informal institutions (i.e., with rules that express the social and behavioural norms of a family, community or society, along with informal groups and community-based organizations), as well as government departments and authorities.

Figure 6: Venn diagram for a group of women within the Itayuni community (Fictional case study)

Fictitious case study: Venn diagram for a group of women within the Itayuni community.

Here the group in question is a group of women, so the larger circle represents this group. Key groups (i.e. groups the women interact with often and have great importance to their lives) include the 'women's group', the 'health group', the 'village council' (lari-ju), and the Chief of the village (lari). All of these either have women as major participants or determine village rules that the women must abide by. Other (perhaps less central) local groups include the farmers' committee, the handicrafts group, the tourist guides association and the festivals committee (led by the Village priests). The Department of Forestry, Fisheries and Natural Resources was positioned partly within the circle because women often come into contact with Forest Officials while collecting resources such as medicinal plants and fibre for handicrafts. While in theory, the women have access to the forests, in the past they have been harassed and made to pay 'taxes'. Similarly, there has recently been conflict with the foreign hydro-electricity company that controls the dam, as water rights in the upstream lakes and rivers are ambiguous. Pro-tic, a local NGO, has helped the women with handicraft training sessions. The women also know of two other international NGOs, which have been working in the past with agricultural development through the farmers' committee (Farmsense) and forest quotas (ZLF). Other organizations the women are aware of, but do not have direct contact with, are the Department for Agriculture and Rural Development, UNESCO, the Mayor of Malo-Otu and the University of Malo-Otu. The circle colours represent the following:

green = local institutions/organizations/groups
blue = national institutions/organizations/groups
red = international institutions/organizations/groups

Here are some additional analytical and discussion questions (and further questions could be adapted from the Africa Climate Change Resilience Alliance Local Adaptive Capacity Framework[26]):

- Do any of the institutions/organizations/groups offer support during the hazards identified in Step 2.4 (historical timeline)?
- What roles do the institutions/organizations/groups play in informing/supporting/ determining coping efforts and/or adaptation strategies for livelihood groups (remembering the ecosystem services they benefit from in Step 2.2)?
- How responsive are the institutions/organizations/groups in light of changing circumstances?
- Do local institutions and informal organizations regulate access to key resources during times of changes in the supply of ecosystem services or climate stress and shock? How do they regulate this? How do you receive information from the different institutions/organizations/ groups?
- How do you communicate information to the different institutions/organizations/ groups?
- Who is excluded from influencing the institutions/organizations/ groups?
- Are there any actors in the socio-ecological system that link otherwise separated groups and do they represent bridges or barriers to cooperation?[27]
- Has ecosystem management followed policies/rules? (This gives a good indication of influence of different institutions/organizations/rules, as well as insight into innovation, the potential for collective action).

An understanding of the subtleties of local environmental, institutional, and political systems is also critical in learning how the vulnerability of different stakeholders varies[28]. Institutions govern such key drivers of intrinsic vulnerability as land-rights, access to and control over resources, health, and capitals. These same factors also strongly influence people's differential capacity to adapt to climate change.

Sources of information may be limited, especially for outside researchers, so significant investments of time may be required to understand the rights, rules, and cultural norms governing particular groups' behaviour. A literature review (particularly ethnographic studies) on the study area and surrounding communities may help. Semi-structured interviews or facilitated discussions as described above with a wide variety of stakeholder groups will also build understanding. The more time that can be spent in the community, and the greater the inclusivity of the process, the deeper the understanding of the social-ecological system.

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[26] Africa Climate Change Resilience Alliance (no date) *Consultation Document: The ACCRA Local Adaptive Capacity Framework (LAC).* Retrieved 03/03/2014 <http://community.eldis.org/.59d669a7/LACFconsult.pdf>

[27] Resilience Alliance (2007) *Assessing Resilience in Socio-Ecological Systems: Workbook for Practitioners –Version 2* Retrieved 03/03/2014 <http://www.resalliance.org/index.php/resilience_assessment>

[28] Schröter, D., Polsky, C., Patt, A. (2005) Assessing vulnerabilities to the effects of global change: An eight step approach. *Mitigation and Adaptation Strategies for Global Change* 10(4): 573-595.

4.1.2 Classify livelihood groups' ability to adapt to the identified potential changes in each important ecosystem service (those with high and medium potential impact on livelihood groups from Step 3.2.4)

Using the adaptive capacity factors identified in 4.1.1, classify livelihood groups' ability to adapt to the identified potential impacts caused by changes in each important ecosystem service. The classifications used could be high, medium and low. Table 16 provides an example of classifications (and justifications for these classifications) related to factors influencing the adaptive capacity of coffee and maize farmers to an identified high climatic vulnerability of the production of coffee beans.

Table 16: Example classification of factors influencing adaptive capacity of coffee and maize farmers to high climatic vulnerability of coffee bean production (Fictional case study)

Adaptive capacity factors	Contribution of each factor to the adaptive capacity of coffee and maize farmers to the potential impacts that result from the high vulnerability of coffee bean production
Natural capital	Alternative crop available – maize; droughts and storms have reduced soil quality/productivity, large areas of land are not available. **Contribution to adaptive capacity = low**
Physical capital	Maize kernels stored safely, partly paved road to main market currently subject to floods, lack of hoes. **Contribution to adaptive capacity = medium**
Social capital	Local community farming collective provides advice on where to plant. **Contribution to adaptive capacity = medium**
Human capital	Strong neighbourhood network shares labour, village school teaches and allows pupils to partake in alternative livelihood schemes. **Contribution to adaptive capacity = high**
Financial capital	Low levels of household savings but strong propensity to save, purchasing extra kernels will be a problem, price of maize is low. **Contribution to adaptive capacity = medium**
Institutions and entitlements	Community own stored maize kernels, local community farming collective does not include women farmers therefore their interests in where to plant are not taken into account. **Contribution to adaptive capacity = medium**
Knowledge and information	Farmers have received information on upcoming periods of drought in the past from radio broadcasts. Training on possible alternative crop types that will be less affected by current climatic impacts has been provided by an NGO. **Contribution to adaptive capacity = medium**
Innovation	Maize became primary livelihood after the droughts of 2008 impacted coffee harvest, lack of willingness to prioritize maize as main livelihood because of memories of terrace collapse and crop loss later in 2008 due to torrential storms. **Contribution to adaptive capacity = medium**
Flexible forward-thinking decision making and governance	Community has heard that government is improving the strength of the bridge that enables access to markets in times of flood although community not consulted; women farmers less likely to be involved in consultations. **Contribution to adaptive capacity = low**
Overall adaptive capacity classification = medium	

4.2 Assess livelihood group's current vulnerability to climatic impact through changes in ecosystem services

Current vulnerability to climatic impact is a combination of potential climatic impact and adaptive capacity. In many VIA methods that use indicators, a 'value' for vulnerability may be calculated from the relationship:

Vulnerability = potential impact (exposure + sensitivity) - adaptive capacity[29]

However, the relationship between potential impact and adaptive capacity is complex and unlikely to be adequately described by a simple subtraction of adaptive capacity scores from potential impact scores. Also, it may not be possible to develop quantitative scores for each of these components. Thus, it may be appropriate for an initial scoping VIA to describe vulnerability as high, medium or low, based on qualitative assessments of potential impact and adaptive capacity (see Tables 17 and 18 below).

Table 17: Reference table for combining results from assessing potential impact of changes in ecosystem services and adaptive capacity to inform current vulnerability classification

Potential impact on livelihood group of climate-induced change in ecosystem service	Adaptive capacity	Vulnerability (combination of potential impact and adaptive capacity)
High	Low	High
High	Medium	Medium to high
High	High	Medium
Medium	Low	Medium to high
Medium	Medium	Medium to high
Medium	High	Low to medium
Low	Low	Low to Medium
Low	High	Low
Low	Medium	Low

[29] Note that in social systems, both planned and spontaneous adaptation can play a large role in reducing vulnerability, and strengthening adaptive capacity can be a key element in an adaptation strategy. The approach suggested in this Guidance therefore involves assessing the sensitivity and adaptive capacity of livelihood groups separately (in Steps 3.2.4 and 4.1, respectively), rather than summarizing them under the term 'resilience' and considering them jointly. (Compare the simplified approach that is recommended for assessing the vulnerability of ecosystem services as described in Step 3.2.3, which involves a consideration of ecosystem resilience.)

Fictional case study: EBA in the Itayuni-Babarka Mountain Landscape

Table 18: Example classification of current vulnerability for farmers in a Babarka settlement (Fictional case study)

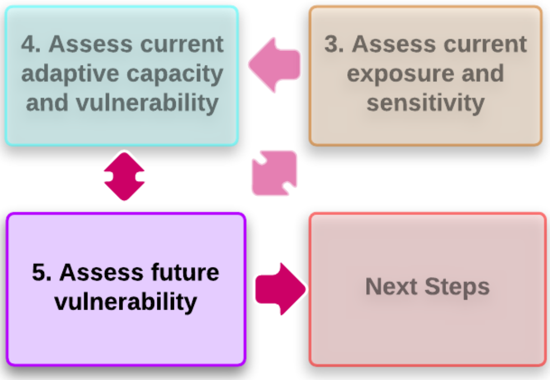
Essential/important ecosystem service	Climatic parameter	Exposure level	Resilience score	Vulnerability of ecosystem service supply	Importance of the ecosystem service to the livelihood group	Potential impact on livelihoods of changes in ecosystem service	Adaptive capacity	Current vulnerability
Timber – from wild trees in the forest (Provisioning service)	Heavy rainfall (above 50 mm/hour)	High *(Trend of increasing heavy rainfall incidents; large area exposed)*	High to Medium *(Seedlings/saplings likely to be damaged)* *Characteristics influencing resilience: biodiversity, disturbance*	Medium to Low	Important	Medium	Low *(Little access to alternatives or resources/control to reduce rainfall impacts)*	Medium to high
	Strong winds (above 75 mph)	Medium *(Storms increasing in frequency; but some trees protected from winds due to topography)*	Low *(Felling and damage to some trees, much of the forest located in moist areas where trees develop shallow root systems; Relevant resilience factors: unfavourable distribution; reduced biodiversity, high disturbance)*	High	Essential	High	Medium *(Little access to alternatives; some windbreaks being developed on forest edges; efforts to reverse forest degradation)*	Medium to high
Flood regulation of wetland (Regulating service)	Dry/hot spells (longer than 1 month without significant rainfall)	High *(Temperature and length of dry spells both increasing)*	Low *(Increased drying of wetland areas in dry season; build up of dead plant matter reduces flood buffering capacity).* *Characteristics influencing resilience: disturbance*	High	Important	High	Low *(Lack of resources and knowledge to restore wetlands)*	High

Step 5. Assess future vulnerability

Key questions

What are the future scenarios faced by the socio-ecological system?

What is the future vulnerability of livelihood groups?



Process

This step involves repeating the actions in Steps 3 and 4 but with the following additional activities:

- **Develop future scenarios** taking into account possible trajectories related to climate change, human population size, socio-economic development and demand for ecosystem services.
- **Use these scenarios to inform your assessment** of future changes in potential impact, adaptive capacity and vulnerability categories.

Table 19: Process for Step 5

Activity	Outputs
5.1 Develop future scenarios	Descriptions of future climate conditions, human population size, development, demand for ecosystem services, and political decisions and institutional change scenarios for the socio-ecological system
5.2 Assess future vulnerability	Revised Steps 3 and 4 outputs to reflect future changes. Tables showing categories for future potential impacts and vulnerability

Guidance

5.1 Develop future scenarios

Future scenarios are needed to assess future vulnerability. In the context of EBA planning, locating activities based only on past and current vulnerability, and choosing activities to address past or currently experienced climatic impact, may lead to maladaptation[30].

Established VIA methodologies and tools provide detailed guidance on how to develop future scenarios that relate to climate, human population size, development (Gross Domestic Product, levels of infrastructure), demand for ecosystem services, political decisions and institutional change (see some examples in Annex 1). Given that this Guidance is designed to be complementary to these, it will not reiterate standard steps to developing scenarios.

5.2 Assess future vulnerability

What do the different scenarios developed mean for vulnerability, considering the same formula as in Steps 3 and 4? Answering this question involves working through Steps 3 and 4 again, keeping in mind how the scenario information changes the context.

First of all, once future scenarios have been selected for the socio-ecological system in question, the list of important ecosystem services should be revisited, and any services that are likely to become more or less important given the expected socio-economic and demographic trends should be highlighted.

Next, the information gathered for the climatic parameters that influence the supply of important ecosystem services (as determined in Step 3) should be reconsidered with the scenarios in mind.

Then, modify the conditions considered throughout Steps 3 and 4 accordingly, in particular the exposure category/value identified in Step 3.1.3, and building on Steps 3.2[31] and 4.1, consider future sensitivity and future adaptive capacity of livelihood groups to changes in ecosystem services, respectively.

Finally, assess the future vulnerability of the livelihood groups related to the supply of important ecosystem services using similar categories (high, medium low) or numerical values, as before.

When assessing future exposure, remember to consider the uncertainty associated with the projections used. This can be done by adding a qualifier to the exposure information, which describes the degree to which different scenarios and climate projections coincide. An 'unknown' category can also be used to indicate that more information should be sought on probability of the projected changes.

An example table from the fictional case study is provided below (Table 20), combining information from the previous steps with an assessment of future vulnerability for two important ecosystem services for a selected livelihood group.

Adaptation planning (see 'Next Steps' section) should be informed by reviewing assessments of current vulnerability (see Table 18) and future vulnerability (see Table 20).

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[30] Maladaptation – adaptation activities that rather than reducing vulnerability, lead to an increase in vulnerability.

[31] Scenarios/projections can also be used to develop bio-climatic models (e.g. those projecting species' range shifts) that can support understanding of future ecosystem sensitivity.

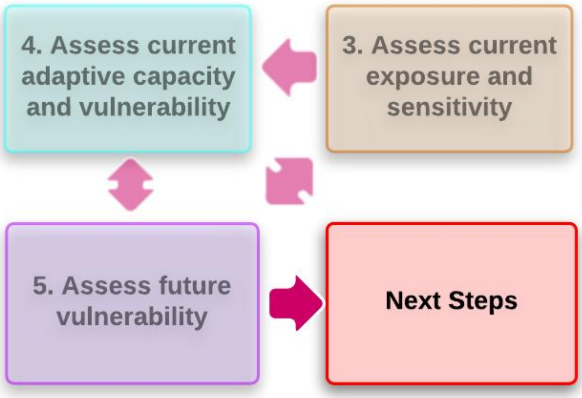
Fictional case study: EBA in the Itayuni-Babarka Mountain Landscape

Table 20: Example classification of future vulnerability for farmers in a Babarka settlement (Fictional case study)

Essential/important ecosystem service	Climatic parameter	Exposure level Certainty assessment based on agreement between projections	Resilience score	Vulnerability of ecosystem service supply	Importance of the ecosystem service to the livelihood group	Potential impact on livelihoods of changes in ecosystem service	Adaptive capacity	Future vulnerability
Timber – from wild trees in the forest (Provisioning service)	Heavy rainfall (above 50 mm/hour)	High *(Projected 23-35% increase in no. of days of heavy rainfall in wet season; large area exposed)* Medium certainty	Medium *(Seedlings/saplings likely to be damaged; continued deforestation reducing resilience)* *Influencing resilience factors: biodiversity, disturbance*	Medium	Important	High	Low	High
	Strong winds (above 75 mph)	Medium *(Likely increase in frequency of storms; cont. deforestation reduces protection)* Low certainty in projections of wind speed	Low *(Felling and damage to more trees; reduced resilience from deforestation and sapling damage (above)*	High	Essential	High	Medium	Medium to high
Flood regulation of wetland (Regulating service)	Dry/hot spells (longer than 1 month without significant rainfall)	High *(Projected increase of 50% in likelihood of dry spells; 11-20% increase in daily average temperatures in dry season; forest cover cont. decreasing)* High certainty	Low *(Increased drying of wetland areas in dry season; build up of dead plant matter reduces flood buffering capacity)* *Influencing resilience factors: biodiversity, disturbance*	Medium	Essential *(Growing importance as rainfall in wet season projected to increase)*	High	Low	High

Next steps

The next steps in the VIA process include validating the results of the VIA with stakeholders and presenting the results to inform adaptation planning.



Validate the VIA with stakeholders

The validation of the VIA's results with stakeholders (including those that were not directly involved in the assessment) in the study area is an important step in finalizing the VIA. This will help to check that the results are realistic and highlight any gaps or inconsistencies, as well as maintain stakeholder engagement (i.e. 'buy-in' or 'ownership') in the activity, which will be essential for effective adaptation planning. It is important to leave time and finances when planning a VIA to allow for this activity.

Combine the results of the previous steps with those of analyses that focus on the same socio-ecological system but consider vulnerability to other climatic impacts beyond those related to ecosystem services. These may form part of the same VIA process, or have been undertaken as separate studies.

Present the VIA to decision-makers

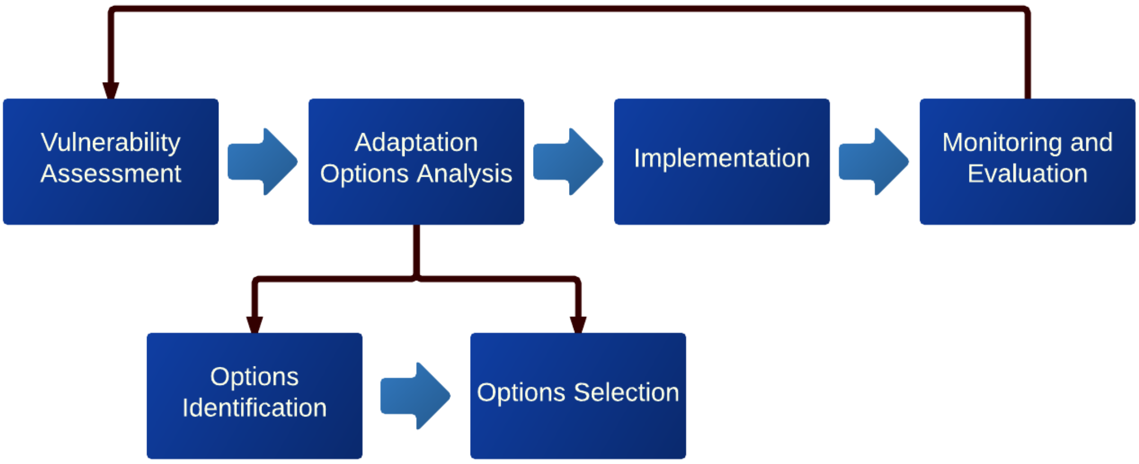
How the results of the VIA are communicated to decision-makers will influence its utility in adaptation planning processes. First, remember that decision-makers include a wider range of stakeholders than just key government officials; community, private sector and other relevant decision-makers will also play a part in designing and implementing future adaptation activities. Second, the presentation of VIA results should be useful and engaging for decision-makers, and could include a range of outreach approaches, such as workshops, seminars, and community meetings to discuss vulnerability maps, or publication of summaries/policy briefings that include tables and matrices.

Use the VIA to inform adaptation planning

Most VIAs are carried out to provide information to support more effective planning and design of adaptation measures (see Figure 7). VIA results should allow those undertaking adaptation planning to:

- Identify vulnerable livelihood groups given their reliance on ecosystem services that are likely to be affected by current climatic variability and trends or projected climate change
- Identify who within these livelihood groups is particularly vulnerable, and to what current and projected climate change impacts
- Identify some of the key drivers of vulnerability (e.g. particular factors of sensitivity or adaptive capacity)
- Understand the characteristics of ecosystem functioning that influence the supply of ecosystem services, and that will need to be managed to enable the continued supply of ecosystem services in the context of climate change.

Figure 7: Options for next steps and interactions between monitoring, evaluation, and vulnerability assessment



Source: adapted from USAID (2013) From Assessment to Implementation: Approaches for Adaptation Options Analysis (p.3, figure 1). USAID and Tetra Tech ARD, Vermont, USA.

Next steps for the design and planning of EBA measures may include:

1. If not done already, consider presenting the VIA results spatially (e.g. vulnerability 'hotspot' maps, or vulnerability maps related to key ecosystem services) to facilitate discussions about where to prioritize (if necessary) EBA measures.

2. Based on the results of the VIA, assess opportunities to address identified shortages in current or future supply of ecosystem services by improving the extent and/or condition of the relevant source ecosystems.

3. Identify potential actions for management of supply of, and demand for, ecosystem services to reduce livelihood groups' vulnerability to the identified impact on each important ecosystem service. These actions should also address adaptive capacity.

   Learn from the experience (good and bad) of coping and adaptation strategies highlighted in compiling historical profiles (see Step 2.4) and other adaptation projects being implemented nearby.

   Consider whether those ecosystem services classified as 'not important' (see Step 2.2.2) could be used (with support) for alternative livelihoods strategies.

4. Assess the economic, social, political and ecological viability and sustainability of the potential EBA actions, together with other adaptation options identified.

5. Select the management measures that will be implemented for maintaining or enhancing the supply of ecosystem services as part of reducing vulnerability to climate change (i.e. the EBA measure(s)).

These measures should also align with the adaptation vision and other stakeholder-determined selection criteria (that inform a multi-criteria analysis).

6. Build upon the spatial information collected for the VIA and create maps to facilitate discussions on what EBA options are possible where. The VIA will have provided information on who/what is vulnerable, where the vulnerability is, and the causes of vulnerability across the focus area. See Box 6 for suggested information layers to be incorporated into such maps. The time and energy required to develop these maps needs to be clearly justified based on their utility and relevance for the system and people in question.

Box 6: Spatial layers to inform EBA planning

- Location of vulnerable ecosystems that provide essential services (layers needed for mapping this include exposure to the hazard, resilience factors, non-climatic pressures, and presence of beneficiaries)
- Factors determining the adaptive capacity of livelihood groups (layers including clarity of tenure, education levels, etc.)
- Factors determining the applicability of EbA options (layers including suitable site conditions, cultural appropriateness and communities' interest to participate)

7. Selection criteria for choosing between management (adaptation) measures may be determined through a participatory process or may already exist as a set of decision rules (e.g. based on an existing project, programme or policy).

   Weightings can be applied so that some of the selected criteria are considered to be more important than others. Examples of selection criteria are provided in Box 7, together with reasoning for their inclusion.

8. Plan the implementation of the selected EBA measures (being aware of the trade-offs between different priorities in the adaptation vision, as well as the socio-political context). Planning should include developing a monitoring and evaluation framework to enable adaptive management and contribution to the evidence base of adaptation measures.

Box 7: Examples of selection criteria for choosing between EBA options

- Clarity on how the EBA option intends to reduce the negative impacts, or take advantage of the positive impacts, posed by climate change:
    - It should be clear how the adaptation option addresses the drivers of vulnerability, and/or the possible opportunities posed by climate change, identified in the vulnerability and impact assessments. What aspects of exposure, sensitivity and adaptive capacity does the EBA option relate to?
    - Considering the ‘pathway to change’ from the EBA option to the adaptation goal will also help to demonstrate that there is a clear logical link. Degree of local evidence (or evidence from sites further away that have similar characteristics) of the option reducing vulnerability or causing maladaptation? Ideally there should be evidence that the EBA option has led to a reduction in the identified drivers of vulnerability in a context similar to that of the area of interest. Evidence can exist in many forms (e.g. anecdotal, observed, experimental) and the reliability of this evidence should be assessed accordingly. Lots of evidence of a particular EBA option causing maladaptation would suggest that such an EBA option is unsuitable (or will require regular and intense monitoring and evaluation to enable adaptive management to avoid perverse results on vulnerability).

- Conditions are in place, or can be put in place, to deliver successful application of the option:
    - Is it possible to achieve the desired state of the ecosystem for the EBA option to be successful?
    - Is there willingness amongst stakeholders to be involved in implementing such an option?

- The adaptation option can work at a sufficient scale to address the adaptation goals (or can be combined with other activities to be effective at the required scale).

- Technical support is available for implementing the option.

- The costs of the option:
    - An idea of the costs to assess against the benefits will help to assess the affordability of the adaptation option.
    - Consider different categories of cost , including:
        - Predicted implementation costs;
        - Opportunity costs – is there a more lucrative (but at the same time equally resilient) use of the land area required by the EBA option?
        - Environmental costs – will there be a reduction in monetary and/or non-monetary value of the ecosystem services provided by the ecosystems as a result of the adaptation intervention?
        - Impact of the intervention on micro- and macro-economics.

- Financial support is available for implementing the option:
    - Is there enough financial support to cover the operational costs over a timeframe appropriate for effective implementation of the option being considered?

- Co-benefits are maximized:
    - Understanding potential co-benefits to assess against the costs will be important to comprehensively determine the affordability of the adaptation option. Co-benefits of EBA could relate to development goals, biodiversity conservation and climate change mitigation (including through carbon sequestration/storage). Synergies with national commitments

related to multilateral environmental agreements and other international agreements may be possible.

- Trade-offs can be minimized:
    - The presence of multiple trade-offs may require negotiation between stakeholders, possibly delaying the start of the adaptation intervention.
    - Those that lose out as a result of decisions made on the trade-off may refuse to engage in the implementation of the adaptation option impacting on its effectiveness.
    - Trade-offs relevant to EBA can be categorized as trade-offs between:
        - land-uses;
        - ecosystem services;
        - different stakeholder priorities;
        - short- and long-term benefits.

- Implementation time:
    - Is the length of time that it takes to initiate the option appropriate for the context?
    - How long does it take for the option to start to deliver positive results against the adaptation goal?

- Complementarity between adaptation options:
    - If undertaking a portfolio of adaptation activities, then it is important that each adaptation option complements, rather than negatively impacts, the others as far as is possible. An example of a negative impact caused by one adaptation option on another is a sea wall leading to changing sediment transfer, which damages fringing coral reefs being conserved to reduce storm surge wave energy.

- Flexibility of the option:
    - If information on the impacts/vulnerabilities to be addressed has a large degree of uncertainty, then the adaptation option should be as flexible as possible. For example, can the option be easily amended as more up-to-date information becomes available (e.g. as the projections of likely changes in rainfall intensity become more certain)?

Annex 1 Useful materials

This annex provides a list of materials that may be useful to users of this Guidance. The list is structured based on the sections and steps of the Guidance. Descriptions are provided to give the reader an overview of the material and to make reference to the specific step within the Guidance that the material is useful for. The materials listed are not a result of an exhaustive search. Rather, they are a selection of the documents that the authors have found useful when formulating the Guidance.

Useful materials for Part II – Key concepts

VIA Methodologies

- **GIZ *Comparative analysis of climate change vulnerability assessments: Lessons from Tunisia and Indonesia*[32]**
  http://www.seachangecop.org/sites/default/files/documents/2013%2003%20GIZ%20-%20Comparative%20analysis%20of%20climate%20change%20vulnerability%20assessments.pdf

This report compares alternative approaches to climate change vulnerability assessments from two case-studies. An awareness of the different kinds of approaches used to undertake VIA are useful to practitioners planning their first VIA in order to select methodologies of most relevance to their particular case. Furthermore, the document provides a good overview of scope and information used for assessing vulnerability in Tunisia and Indonesia, and thus is most useful for Step 1.

- **PROVIA *Guidance on Assessing Vulnerability, Impacts and Adaptation to Climate Change*[33]**
  http://www.unep.org/provia/Portals/24128/PROVIA_guidance_report_low_resolution.pdf

This document presents multiple methods for assessing climate change vulnerability, impacts and adaptation options. This will help users of this current Guidance to relate the methodologies profiled to existing climate change impact and vulnerability assessments.

More specifically, the PROVIA guidance provides a useful introduction to participatory approaches to data collection, which may help when eliciting information on livelihoods and ecosystem services for Step 2 of this current Guidance. There are descriptions of stakeholder analysis and social network analysis that can assist in defining the scope of the system (Step 1). Furthermore, the section on impact analysis facilitates useful reflection on climate variables relevant to Step 3.1 (exposure) and Step 5 (future vulnerability). Users of

[32] Hammill, A., Bizikova, L., Dekens, J., McCandless, M. (2013) *Comparative analysis of climate change vulnerability assessments: Lessons from Tunisia and Indonesia.* March 2013. GIZ GmbH, Eschborn.
[33] PROVIA (2013) *PROVIA Guidance on Assessing Vulnerability, Impacts and Adaptation to Climate Change.* Consultation document. UNEP, Nairobi, Kenya.

the PROVIA guidance should have a background in adaptation research given its level of technical detail.

Differential Vulnerability

- **CARE *Climate vulnerability capacity assessment (CVCA)*[34]**
  http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf

CARE's CVCA is a well-recognized methodology for gathering, organizing and analyzing information on the vulnerability and adaptive capacity of communities, households and individuals. It provides guidance and tools for participatory research, analysis and learning. It also takes into account the role of local and national institutions and policies in facilitating adaptation. The CVCA is also recommended for its sensitivity to the differential vulnerability of women and vulnerable groups. It contains some questions important for addressing differential vulnerability at the community and household level. These can be used in conjunction with the principles outlined in Box 1 to help users of this Guidance consider how to design their VIA in a manner that considers differential vulnerability.

The CVCA contains field guides on how to conduct a number of participatory exercises useful for a participatory learning and analysis approach to climate change vulnerability assessment, including historical timelines and institutional mapping as described in this Guidance (useful for Step 2, on livelihood context and historical profiles, and Step 4.1.1, on adaptive capacity and Venn diagrams). Numerous guiding questions for assessing the socioeconomic drivers of vulnerability at different scales are also provided (for determining current vulnerability, Steps 3 and 4).

- **World Food Program *Thematic guidelines on integrating a gender perspective into vulnerability analysis*[35]**
  http://documents.wfp.org/stellent/groups/public/documents/manual_guide_proced/wfp197271.pdf

Designed in the context of food security (a key aspect of vulnerability), these guidelines are useful for developing data collection techniques that integrate gender concerns, e.g. by describing tools for gathering gender-specific data such as time use, labour division, and access to/control over resources. These techniques may be useful for identifying the relationships between livelihood groups and ecosystem services in Step 2.

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[34] CARE (2009) *Climate vulnerability and capacity analysis: Handbook.* Retrieved 03/03/2014 <http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf>

[35] Ah Poe, C. (2005) *Thematic Guidelines: Integrating a Gender Perspective into Vulnerability Analysis*. WFP, Rome, Italy.

For Part III – Step 2

Understanding the socio-ecological system (please also see CARE and World Food Program resources provided for Part II)

- **Practical Action *From Vulnerability to Resilience: A handbook for programming design based on field experience in Nepal*[36]**
  http://practicalaction.org/media/download/16891

  The framework provides an accessible framework for assessing livelihoods and hazards. There are useful suggestions for participatory tools for eliciting information for use in livelihoods and hazard analysis, including in spatial, historical and social relations aspects. Activities are designed for participatory workshops at the programme or project sites, and can be undertaken over the course of one day, with an additional day of write up.

- **UNEP-WCMC *Adaptation and Resilience Planning for Communities and Protected Area Management*[37] (available upon request; please contact** ccb@unep-wcmc.org**)**

This manual is a community-level planning tool for practitioners, researchers, communities and interested individuals to assess the climate resilience of those living in and around protected areas. The proposed approach is first to understand the vulnerability of those living in and around protected areas, including through the ascertaining of community understanding of climate impacts and natural resource use. The manual then describes methods to reveal community aspirations for future activities; and for developing adaptation plans in the context of protected areas. The manual describes how these steps can be achieved through a three-day community adaptation planning workshop, followed by one-on-one interviews and an optional two-day scenario development workshop. This is a practical community level planning tool ideally suited for work with subsistence-based communities.

Historical Hazard Profiles

- ***DESINVENTAR Online: Inventory system of the effects of disasters*[38]**
  http://online.desinventar.org/

This free resource is useful for informing historic profile exercises. DESINVENTAR is a disaster loss and damage inventory system currently being used in over 60 countries worldwide. It originated in Latin America, designed by La Red, the Latin American network for social studies on disasters. It tallies documented losses at the subnational level on a yearly basis. Some countries, like Colombia, have compiled over 70 years of registered losses. It provides an in-depth geographical overview of disaster loss and damage, and provides a useful source of information on the actual distribution of risk at the subnational scale for determining potential exposure and vulnerability (complementing Steps 3, 4 and 5). It also highlights the importance of 'extensive risk', which is mostly composed of small and medium

[36] Ibrahim, M., Ward, N. (2012) *From Vulnerability to Resilience: A handbook for programming design based on field experience in Nepal*. Practical Action, Rugby, UK.
[37] UNEP-WCMC (in press) *Adaptation and Resilience Planning for Communities and Protected Area Management*. Cambridge, UK.
[38] DESINVENTAR Online: Inventory system of the effects of disasters. Accessed 13/03/2014 http://online.desinventar.org/

intensity disasters. After starting in Latin America, DESINVENTAR now includes databases for India, Iran, Sri Lanka, Nepal and Mali.

- **Livelihoods and Forestry Programme *Participatory Tools and Techniques for Assessing Climate Change Impacts and Exploring Adaptation Options: A Community Based Tool Kit for Practitioners*[39]** http://www.forestrynepal.org/images/publications/Final%20CC-Tools.pdf

This tool kit is designed to help communities and planners understand the likely local hazards and risks of climate change, and to look at the vulnerability of their environment and livelihoods. The tools help planners analyse existing methods of coping and adapting, thus making the kit particular useful for Step 2 of this Guidance. For example, Tools 2-4, Climatic Hazard Trend Analysis, Hazard Ranking, and Hazard Impact Assessment, are very applicable for Step 2.4 (historic hazard profiles). Tool 6, Assessing Livelihoods, is also useful for this stage of the process, and Tools 7-9 contain accessible tools for assessing vulnerability and livelihood exposure to hazards (complementing Steps 3, 4 and 5). This report is highly recommended for its simple and easy to use style, explaining the expected outcomes and procedure in a clear fashion, and providing guidance notes for each tool.

Applying an ecosystem services approach

- **BirdLife International *TESSA: A toolkit for rapid assessment of ecosystem services at sites of biodiversity conservation importance*[40]**

http://www.birdlife.org/datazone/info/estoolkit

The Toolkit for Ecosystem Service Site-based Assessment (TESSA) has been developed for site scale assessments of the delivery of ecosystem services and the distribution of benefits from these services amongst stakeholders. It is intended for use by local non-specialists, using participatory methods and field measurements that are relatively low cost, which are presented in a simple workbook structure. This resource can help in understanding the trends in ecosystem service supply (Step 2.2). The ecosystem services covered by the tool are: harvested wild goods, water related services, cultivated goods, nature-based recreation (including tourism), coastal protection, cultural services and global climate regulation. The tool is based on deciding upon a plausible alternative state for the area assessed and then identifying a site that represents that state, so that data can be gathered to understand how change impacts the supply of the ecosystem services. This could be used for understanding the impact of climate change on ecosystem services by identifying a site that had the land cover and land use qualities (an analogue site) that would be expected under a climate change scenario.

- **WWF *Rapid Integrated & Ecosystem-Based Assessment of Climate Change Vulnerability & Adaptation for Ben Tre Province, Vietnam*[41]** http://dragon.ctu.edu.vn/eng/images/files/RIVAA_WWF_FinalReport-EN.pdf

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[39] Regmi, B.R., Morcrette, A., Paudyal, A., Bastakoti, R., Pradhan, S. (2010) *Participatory Tools and Techniques for Assessing Climate Change Impacts and Exploring Adaptation Options: A Community Based Tool Kit for Practitioners*. Livelihoods and Forestry Programme and UKAID, Kathmandu, Nepal.

[40] BirdLife International (2013) *TESSA: A toolkit for rapid assessment of ecosystem services at sites of biodiversity conservation importance*. Cambridge, UK.

[41] Tuan, L.A., Du, L.V., Skinner, T. (ed) (2012) *Rapid Integrated & Ecosystem-based Assessment of Climate Change Vulnerability and Adaptation for Ben Tre Province, Vietnam*. Completed under the 'Global Cooperation on Water Resource Management' (WWF and Coca-Cola) and the 'Capacity building and sustainable production' programme (WWF – DANIDA) by WWF.

This report documents the Rapid Integrated Vulnerability and Adaptation Assessment project implemented in three communities in Ben Tre Province, Vietnam. Useful features include a description of 'bottom-up' (community-based) data, for eliciting information on social-ecological interactions and dependencies (for Step 2.3 'Identifying the ecosystems that supply important ecosystem services'), and current climate and non-climate pressures on ecosystems/livelihoods (useful for assessing current exposure and sensitivity, Step 3). The report also describes a 'top-down assessment' (i.e. a literature review) of current institutional and policy arrangements (valuable for Step 4.1.1 – adaptive capacity factors) for climate change adaptation, and projected climate trends for Ben Tre Province (Step 1.2 – background research, Step 3.1.3 – gathering exposure information). Finally, the report describes how these are combined to produce a risk assessment and adaptive capacity assessment, useful for Steps 4 and 5. The risk rating results are in the form of qualitative descriptions/categories.

Developing quantitative ecosystem service indicators

- **UNEP-WCMC *Developing ecosystem service indicators: Experience and lessons learned from sub-global assessments and other initiatives***[42]
  http://www.cbd.int/doc/publications/cbd-ts-58-en.pdf

This report presents the principal results of a project completed by UNEP-WCMC, together with a wide range of international partners, to take stock of key lessons regarding developing and using ecosystem service indicators in a range of assessment contexts. The project examined the methodologies, metrics and data sources employed in delivering ecosystem service indicators, in order to inform future indicator development. It contains information and advice on practical ways to measure and assess ecosystem services. This resource may help users wanting to complement largely participatory steps that produce qualitative information with quantitative information.

For Part III – Step 3

Assessing exposure and sensitivity

- **Sabelli, A. *Scale Counts. A Review of Indicator-based Climate Change Vulnerability Assessments***[43]
  http://www.cambioclimatico-regatta.org/index.php/en/documents-and-tools/category/cat-1-sub-2

This is a review of 35 indicator-based climate change vulnerability assessments for assessing water or agriculture sectors. Case studies and lessons learnt are provided, including many country-specific examples from Latin America and the Caribbean. The document itself is succinct, with most of the information in bullet points or tables. This resource may help users wanting to complement the largely participatory steps presented in this Guidance that produce qualitative information, with a quantitative, indicator-based approach.

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[42] UNEP-WCMC (2011) *Developing ecosystem service indicators: Experiences and lessons learned from sub-global assessments and other initiatives*. Technical Series No. 58. Secretariat of the Convention on Biological Diversity, Montreal, Canada.

[43] Sabelli, A. (2011) *Scale Counts. A Review of Indicator-based Climate Change Vulnerability Assessments*. UNEP.

For Part III – Step 4

Assessing adaptive capacity

- **Africa Climate Change Resilience Alliance *Consultation Document: The ACCRA Local Adaptive Capacity Framework*[44]**
  http://community.eldis.org/.59d669a7/LACFconsult.pdf

This document is a practical framework of questions (in the form of a set of tables) which analyse components of adaptive capacity at the local level. This Guidance draws upon the five factors of adaptive capacity presented in this framework in Step 4: asset base; institutions and entitlements; knowledge and information; innovation; and flexible forward-looking decision-making and governance.

For Part III – Step 5

Climatic data source for assessing future vulnerability

- **World Bank *Climate Change Knowledge Portal (CCKP) Beta*[45]**
  http://sdwebx.worldbank.org/climateportal/index.cfm

The Portal provides online access to comprehensive global, regional, and country data related to climate change (rainfall, temperature) and development, available in map and graphical form. It is easy to use, and applies to all countries. The CCKP uses climate datasets from the world's top meteorological and climate research institutions to show past, present, and future (predicted) climate patterns, and is thus useful for several of the Steps in estimating current and future vulnerability. For the purposes of current exposure and sensitivity (Step 3) it can display climate parameters information (at a national or major water basin scale), including warm and cold days incidence, maximum precipitation and others. For the purposes of Step 5, it can show future climate data based on climate change scenarios. It also incorporates other vulnerability indicators (such as socio-economic conditions, advances in technology and the natural resource base) to better consider trends. This may be useful for Step 2.2 on trends in the supply of ecosystem services, and for complementing Steps 3 and 4 – assessing current vulnerability. It and in the development of development scenarios for Step 5.1.2.

Developing scenarios

- **CGIAR Climate Change, Agriculture and Food Security (CCAFS) (2013) *Climate Analogues*[46]**
  http://www.ccafs-analogues.org/welcome-to-climate-analogues/

The Climate Analogues approach helps users to glimpse into the future by locating areas where climate today is similar to the projected future climate of a place of interest. It can be very useful for thinking about future impacts and vulnerability. CCAFS provides two platforms to apply the Climate Analogues approach. The online tool is a user-friendly and

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[44] Africa Climate Change Resilience Alliance (no date) *Consultation Document: The ACCRA Local Adaptive Capacity Framework (LAC).* Retrieved 03/03/2014 <http://community.eldis.org/.59d669a7/LACFconsult.pdf>

[45] The World Bank Group: Climate Change Knowledge Portal: For Development Practitioners and Policy Makers. Accessed 13/03/2014 http://sdwebx.worldbank.org/climateportal/index.cfm

[46] CGIAR Climate Change, Agriculture and Food Security (2013) Climate Analogues, Accessed 03/03/2014 <http://analogues.ciat.cgiar.org/climate/>

readily accessible platform that will facilitate quick identification of likely analogue sites. The Analogues R-package allows a more detailed analysis to be performed, with the potential introduction of user defined data and improved uncertainty quantification.

Assessing the impact of climate change on hydrological ecosystem services

- **Kings College London *WaterWorld*[47]**
  http://www.policysupport.org/waterworld

WaterWorld provides detailed process-based modelling of water quantity, quality and some regulating ecosystem services, which can be used to understand the impact of climate change, land use change, land and water management on hydrology and water resources baselines. It incorporates high resolution spatial datasets for the entire world, spatial models for biophysical and socioeconomic processes, along with scenarios for climate, land use and economic change. The tool is offered freely online and with free training courses (online and London-based). Using the datasets provided in the tool will save time compared to inputting users' own datasets, with a trade-off that global-scale data may not accurately reflect the dynamics of the system in question.

For Part III – Next steps

Adaptation options appraisal

- **USAID *From Assessment to Implementation: Approaches for Adaptation Options Analysis*[48]**
  http://www.ganadapt.org/news-events/news/gan-news/238-arcc-publishes-new-reports-on-planning-climate-change-adaptation-options

This report provides an overview of approaches that can be used to analyse adaptation options, attempting to fill a gap in how to link vulnerability assessments to climate change adaptation activities. It presents key considerations for adaptation options analysis, including ensuring participation and managing uncertainty. The adaptation option analysis methods included in this resource are: decision rules, multi-criteria analysis and economic methods.

Economic analyses

- **Rao, N.S. et al. *An economic analysis of ecosystem-based adaptation and engineering options for climate change adaptation in Lami Town, Republic of the Fiji Islands*[49]**
  http://www.sprep.org/attachments/Publications/Lami_Town_EBA_Technical.pdf

[47] Kings College London: Waterworld. Accessed 03/03/2014 http://www.policysupport.org/waterworld

[48] USAID (2013) *From assessment to implementation: approaches for adaptation options analysis*. USAID African and Latin American Resilience to Climate Change and Tetra Tech ARD, Vermont, USA.

[49] Rao, N.S., Carruthers, T., Anderson, P., Sivo, L., Saxby, T., Durbin, T., Junglut, V., Hills, T., Chape, S. (2013) *An economic analysis of ecosystem-based adaptation and engineering options for climate change adaptation in Lami Town, Republic of the Fiji Islands*. Technical report. SPREP, Apia, Samoa.

This study utilizes two methodologies, 'least-cost' (cost for the various options) and cost:benefit (considers value of the benefits [i.e. avoided costs] to identify whether these are greater than the implementation costs). There are some caveats in the approach, including: whether costs will increase in the future because climate change is avoided; not all avoided costs are included (nor is loss of life or injury); and the assessment areas are administrative boundaries rather than socio-ecological system boundaries. However, this is an important study to learn from as it is one of the only widely publicized applications of such methods for EBA.

- **USAID *Methods for economic analysis of climate change adaptation interventions*[50]**
  http://www.ganadapt.org/news-events/news/gan-news/238-arcc-publishes-new-reports-on-planning-climate-change-adaptation-options

This report describes when and how to carry out economic evaluations of proposed climate change adaptation activities, focusing primarily on cost-benefit analysis. Making the case for adaptation interventions in cost-benefit analysis terms is likely to resonate with finance ministries, for example. The document covers developing baselines, tools for estimating the monetary value of harm by exposure to climate change hazards, and conceptual issues to consider when quantifying direct and indirect benefits and costs of adaptation activities (both hard and soft adaptation actions). It also explores some of the difficulties in valuing environmental impacts.

Mapping EBA feasibility

- **UNEP-WCMC Mountain Ecosystem-based Adaptation Mapping Workshop 24th-28th September 2012, Cambridge, UK (available upon request; please contact** ccb@unep-wcmc.org)

This project document describes the process for developing a conceptual framework for mapping vulnerability, and mapping suitable areas for EBA implementation. This includes case studies from Peru and Nepal, as well as a list of tools to support the development of such maps.

Monitoring and evaluation

- **SEA Change Resource Library**
  http://www.seachangecop.org/resources

SEA Change is the Southeast Asian Community of Practice for Monitoring and Evaluation of Climate Change Interventions. Its Resource Library provides a list of documents shared by SEA Change members, primarily on adaptation monitoring and evaluation, but also on adaptation planning. The list can be filtered and searched. Currently materials are uploaded regularly and are not restricted to those solely applied in Asia.

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[50] USAID (2013) *Methods for economic analysis of climate change adaptation interventions*. USAID African and Latin American Resilience to Climate Change and Tetra Tech ARD. Vermont, USA.

- **Bours, D., McGinn, C., Pringle, P.** ***Monitoring and evaluation of climate change adaptation: A synthesis of tools, frameworks and approaches***[51]
  http://www.seachangecop.org/sites/default/files/documents/2013%2010%2009%20SEA%20Change%20UKCIP%20CCA%20MandE%20Synthesis%20Report-final.pdf

This is a key resource for understanding differences between the many climate change adaptation monitoring and evaluation (M&E) initiatives, guidelines and frameworks. Writing for a professional audience, and therefore assuming a working knowledge of key concepts, this report supports the reader to choose the materials that will be most useful for their needs. Each resource included is reviewed in terms of purpose, content and approach, potential application, and contribution to broader understanding of adaptation M&E. Those using this Guidance may find helpful those tools with applicability at the sub-national/community level. This resource has also been used to inform the useful materials listed below and their summaries.

- **CARE International** ***Participatory Monitoring, Evaluation, Reflection and Learning for Community-based Adaptation: PMERL Manual – A manual for local practitioners***[52]
  http://www.care.org/sites/default/files/documents/CC-2012-CARE_PMERL_Manual_2012.pdf

Designed to be used by field-level project teams, this manual offers a clear step-by-step guide for community-based approaches to climate change adaptation monitoring and evaluation. A supplementary framework of milestones and indicators has also been developed by CARE for those seeking examples as they develop their M&E system www.seachangecop.org/node/117. A webinar on the tool is also available www.seachangecop.org/node/1859

Pringle ***AdaptME: Adaptation monitoring and evaluation***[53]

www.seachangecop.org/node/116

This Toolkit uses a question-based approach (rather than a comprehensive set of instructions or one-size-fits-all approach) for devising a climate change adaptation monitoring and evaluation framework. The approach is based around six key areas: purpose of evaluation; the subject being monitored/evaluated; logic and assumptions within the theory of change; challenges and limitations; how progress will be measured; and engaging and communicating in the process. The document is especially helpful in bridging the conceptual challenges of linking adaptation M&E with practical tasks. This document is not recommended for users new to climate change adaptation, as it is deliberately succinct and refers the reader to other documents on a number of issues.

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[51] Bours, D., McGinn, C., Pringle, P. (2013) *Monitoring & evaluation for climate change adaptation: A synthesis of tools, frameworks and approaches. SEA Change CoP, Phnom Penh and UKCIP, Oxford, UK.*

[52] Ayers, J., Anderson, S., Pradhan, S., Rossing, T. (2012) Participatory Monitoring, Evaluation, Reflection and Learning for Community-based Adaptation: PMERL Manual – A manual for local practitioners. CARE International.

[53] Pringle, P. (2011) *AdaptMe: Adaptation monitoring and evaluation.* UKCIP, Oxford, UK.

Annex 2 Indicative list of ecosystem services

Source: Landsberg, F., Ozment, S., Stickler, M., Henninger, N., Treweek, J., Venn, O., Mock, G. (2011) *Ecosystem Services Review for Impact Assessment Dependence Scoping Tool Version 1.1, World Resources Institute, Washington, DC., USA.* http://www.wri.org/publication/ecosystem-services-review-for-impact-assessment

The ecosystem services categories shown here are based on the classification developed for the Millennium Ecosystem Assessment[54], which is still the most widely used classification, and categorizes ecosystem services as provisioning, regulating, cultural and supporting types. There are some overlaps and inter-relationships between these categories.

Provisioning ecosystem services (the physical goods and products from ecosystems) are the most straightforward to identify and quantify. Farming for food and harvesting of natural products are often the objective of many livelihood strategies. Many farming and land management activities alter the structure and processes of ecosystems for the supply of provisioning ecosystem services.

Regulating ecosystem services are the benefits obtained from an ecosystem's influence on natural processes, such as regulation of water flows and flooding by the type of vegetation structure. The supply of many regulating ecosystem services greatly influences the supply of many provisioning ecosystem services.

Cultural ecosystem services are the non-material benefits obtained from ecosystems. The 'supply' of cultural ecosystem services depends on peoples' interactions with the physical structure of the ecosystem as part of their environment. This can also include intellectual, health, cultural and spiritual values from obtaining provisioning ecosystem services through farming and harvesting wild products.

The Millennium Ecosystem Assessment also included the category of supporting ecosystem services. These are the ecosystem processes, such as conversion of the Sun's energy to organic matter by plants, which are necessary for the supply of the other ecosystem services categories. This Guidance recommends taking the approach of not separately listing supporting ecosystem services, but including them as key aspects of the necessary ecosystem functioning for the other identified ecosystem services.

[54] Millennium Ecosystem Assessment. (2005) *Ecosystems and Human Well-being: Synthesis*. Island Press. Washington, DC., USA.

Table 21: Indicative list of ecosystem services

Provisioning services: The goods and products obtained from ecosystems	
Food from crops, livestock, capture fisheries, aquaculture, and wild foods	Cultivated plants or agricultural produce harvested by people for human or animal consumption as food. *Examples: Grains, vegetables, fruit* Animals raised for domestic or commercial consumption or use. *Examples: Chicken, pigs, cattle* Wild fish captured through trawling and other non-farming methods. *Examples: Cod, crabs, tuna* Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for purposes of harvesting. *Examples: Shrimp, oysters, salmon* Edible plant and animal species gathered or captured in the wild. *Examples: Fruit and nuts, fungi, bushmeat*
Biological raw materials from timber and other wood products, fibres and resins, animal skins, sand, and ornamental resources	Products made from trees harvested from natural forest ecosystems, plantations, or non-forested lands. *Examples: Industrial roundwood, wood pulp, paper, construction materials* Non-wood and non-fuel fibres and resins. *Examples: Cotton, hemp, silk, twine, rope, natural rubber* Processed skins of cattle, deer, pig, snakes, sting rays, or other animals. *Examples: Leather, rawhide, and cordwain* Sand formed from coral and shells. *Examples: White sand from coral and white shells, coloured sand from shells* Products derived from ecosystems that serve aesthetic purposes. *Examples: Tagua nut, wild flowers, coral jewellery*
Biomass fuel	Biological material derived from living or recently living organisms–both plant and animal–that serves as a source of energy. *Examples: Fuelwood, charcoal, grain for ethanol production, dung*
Freshwater	Inland bodies of water, groundwater, rainwater, and surface waters for household, industrial, and agricultural uses. *Examples: Freshwater for drinking, cleaning, cooling, industrial processes, electricity generation, or mode of transportation*
Genetic resources	Genes and genetic information used for animal breeding, plant improvement, and biotechnology. *Example: Genes used to increase crop resistance to disease*
Biochemicals, natural medicines, and pharmaceuticals	Medicines, biocides, food additives, and other biological materials derived from ecosystems for commercial or domestic use. *Examples: Echinacea; ginseng; garlic; paclitaxel as basis for cancer drugs; tree extracts used for pest control*
Regulating services: The benefits obtained from an ecosystem's natural processes	
Regulation of air quality	Influence ecosystems have on air quality by emitting chemicals to the atmosphere (i.e. serving as a “source”) or extracting chemicals from the atmosphere (i.e., serving as a “sink”). *Examples: Lakes serve as a sink for industrial emissions of sulphur compounds; vegetation fires emit particulates, ground-level ozone, and volatile organic compounds*
Regulation of local, regional, and/or global climate	Global: Influence ecosystems have on the global climate by emitting greenhouse gases or aerosols to the atmosphere or by absorbing greenhouse gases or aerosols from the atmosphere.

	Examples: Forests capture and store carbon dioxide; cattle and rice paddies emit methane Regional, local: Influence ecosystems have on local or regional temperature, precipitation, and other climatic factors. *Example: Forests can impact regional rainfall levels, mountains have an effect on rainfall patterns*
Regulation of water timing and flows	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge, particularly in terms of the water storage potential of the ecosystem or landscape. *Examples: Permeable soil facilitates aquifer recharge; river floodplains and wetlands retain water—which can decrease flooding during runoff peaks—reducing the need for engineered flood control infrastructure*
Erosion control	Role vegetative cover plays in soil retention. *Examples: Vegetation such as grass and trees prevents soil loss due to wind and rain; forests on slopes hold soil in place, thereby preventing landslides*
Water purification and waste treatment	Role ecosystems play in the filtration and decomposition of organic wastes and pollutants in water; assimilation and detoxification of compounds through soil and subsoil processes. *Examples: Wetlands remove harmful pollutants from water by trapping metals and organic materials; soil microbes degrade organic waste rendering it less harmful*
Regulation of diseases	Influence ecosystems have on the incidence and abundance of human pathogens. *Example: Intact forests reduce the occurrence of standing water—a breeding area for mosquitoes—and thereby can reduce the prevalence of malaria*
Regulation of soil quality	Role ecosystems play in sustaining soil's biological activity, diversity, and productivity; in regulating and partitioning water and solute flow; and in storing and recycling nutrients and gases. *Example: Some organisms aid in decomposition of organic matter, increasing soil nutrient levels; some organisms aerate soil, improve soil chemistry, and increase moisture retention; animal waste fertilizes soil*
Regulation of pests	Influence ecosystems have on the prevalence of crop and livestock pests and diseases. *Example: Predators from nearby forests—such as bats, toads, snakes—consume crop pests*
Pollination	Role ecosystems play in transferring pollen from male to female flower parts. *Example: Bees from nearby forests pollinate crops*
Regulation of natural hazards	Capacity for ecosystems to reduce the damage caused by natural disasters such as hurricanes and to maintain natural fire frequency and intensity. *Examples: Mangrove forests and coral reefs protect coastlines from storm surges; biological decomposition processes reduce potential fuel for wildfires*
Cultural services: The nonmaterial benefits obtained from ecosystems	
Recreation and ecotourism	Recreational pleasure people derive from natural or cultivated ecosystems. *Examples: Hiking, camping, bird watching, scuba diving, and going on safari*
Ethical and spiritual values	Spiritual, religious, aesthetic, intrinsic, existence or other values people attach to ecosystems, landscapes, or species. *Examples: Spiritual fulfilment derived from sacred lands and rivers; belief that all species are worth protecting regardless of their utility to people–"biodiversity for biodiversity's sake"*
Educational and inspirational values	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation. *Examples: The structure of tree leaves has inspired technological improvements in solar power cells; school fieldtrips to nature reserves and parks aid in teaching scientific concepts and research skills*
Supporting services: The natural processes that maintain the other ecosystem services	

Habitat	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances. *Examples: Native plants in gardens and fields provide pollinators with food and structure for reproduction; rivers and estuaries provide nurseries for fish reproduction and juvenile development*
Nutrient cycling	Flow of nutrients (e.g. nitrogen, sulphur, phosphorus, carbon) through ecosystems. *Examples: Transfer of nitrogen from plants to soil, from soil to oceans, from oceans to the atmosphere, and from the atmosphere to plants; soil deposition by rivers*
Primary production	Formation of biological material by plants through photosynthesis and nutrient assimilation. *Examples: Algae transform sunlight and nutrients into biomass, thereby forming the base of the food chain in aquatic ecosystems*
Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms. *Examples: Transfer of water from soil to plants, plants to air, and air to rain*

Annex 3 Key elements to consider in determining important characteristics of ecosystem functioning

The following classifications can be used to describe characteristics of ecosystem functioning and to help identify appropriate sources of information in order to assess the impacts of climate change on ecosystem service supply:

Vegetation structure

Consider whether the supply of the ecosystem services requires a particular vegetation structure, which can be described in terms of:

- grass and herb soil coverage
- shrub layer
- tree layer and canopy cover
- root depth
- abundance of dead and decaying vegetation, and
- plant biomass and leaf area at ground level, in shrubs, trees, and below-ground (roots)

Soil structure

This can be described in terms of:

- whether the surface is bare or covered with vegetation
- whether the soil surface has formed a hard cap that is resistant to water and air flow
- the depth of the organic layer, and
- the soil crumb structure (aggregated soil particles held together with "glue" provided by decomposing organic matter) – the space around each crumb provides room for water and air, and this in turn promotes plant growth and organic decomposition

Food web structure

For some ecosystem services, consider if there is a particular structure or composition of the food web that is required for the ecosystem service supply. A detailed analysis and description of the food web is not required. But the presence and roles of the four main food web categories (or 'trophic levels') can be briefly described if they are considered to provide the ecosystem characteristics necessary for the ecosystem service:

1. Decomposers – consider their role and abundance for soil formation and the availability of minerals for plant growth and water quality.

2. Plants – consider the amount of growth necessary for crop production; to provide food for herbivores, predators and decomposers; as well as the physical role of plants in water and mineral cycling.
3. Herbivores – including domesticated and wild animals, and insects. Consider their roles in grazing vegetation for desired vegetation growth and landscape value, their influence on mineral cycling, and as prey for predators.
4. Predators – consider their role in regulating the populations of desired species and pest species, as well as for any cultural ecosystem service values from the existence of predators and hunting.

For each food web category the desired ecosystem structure could be described in terms of:

- desired total biomass
- key species presence and abundance for the identified ecosystem services (provisioning, regulating, cultural)
- spatial distribution and variation, and
- the physical role (i.e. decomposers, plants, herbivores or predators) in the water and mineral cycles

Key ecological interactions

Important ecological interactions that greatly influence the ecosystem structure are:

- herbivory (subsistence on plants)
- predation (predator feeding on prey)
- frugivory (fruit eating) and
- parasitism (a species benefiting at the expense of a host species)

Key species composition

The description of ecosystem structure and key ecological interactions enables the identification of which species are key in generating the structure and interactions. It may be easiest to first identify the dominant vegetation species for the vegetation structure, then identify the key species for the food web structure and key ecological interactions.

Annex 4 Key Terms

Adaptation: Actions undertaken to reduce the adverse consequences of climate change, as well as to harness any beneficial opportunities.

> Source: NCCARF (2013) *What is adaptation?* Retrieved 03/03/2014 <http://www.nccarf.edu.au/content/adaptation>

Adaptive capacity: The ability of a socio-ecological system to adjust to climate change, to moderate potential damage, to take advantage of opportunities, or to cope with the consequences.

> Source: IPCC (2007) *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Parry, M., Canziani, O., Palutikof, J., van der Linden, P., Hanson, C., (eds)]. Cambridge University Press, Cambridge, UK and New York, USA.

Climate hazard: The potential occurrence of a natural or human-induced climatic event, trend or physical impact, which may cause loss of life, injury, or other health impacts, as well as damage and loss of property, infrastructure, livelihoods, service provision, and environmental resources.

> Source: IPCC (2014) Glossary [Agard, J., et al. (eds.)]. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, USA.

Climatic parameters: The climatic elements that aspects of ecosystem functioning are reliant upon.

Differential vulnerability: Within a system there is likely to be unevenness in the vulnerability of different groups, locations, or sectors. This differential vulnerability can occur through a variety of factors including demographics (age, sex, education and place of residence), resource dependence, poverty levels and unequal power relations between different groups in society causing inequalities in the distribution of rights, roles, opportunities, power and access to and control over resources. For example, gender differences in access to, and use of, ecosystem services such as clean water can influence the extent to which women, girls, men and boys are affected by changes in the socio-ecological system caused by climate change. Vulnerability assessment processes should be designed with differential vulnerability in mind, including by assessing the impact of climate change on sub-groups within communities.

Ecosystem: An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit. Humans are an integral part of ecosystems.

> Source: Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Synthesis* Island Press. Washington, DC., USA.

Ecosystem functioning: The functioning of an ecosystem is the outcome of the processes and interactions between all of the various aspects of the ecosystem, the flows of inputs to that ecosystem, and the structure of the ecosystem itself. The functioning of an ecosystem determines the supply of ecosystem services. Key elements to consider in determining the ecosystem functioning necessary for ecosystem services include vegetation structure, soil structure, food web structure, key ecological interactions, and key species composition.

> Source: Hicks, C., Woroniecki, S., Fancourt, M., Bieri, M., Garcia Robles, H., Trumper, K., Mant, R. (2014) *The relationship between biodiversity, carbon storage and the provision of other ecosystem services: Critical Review for the Forestry Component of the International Climate Fund*. UNEP-WCMC. Cambridge, UK.

Ecosystem services: The benefits people obtain from ecosystems (MEA, 2005, see above).

Ecosystem-based adaptation (EBA): The use of biodiversity and ecosystem services as part of an overall adaptation strategy *to help people* adapt to the adverse effects of climate change.

> Sources: 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*. Technical Series No. 41. Montreal, Canada.

Emission scenarios: Global emission scenarios, based on so-called narrative storylines for humankind's development over the next 100 years, describe how GHG emissions might develop in the future. The associated emission pathways are used as the basis for simulations using general circulation models (GCMs), which calculate the interrelationship of the elements of the earth system and thereby project future climate trends. Regional climate models (RCMs) are based on the results of the GCM, and project the climate in more precise geographical detail. The results of the GCM and the RCM are (regional) climate change scenarios (i.e. not *emission* scenarios) which describe, for example, how temperature, precipitation or other climatic parameters are expected to change in an area under investigation. An example of an emission scenario storyline summary used in past Intergovernmental Panel on Climate Change Assessment Reports (that came from the Special Report on Emissions Scenarios) is: A1: Rapid economic growth with a global population that reaches nine billion in 2050 and then gradually declines; the quick spread of new and efficient technologies; a convergent world – income and way of life converge between regions; and extensive social and cultural interactions worldwide. For the most recent (5th) Assessment Report new scenarios have been developed by the research community. These are called Representative Concentration Pathways (RCPs). For information on the characteristics of these new scenarios and how they relate to previous scenarios, see Wayne, G. (2013) *The Beginner's Guide to Representative Concentration Pathways*, Version 1.0, August 2013, SkepticalScience http://www.skepticalscience.com/docs/RCP_Guide.pdf.

Exposure: The character, magnitude, and rate of climate variation to which a system is exposed.

Human well-being: Well-being has several key components: the basic material needs for a good life; freedom and choice; health; good social relations; and personal security. Well-being exists on a continuum with poverty, which has been defined as "pronounced deprivation in wellbeing" (MEA, 2005, see above).

Potential impact: The consequence of sensitivity and exposure to climate change on a socio-ecological system.

Resilience: The ability of a social or ecological system to maintain basic structural and functional characteristics over time despite external pressures (informed by Epple and Dunning, 2014).

Source: Epple, C., Dunning, E. (2014) *Ecosystem resilience to climate change: What is it and how can it be addressed in the context of climate change adaptation?* Technical report for the Mountain EbA Project. UNEP-WCMC, Cambridge, UK.

Risk: The combination of the magnitude of the impact with the probability of its occurrence.

Source: Schneider, S.H., Semenov, S., Patwardhan, A., Burton, I., Magadza, A.H.I, Oppenheimer, M., Pittock, A.B., Rahman, A., Smith, B., Suarez, A., Yamin, F. (2007) *Assessing key vulnerabilities and the risk from climate change. Climate Change 2007: Impacts, Adaptation and Vulnerability*. *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, USA.

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate change, either directly or indirectly.

Socio-ecological systems: Linked systems of people and nature. The term emphasizes that humans must be seen as a part of, not apart from, nature and that the delineation between social and ecological systems is artificial and arbitrary.

Sources: Stockholm Resilience Centre (2014) *Resilience Dictionary: Social-Ecological System.* Retrieved 03/03/2014, <http://www.stockholmresilience.org/21/research/what-is-resilience/resilience-dictionary.html>

See also: Berkes, F., Folke, C., (eds.) (1998) *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge University Press, New York, USA.

Vulnerability (to climate change): the degree to which a system (social, ecological or socio-ecological) 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 variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007, see above).