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Ecosystem Services Review for Impact Assessment

Introduction and Guide to Scoping

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1. INTRODUCTION

In recent decades, the socio-economic implications of environmental change have made themselves clearer and clearer. Rapidly degrading ecosystems all over the world have resulted in people competing for increasingly scarce natural resources, companies facing unplanned higher production costs and therefore lower profits due to ecosystem changes, and governments having to invest in infrastructure to replace services that used to be provided by the environment for free.

As a first source of information regarding development projects, environmental and social impact assessment (ESIA) needs to reflect the linkages between environmental change and socio-economic achievements. It needs to demonstrate not only how the project might impact the environment and what the socio-economic implications of these impacts could be; in a context of degrading ecosystems and ever more scarce natural resources, ESIA also needs to inform developers about how project performance could be affected by environmental change driven by third-party activities such as farmers diverting water upstream from the project.

Despite a number of initiatives to promote integrated impact assessment (Brownlie 2005, Slootweg et al. 2001), ESIA still typically assesses different biophysical elements (e.g., air, water, land, fauna and flora/biodiversity) and socio-economic elements (e.g., demography, health, culture, and livelihoods) separately. However, new regulatory and financial impact assessment standards require that ESIA systematically addresses impacts on ecosystem services, which by definition link people and their environment (Box 1). Addressing ecosystem services in ESIA acknowledges that some biophysical aspects are socio-economically important and calls for an integrated approach across biophysical and socio-economic disciplines.

Box 1 | Ecosystem Services: Linking People to Their Environment Across Temporal and Spatial Scales

Ecosystem services are the many benefits—large and small, direct and indirect—that ecosystems provide to people. These consist of all the natural products and processes that contribute to human well-being, as well as the personal and social enjoyment derived from nature. For example, forests provide wood products and a host of non-timber products and act as a venue for recreation and spiritual renewal; they also help to mitigate climate change by sequestering carbon. Wetlands absorb pollutants, purify water, and help reduce floods. Since different ecosystems provide different bundles of ecosystem services, there are tradeoffs and synergies amongst ecosystem services. For example, conversion of forest to agriculture lowers the wood supply and potentially the water flow regulation but it increases food production from crops. On the other hand, restoring a wetland may remove more pollutants from drinking water supplies and increase recreation benefits for bird watching.

Scientists generally divide ecosystem services into four categories (see Annex 1 for a list of ecosystem services with definitions and examples):

- *Provisioning services* are the goods or products obtained from ecosystems, such as food, timber, medicines, fiber, and freshwater.
- *Regulating services* are the benefits obtained from an ecosystem's control of natural processes, such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards.
- *Cultural services* are the nonmaterial benefits obtained from ecosystems, such as recreation, spiritual values, and aesthetic enjoyment.
- *Supporting services* are the natural processes that maintain the other ecosystem services, such as nutrient cycling and primary production.

The benefits of ecosystems are conferred at many scales and to many different beneficiaries. At the local level, ecosystem services are frequently the basis for rural livelihoods and subsistence, particularly for the poor. Artisanal fishing of coastal waters and inland lakes and rivers, for example, provides both cash income and food for millions of low-income families. Benefits can also be regional, such as the provision of water to communities and businesses from a forested watershed. At the global scale, well-functioning ecosystems regulate climate and act as a reservoir of biodiversity that underpins biological production of all types, including agriculture. Ecosystem services also work over different temporal scales, from the annual production of crops to the long cycles of soil formation and climate regulation.

Source: Adapted from MA 2003.

1.1 Growing need for technical guidance to address ecosystem services in impact assessment

At a time when governments have started to require the explicit consideration of ecosystem services in ESIA (CEQ 2009), the International Finance Corporation (IFC) officially recognized the importance of addressing ecosystem services systematically in the project planning cycle for its investments and released new performance standards that require client projects to "maintain the benefits from ecosystem services" (IFC 2011). Because of its worldwide reach, the new IFC Performance Standards are expected to greatly multiply the demand for guidance on how to assess project impact and dependence on ecosystem services.

There are a number of ESIA-specific resources to help practitioners address ecosystem services in their assessments. They include the Convention on Biological Diversity's voluntary guidelines on including biodiversity and ecosystem services in impact assessment (Slootweg et al. 2006), the Organisation for Economic Co-operation and Development's recommendations on how to include ecosystem services in Strategic Environmental Assessments (OECD 2008), and the oil and gas sector's checklists regarding ecosystem service dependencies and impacts (IPIECA and OGP 2011). While important in establishing the theory and general approach for considering ecosystem services in ESIAs, these resources do not offer ESIA practitioners detailed instructions on how to

incorporate ecosystem services throughout the ESIA process and do not fully address the lack of guidance identified by practitioners as one of the main barriers to a wider use of ecosystem services in ESIAs (WRI 2010).

To fill this gap, the "Ecosystem Services Review for Impact Assessment" (ESR for IA) presented here provides practical instructions for ESIA practitioners to address ecosystem services in a systematic and efficient manner throughout the ESIA process by helping them:

- *At the scoping stage*: systematically and comprehensively identify the ecosystem services to be addressed in further stages of the ESIA;
- *At the impact analysis stage*: assess (1) the negative project impact on ecosystem services in terms of changes in the well-being of their beneficiaries and (2) the project dependence on ecosystem services in terms of changes in project performance; and
- *At the mitigation stage*: identify options through the mitigation hierarchy to enhance or at least maintain (1) the well-being affected beneficiaries derive from ecosystem services and (2) the performance the project derives from ecosystem services at acceptable levels.

1.2 Expected outputs of the Ecosystem Services Review for Impact Assessment

The ESR for IA helps environmental and social impact assessment practitioners deliver on the following matters:

- *Systematic integration of environmental and socio-economic issues.* The ESR for IA fundamentally connects biophysical and socio-economic environments. It is an efficient and cost-effective way to identify socio-economically significant environmental impacts and environmentally significant socio-economic impacts.
- *Assessment of project dependence on ecosystem services.* Evaluating project dependence on ecosystem services and on the third-parties that affect these services can help manage risks and take advantage of opportunities related to ecosystem change.
- *Consideration of multi-scale impacts and dependence.* Ecosystem services occur at local, regional, and sometimes global scales. The ESR for IA helps practitioners ensure that impact and dependence assessments cover all relevant scales.
- *Identification of indirect and cumulative impacts.* The explicit assessment of the ways the project contributes to existing and foreseeable drivers of ecosystem change allows practitioners to factor in ecosystem changes external to the project and to highlight whether and how a project could interact with them.
- *Identification, communication, and negotiation with stakeholders.* The ESR for IA helps stakeholders better understand the social and economic implications of project impact and can be useful in discussing tradeoffs to reach an optimal design and environmental management plan for the project.

While beneficial to any project subject to an ESIA, the projects that would benefit the most from addressing ecosystem services in their ESIA are those projects that:

- May lead to ecosystem change in contexts where people and communities have a high level of dependency on ecosystems to maintain their livelihoods and cultural identity and are therefore vulnerable to ecosystem change. This includes remote areas that are opening up to development.
- Depend on ecosystem services and are therefore vulnerable to ecosystem change. This includes projects that, for example, share water resources with other stakeholders, or require erosion control for viability.
- Are controversial and require the developer to be proactive in their relations with affected people to avoid legal battles or delays in project implementation or operation. This includes areas where citizens are actively involved and likely to demand project oversight.

1.3 Roadmap to the Ecosystem Services Review for Impact Assessment

The ESR for IA is presented in two successive working papers: *Ecosystem Services Review for Impact Assessment: Introduction and Guide to Scoping* and *Ecosystem Services Review for Impact Assessment: Guide to Impact Analysis and Mitigation* (to be published in early 2012). These two working papers will be road-tested between January and September 2012 before being finalized as one guidance note.

More specifically, the ESR for IA provides practitioners with:

- A conceptual framework for an overall vision of the linkages between the project, ecosystem services, and human well-being (*Working Paper 1*);
- An overview of the seven steps to implement the conceptual framework throughout the ESIA process (scoping, impact analysis, and mitigation stages) in a structured and systematic manner (*Working Paper 1*); and
- Detailed instructions accompanied with supporting tools and guidance to help ESIA practitioners throughout the three steps of the scoping stage (*Working Paper 1*); the three steps of the impact analysis stage (*Working Paper 2*); and the one step of the mitigation stage (*Working Paper 2*).

2. A METHODOLOGY TO ADDRESS ECOSYSTEM SERVICES IN IMPACT ASSESSMENT

The two main objectives for addressing ecosystem services in impact assessment are (1) to enhance or at least maintain the well-being of people benefiting from ecosystems that may be impacted by the project at a level the affected beneficiaries deem acceptable; and (2) to enhance or at least maintain project performance at a level the project developers deem acceptable over the life of the project and despite ecosystem change.

A practical methodology for addressing ecosystem services in impact assessment, therefore, needs to meet two requirements: (1) conceptually, the methodology needs to provide an overall vision of how the project, ecosystem services and human well-being are linked; (2) practically, the methodology needs to provide instruction on how to systematically incorporate ecosystem services in the ESIA process and whom to involve in the process of assessing project impact and dependence on ecosystem services.

To meet these requirements, the ESR for IA proposes a conceptual framework linking ecosystem services, human well-being and the project for which the ESIA is carried out. It also provides specific steps to implement this framework seamlessly within the ESIA process, including guidance on engaging ecosystem service beneficiaries. The framework builds on the *Millennium Ecosystem Assessment* (MA 2003), which developed a framework to assess ecosystem services. The associated implementation steps draw on the *Corporate Ecosystem Services Review* (WRI et al. 2008), which is a structured methodology to manage business risks and opportunities arising from changes in ecosystem services.

2.1 The Ecosystem Services Review for Impact Assessment conceptual framework

The ESR for IA conceptual framework builds on the elements and causal relations of the original Millennium Ecosystem Assessment (MA) framework, which need to be examined when assessing the consequences of ecosystem change on human well-being (Figure 1):

- *Well-being of ecosystem service beneficiaries* (A). Assessing ecosystem services implies focusing on how the environment contributes to people's well-being. This includes contributions to the basic material for a good life (e.g., food, livelihood, income); health (e.g., clean environment for good hygiene and health); security (e.g., security from disasters, secure access to natural resources); and social cohesion (e.g., absence of conflict, sense of belonging).
- *Ecosystem services* (B). These are the benefits humans obtain from ecosystems. When assessing ecosystem services, it is important that the assessment covers systematically all four categories of ecosystem services and acknowledges the complex relations among different ecosystem services (Box 1).

- *Ecosystems* (C). The supply of ecosystem services depends primarily on the type of ecosystem and its condition. Different ecosystems supply different bundles of services (Annex 2). The geographic extent of an ecosystem and its underlying species composition can also affect the quantity and quality of services the ecosystem supplies and are important measures to gauge its condition.
- *Direct drivers of ecosystem change* (D). Ecosystems are directly affected through natural processes (e.g., volcanic eruptions) and human activities. Five direct drivers of ecosystem change have had, and are expected to have, the greatest effects on ecosystem health and condition, and therefore on the supply of ecosystem services. These five drivers are: changes in local land use and land cover; harvest and resource consumption; pollution; introduction of invasive species; and climate change.
- *Indirect drivers of ecosystem change* (E). The level or rate at which the direct drivers lead to ecosystem change is affected by indirect drivers, such as demographic, economic (e.g., globalization, trade, market and policy framework), sociopolitical (e.g., governance, institutional, and legal framework), cultural and religious (e.g., beliefs, consumption choices), or scientific and technological factors. Demographic pressures or economic growth, for example, may accelerate land cover changes.
- *Well-being of ecosystem service beneficiaries as a factor affecting direct and indirect drivers of ecosystem change* (A). Changes in the well-being of ecosystem service beneficiaries can affect indirect drivers. For example, when high poverty levels and poor health affect demographic and economic drivers. Also, a change in the capacity of ecosystem service beneficiaries to provide for their well-being might affect the rate of direct drivers of change. For example, when crop failure decreases cash income, it might force farmers to start harvesting woody biomass to produce charcoal, which will drive ecosystem change in bushland.

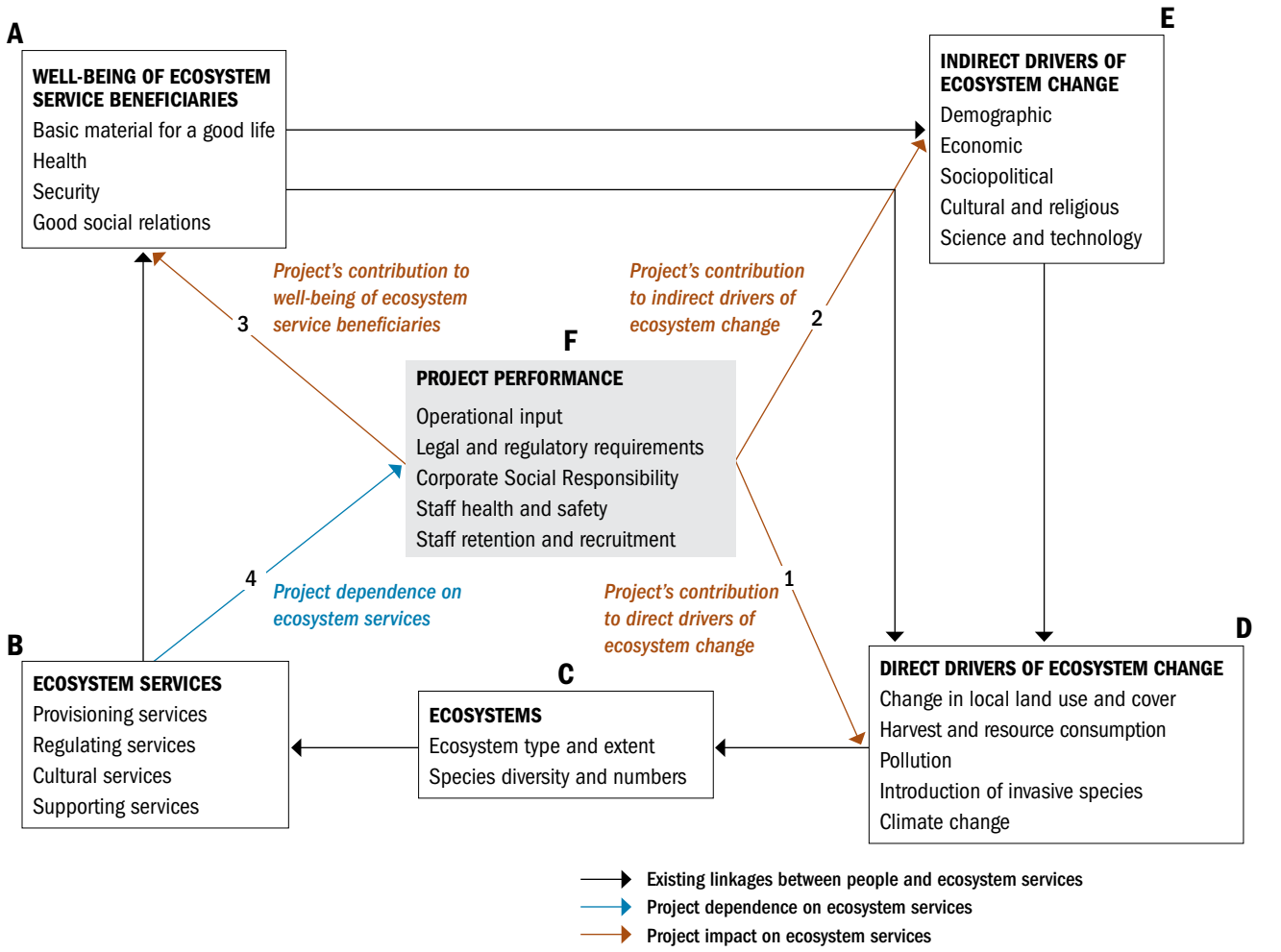
By describing the feedback loops among ecosystem services, human well-being, and drivers of ecosystem change, the MA framework emphasizes that changes in ecosystems affect human well-being and that changes in human well-being affect ecosystems. The conceptual framework for the ESR for IA (Figure 1) puts the proposed project (F) at the center of the interactions between human well-being, ecosystem services, ecosystems, and drivers of ecosystem change—it affects all the components of the framework and is itself affected by all of them. It reflects the two ways the project relates to ecosystem services: firstly, it could impact the existing relationships between human well-being, ecosystem services, and ecosystems; secondly, the achievement of successful project performance could depend on these relationships.

The project may ***impact*** ecosystems and therefore lead to changes in beneficiaries' well-being in multiple ways. First, it can contribute to existing direct drivers of ecosystem change or introduce new ones (Arrow 1), for example, by polluting waterways, overharvesting water, or draining a wetland. The project can also accelerate or decelerate ecosystem change by affecting the indirect drivers of ecosystem change (Arrow 2), such as by increasing the local population, improving incomes, or facilitating access to markets. Eventually, the project can accelerate or decelerate ecosystem change by affecting the beneficiaries' well-being and therefore their demand for ecosystem services (Arrow 3). For example, the project may provide an alternative source of income that reduces beneficiaries' reliance on ecosystem services for meeting that aspect of their well-being.

The project may also ***depend on*** certain ecosystem services for its operations, for achieving some of its Corporate Social Responsibility objectives, or for providing good working conditions to its staff. These dependencies constitute the contribution of ecosystem services to project performance (Arrow 4) and could include the following (ESR 2008, and IPIECA and OGP 2011):

- *Being an operational input:* making available inputs or processes in necessary quantity and quality, in due time, and at reasonable price (e.g., supply of freshwater from river to cool down machinery; supply of wildlife to tourism industry);

Figure 1 | **Conceptual Framework for Assessing Project Impact and Dependence On Ecosystem Services**



Source: WRI, adapted from MA 2003.

- *Helping meet legal and regulatory requirements:* minimizing costs related to compliance (e.g., treatment of effluent by wetlands to keep water quality within national standards);
- *Contributing to Corporate Social Responsibility (CSR) activities:* supporting socio-economic improvements for ecosystem service beneficiaries (e.g., reforestation of landscape for improved water quality and quantity);
- *Ensuring staff health and safety:* contributing to a clean physical environment for good personal hygiene and health, and security from natural and human-made disasters (e.g., access to safe drinking water; low incidence of vector-borne diseases);
- *Increasing staff retention and recruitment:* providing agreeable working conditions, leisure activities, or sources of personal fulfillment (e.g., enabling environment for hiking, wildlife viewing, hunting, snorkeling, or sightseeing).

By explicitly recognizing the causal interactions between the project, human well-being, and the indirect and direct drivers of ecosystem change, the ESR for IA framework supports an integrated assessment of elements commonly assessed separately in an ESIA.

To conduct an integrated assessment of project impact and dependence on ecosystem services, this framework needs to be systematically implemented at the scoping, impact analysis, and mitigation stages of the ESIA. (The framework is not implemented at the screening stage because that stage usually follows well established rules defining which projects require an impact assessment and which do not, leaving little room for influencing the decision-making process.)

2.2 Seven steps to implement the Ecosystem Services Review for Impact Assessment conceptual framework

The ESR for IA proposes seven steps to implement the conceptual framework. These seven steps must be carried out by an inter-disciplinary team so as to reflect the biophysical and socio-economic nature of ecosystem services. Alternatively, the ESIA team can be staffed with an ecosystem services specialist whose task is to implement the conceptual framework by coordinating with members of the ESIA team on their particular discipline and integrating their respective analyses.

While projects or their CSR activities may also enhance the well-being people derive from ecosystems, the ESR for IA focuses on the negative project impact and therefore, from here on, any reference to "project impact" should be understood as "negative project impact". The ESR for IA can, however, be expanded to identify, assess, and enhance the positive project impact on ecosystems in terms of improvement in the well-being of beneficiaries.

The seven steps of the ESR for IA are implemented seamlessly within the following ESIA stages:

- ***Scoping stage.*** This ESIA stage provides an opportunity to identify the key ecosystem services that could be impacted by, or could constrain the successful implementation of, the project at a point when the project design is still amenable to modification. Scoping for ecosystem services entails three steps:
  - *Step 1* prioritizes ecosystem services that need to be addressed in further stages of the ESIA because of project impact.
  - *Step 2* prioritizes ecosystem services that need to be addressed in further stages of the ESIA because of project dependence.
  - *Step 3* helps the ESIA team prepare the terms of reference for the ESIA by describing the requirements for assessing project impact and dependence on ecosystem services.
- ***Impact analysis stage.*** Once the priority ecosystem services relevant to the project are identified during scoping, the impact analysis stage of the ESIA involves an assessment of impact and dependence on these ecosystem services across biophysical and socio-economic disciplines. Conducting an integrated assessment of the project impact and dependence on these priority ecosystem services entails three steps:
  - *Step 4* assesses the negative project impact on priority ecosystem services in terms of changes in beneficiaries' well-being.
  - *Step 5* assesses the dependence of the project on priority ecosystem services in terms of changes in project performance.
  - *Step 6* consists of the production of a summary report on the findings of *Steps 4* and *5*.

- ***Mitigation stage.*** Addressing ecosystem services at this stage will ensure that the project design and environmental management plan are informed by the mitigation hierarchy to enhance or at least maintain beneficiaries' well-being at levels they deem acceptable, and to manage project dependence on priority ecosystem services to enhance or at least maintain project performance at levels the project developers deem acceptable.

  It includes one step:

  – *Step 7* proposes relevant biophysical and/or socio-economic options to enhance or at least maintain the well-being of affected beneficiaries and project performance at acceptable levels.

Each step is associated with supporting tools and guidance, and many of them require engaging the ecosystem service beneficiaries (Table 1).

Table 1 | **ESR for IA Steps to Address Ecosystem Services in Impact Assessment, and Associated Tools**

ESIA stages	ESR for IA steps	Associated tools
Scoping	1. Prioritize ecosystem services because of project impact[a]	• *Impact Scoping Tool* —Questionnaire to identify drivers of ecosystem change likely to be associated with the project —Questionnaires to identify potentially impacted ecosystems and ecosystem services, and potentially affected beneficiaries —Questionnaire to assess project impact on ecosystem services • Guidance on engaging affected beneficiaries to assess the significance of project impact on ecosystem services
	2. Prioritize ecosystem services because of project dependence	• *Dependence Scoping Tool* —Questionnaire to assess project dependence on ecosystem services
	3. Establish the ESIA Terms of Reference for ecosystem services	• Guidance on producing the ToR regarding ecosystem services
Impact analysis	4. Assess negative project impact on priority ecosystem services[a]	• *Baseline Tool* —Questionnaire to assess current supply of priority ecosystem services and their contribution to beneficiaries' well-being —Questionnaire to estimate foreseeable supply of priority ecosystem services and their contribution to beneficiaries' well-being in the absence of the project • *Impact Analysis Tool* —Questionnaire to assess project impact on supply of priority ecosystem services in terms of changes in beneficiaries' well-being • Guidance on engaging affected beneficiaries to assess changes in their well-being due to the project and define acceptable levels of change
	5. Assess project dependence on priority ecosystem services[b]	• *Dependence Analysis Tool* – Questionnaire to assess project dependence on supply of priority ecosystem services in terms of changes in project performance • Guidance on engaging third-party beneficiaries to assess their impact on priority ecosystem services
	6. Produce summary report	• Guidance on summarizing results of project impact and dependence assessments on priority ecosystem services
Mitigation	7. Identify options to enhance or at least maintain affected beneficiaries' well-being and project performance derived from ecosystem services at acceptable levels[a,b]	• Guidance on identifying options to mitigate negative project impact on beneficiaries' well-being and manage project dependence on ecosystem services • Guidance on engaging affected beneficiaries to enhance or at least maintain their well-being, and third-party beneficiaries to enhance or at least maintain project performance at acceptable levels

[a] This step requires engaging affected ecosystem service beneficiaries.
[b] This step requires engaging third-party ecosystem service beneficiaries.

Section 3 of this working paper provides detailed instructions on how to carry out *Steps 1, 2,* and *3* of the ESR for IA and introduces the associated tools to address ecosystem services during scoping. Instructions for steps 4 to 7 will be presented in the second working paper *Ecosystem Services Review for Impact Assessment: Guide to Impact Analysis and Mitigation*.

Projects that take place among communities who are vulnerable to ecosystem change or where its performance is vulnerable to ecosystem change would obviously benefit from addressing ecosystem services. However, all projects that require an ESIA should go through steps 1 and 2 to decide whether any ecosystem services should be included in further stages of the ESIA, and if so whether they should be undergoing an integrated impact assessment across biophysical and socio-economic disciplines.

2.3 Engagement of ecosystem service beneficiaries throughout the Ecosystem Services Review for Impact Assessment

Stakeholder engagement is now understood to be a continuous process spanning the life of the project between a company and "persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively" (IFC 2007). The economic and reputational advantages of maintaining constructive relationships with various stakeholders have led companies to go beyond engaging them at the scoping and review stages to voluntarily applying principles for more effective engagement. These include preparing stakeholders before engaging; gaining their free, prior, and informed consent; and promoting participatory monitoring by stakeholders themselves (Herbertson 2009).

While engaging stakeholders during scoping and review of the ESIA report is often a legal requirement, input from ecosystem services beneficiaries is absolutely essential throughout the ESIA process for assessing the links between ecosystem services, human well-being, and the project to (1) enhance or at least maintain the well-being of people benefiting from ecosystems impacted by the project at a level they deem acceptable; and (2) enhance or at least maintain project performance at a level the project developers deem acceptable.

Following these two objectives, there are two distinct, but not mutually exclusive, groups of stakeholders regarding ecosystem services: namely, "affected (ecosystem service) beneficiaries" who may be affected by the project as a result of its negative impact on the services that support their well-being, and "third-party (ecosystem service) beneficiaries" who may affect project performance as a result of their impact on services upon which the project depends. Both affected and third-party beneficiaries might be identified at local, regional, and/or global scales, depending on the ecosystem service they depend on or impact.

Enhancing or at least maintaining the well-being of affected beneficiaries at a level they deem acceptable must be informed by the beneficiaries themselves. It requires these beneficiaries to explain their level of dependence on affected ecosystem services, which allows the ESIA team to predict the change in well-being due to the project impact on these services. These beneficiaries also have to define the extent of loss in well-being they would be ready to accept, and help find options to mitigate the loss of well-being they define as unacceptable. This first group of stakeholders needs to be engaged as early as possible in the ESIA process, certainly starting with the prioritization of ecosystem services because of impact (*Step 1*).

The other category of stakeholders who need to be engaged when addressing ecosystem services in ESIA are those who affect the ecosystem services on which the project depends. These third-party beneficiaries are the ones who drive change in the ecosystems that supply services important to the project and could therefore impact project performance. These stakeholders need to be engaged to understand how they drive ecosystem change and what could influence their behavior to limit risks to project performance. This second category of stakeholders can be engaged later in the

ESIA process, at the latest during the assessment of project dependence on priority ecosystem services (*Step 5*).

In the instructions presented in the rest of the guidance note, the ESIA team will be advised about which group of stakeholders to engage regarding ecosystem services and why it is necessary to engage them in each step of the ESR for IA where stakeholder input is required.

3. SCOPING STAGE: STEPS AND ASSOCIATED TOOLS

At the ESIA scoping stage, the ESIA team selects the environmental and socio-economic aspects that warrant further study and also establishes the terms of reference for the ESIA (IAIA 1999, UK Environment Agency 2002). Addressing ecosystem services during scoping requires the ESIA team to identify priority ecosystem services, namely those services that are particularly important for enhancing or at least maintaining the well-being of affected beneficiaries or project performance. These priority ecosystem services should be addressed in an integrated way in subsequent steps of the ESIA, which requires the ESIA team to establish ecosystem services data and analysis requirements in the ESIA terms of reference.

Addressing ecosystem services at the scoping stage entails three steps:

Step 1 - Prioritize ecosystem services because of project impact: Identify and rank ecosystem services according to the significance of project impact on each of them.

Step 2 - Prioritize ecosystem services because of project dependence: Identify and rank ecosystem services according to the extent of project dependence on each of them.

Step 3 - Establish the ESIA terms of reference regarding ecosystem services: Specify what the ESIA team will need to include in the ESIA in terms of data needs, analyses, and stakeholder engagement to assess the project impact and dependence on ecosystem services.

Scoping for ecosystem services does not require much information beyond the data used for a typical ESIA scoping process. However, it does necessitate more dialogue between the biophysical and socio-economic teams. When the ESIA team convenes to address ecosystem services during scoping, the individual specialists should have already conducted their own scoping exercise, resulting in the identification of key biophysical and socio-economic issues to be addressed in the ESIA and the delineation of geographic impact areas. Addressing ecosystem services will heavily rely on, and benefit from, the scoping exercises conducted by each specialist separately.

Step 1 – Prioritize ecosystem services because of project impact

The goal of this step is to determine which ecosystem services impacted by the project could add the most value to the ESIA if they were assessed using an integrated approach across biophysical and socio-economic disciplines.

For a project to **impact** an ecosystem service, it must impact an ecosystem that has the ecological capacity to supply this service and for which ecosystem service beneficiaries can be identified. For a project to **significantly impact** an ecosystem service, it must lead to a loss of beneficiaries' well-being. The significance of a project impact on an ecosystem service is therefore a function of the potential *magnitude of impact* on that ecosystem service and the *vulnerability of the affected beneficiaries* to changes in that ecosystem service.

There are six questions practitioners should answer to identify which ecosystem services are likely to be impacted (questions 1.1, 1.2, 1.3, and 1.4) and to assess the significance of the potential impact on these ecosystem services (questions 1.5 and 1.6):

Question 1.1: Which drivers of ecosystem change are likely to be associated with the project?

The project can drive ecosystem change in various ways. It can be associated with:

1. Direct drivers of change (e.g., effluent discharge);
2. Indirect drivers of ecosystem change (e.g., increase in migration), which in turn might change the rate at which direct drivers affect ecosystems;
3. Changes in the well-being of the ecosystem service beneficiaries (e.g., alternative source of income), which in turn might change the beneficiaries' demand for ecosystem services and therefore the rate at which direct drivers affect ecosystems.

Based on the technical description of the project and knowledge of the project sector, the ESIA team needs to systematically identify which drivers of ecosystem change are likely to be associated with the project.

Question 1.2: Which ecosystems could be impacted by the project?

Once all the drivers of change associated with the project are identified, the ESIA team needs to identify which ecosystems could be affected. There are two types of ecosystems potentially impacted: (1) ecosystems impacted as a result of the project's contribution to direct drivers of ecosystem change (biophysical changes) and, (2) ecosystems impacted as a result of the project's contribution to indirect drivers of ecosystem change, or to the well-being of the ecosystem services beneficiaries (socio-economic changes). The process to identify these two types of ecosystems is different.

Regarding the ecosystems impacted by the project's contribution to direct drivers, practitioners need to identify the ecosystems where the project's own activities induce land cover changes, pollution, introduction of invasive species, or consumption of natural resources. These ecosystems have most likely already been identified by the biophysical specialists during their respective scoping exercises.

Regarding the ecosystems impacted as a result of the project's contribution to indirect drivers of ecosystem change or to beneficiaries' well-being, the practitioners need to predict how demographic, social, economic, or cultural changes identified by the socio-economic specialists during their own scoping exercises might affect ecosystems. For example, the project may attract numerous job seekers due to the employment opportunities offered by the project (demographic/economic changes). In this case, practitioners will need to identify the ecosystems at risk of conversion to settlement or agriculture, pollution, or resource consumption as a result of the newcomers. For example, if the project aims to provide electricity to rural communities, these communities are likely to rely less on forests or bushland for firewood.

At this stage, it is not necessary to assess *how much* the project could affect these ecosystems—only that there could be some impact.

Question 1.3: Which ecosystem services could be impacted as a result of the project impact on these ecosystems?

Once the ecosystems that could be impacted by the project are identified, the practitioners can infer which ecosystem services might be impacted as a result (Annex 2). At this stage, the ecosystem services are identified based on the ecological capacity of the ecosystems potentially impacted to supply them.

Question 1.4: Who are the potentially affected ecosystem service beneficiaries?

Ecosystem service beneficiaries are those people who depend on ecosystem services to maintain their basic subsistence, health, income, personal security, or culture. Practitioners should be sure to consider local, regional, and global beneficiaries of each service, where applicable. If no beneficiaries can be found for a service identified in Question 1.3, no assessment of project impact significance is necessary, since by definition there are no ecosystem services without beneficiaries.

Based on the list of potentially impacted ecosystem services, the ESIA practitioners need to check with people who might be benefiting from these ecosystem services to ensure they are not overlooking any potentially affected beneficiaries. Note that the socio-economic team needs to be assisted by the biophysical team when engaging ecosystem service beneficiaries at this early stage. Indeed, while beneficiaries might easily identify ecosystem services they directly benefit from (most likely provisioning and cultural services), they are likely to overlook those on which they depend indirectly (regulating and supporting services). The biophysical team would help unveil the latter services.

Question 1.5: Could the project reduce the benefits that any beneficiaries derive from this ecosystem service?
The project has a high magnitude of impact if it would reduce the benefits that beneficiaries derive from an ecosystem service, as in any of the following cases:

- The project physically restricts access to the ecosystem supplying this ecosystem service, preventing the beneficiaries from accessing the service; or
- The project impact on this ecosystem service triggers a regulatory response from local or national government, which results in restricted access to the ecosystem service (e.g., as a result of the project, toxicity exceeds the legal limit leading to a government ban on use of the water by humans); or
- The project diminishes the supply of this ecosystem service by degrading the ecosystem that supplies the service. The reduced supply leads to scarcity of the service and thereby decreases the ability of some beneficiaries to meet their demand for this service; or
- The project increases the demand for this ecosystem service either directly (because it depends on the service for its own performance) or indirectly (by increasing demand for this ecosystem service by others). The increased demand heightens competition for this ecosystem service and thus reduces the ability of some beneficiaries to meet their demand for this service.

Question 1.6: Is this ecosystem service a major contributor to the well-being of any of the potentially affected beneficiaries?
To estimate the *vulnerability of the affected beneficiaries* to change in the ecosystem services potentially impacted with high magnitude, practitioners need to find out from the potentially affected beneficiaries whether any of these ecosystem services is a major contributor to their basic subsistence, health, income, personal security, or culture. During this engagement with stakeholders, the ESIA team should also work with the affected beneficiaries to rank ecosystem services with "high significance of impact" according to their sensitivity and ability to adapt to changes in these ecosystem services.

Based on the answers to these questions, practitioners identify potentially impacted ecosystem services and place them in three categories (Figure 2):

- Ecosystem services with **"high significance of impact"**. These ecosystem services are priority ecosystem services. Their socio-economic and biophysical aspects need to be addressed in further stages of the ESIA in an integrated way across both disciplines.
- Ecosystem services with **"medium significance of impact"**. Both socio-economic and biophysical aspects of these ecosystem services should be addressed in further stages of the ESIA and therefore are also included in the ToR as ecosystem services. However, though highly impacted, they are not deemed important enough to their beneficiaries to warrant an integrated assessment. Instead, these ecosystem services are addressed only by the biophysical team with the aim of maintaining the conditions under which they can contribute to beneficiaries' well-being. For example, if a river is known to be a source of drinking water, the biophysical team needs to mitigate project pollution within WHO standards. However, practitioners need to consider re-classifying a non-priority ecosystem service as a priority ecosystem service if further data collection and stakeholder engagement reveal that the ecosystem service is actually important enough to be addressed in an integrated way across biophysical and socio-economic disciplines.

- Ecosystem services with **"low significance of impact"**. These ecosystem services are impacted but not to the point where beneficiaries suffer losses in well-being. From an ecosystem service perspective, they will be excluded from further stages of the ESIA. In case they are included in the ToR by an individual specialist, they are addressed without consideration for their contribution to human well-being.

Annex 3 illustrates a hypothetical but realistic example of Step 1.

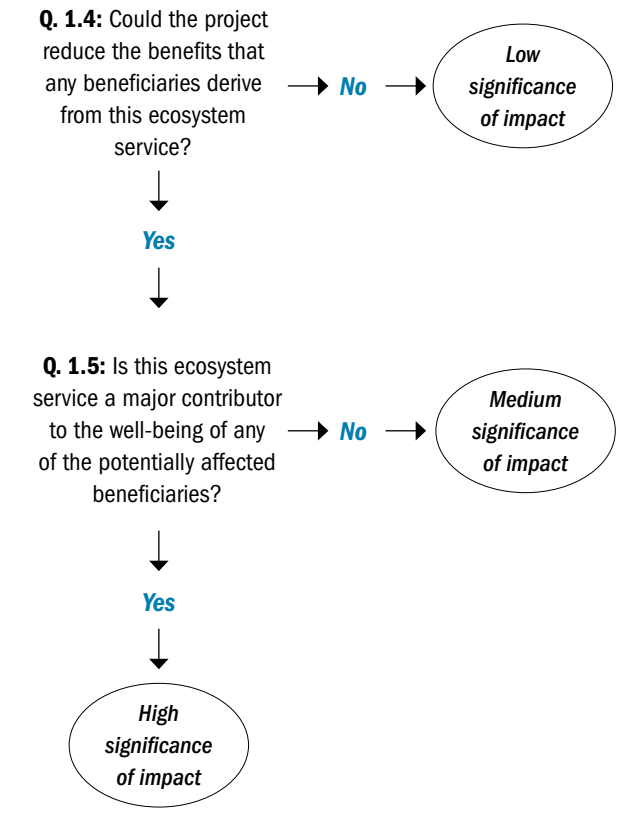
Step 2 – Prioritize ecosystem services because of project dependence

ESIAs commonly focus on the project's impact on the biophysical and socio-economic environments. However, rising scarcity of some ecosystem services makes the case for ESIAs to examine both project impact and dependence on ecosystem services. Information about project dependence on ecosystem services and the ecosystems that supply them can uncover potential sources of operational ecosystem-related risks and opportunities and help improve project design.

This step aims to determine which ecosystem services should be analyzed in an integrated way across biophysical and socio-economic disciplines to help manage project dependence on ecosystems.

The **extent** of project dependence on an ecosystem service is a function of whether the project has cost-effective alternatives to this ecosystem service to achieve successful performance. Practitioners should answer three questions to assess the extent of ecosystem service dependence (questions 2.1 and 2.2) and to identify which ecosystems are supplying these services and might therefore need to be managed carefully to ensure successful project performance (question 2.3):

Figure 2 | **Decision Tree to Evaluate the Significance of Negative Project Impact on Ecosystem Services**



Source: WRI, adapted from ESR 2008.

Question 2.1: Does the project depend on this ecosystem service for successful performance?

A project *depends* on an ecosystem service if the service fulfills any of the following objectives:

- This ecosystem service is an operational input or process; it enables project success by providing an input or process in the necessary quantity and quality, in due time, and at reasonable price; or
- This ecosystem service helps the project meet legal and regulatory requirements while minimizing compliance costs; or

- This ecosystem service supports a Corporate Social Responsibility activity; or
- This ecosystem service contributes to staff health and safety by providing a clean physical environment for good personal hygiene and health, and security from natural and human-made disasters; or
- This ecosystem service helps with staff retention and recruitment by providing agreeable working conditions, leisure activities, or sources of personal fulfillment.

Note that the biophysical team plays an important role in identifying the ecosystem services the project indirectly depends on (regulating and supporting services) which otherwise are likely to be overlooked.

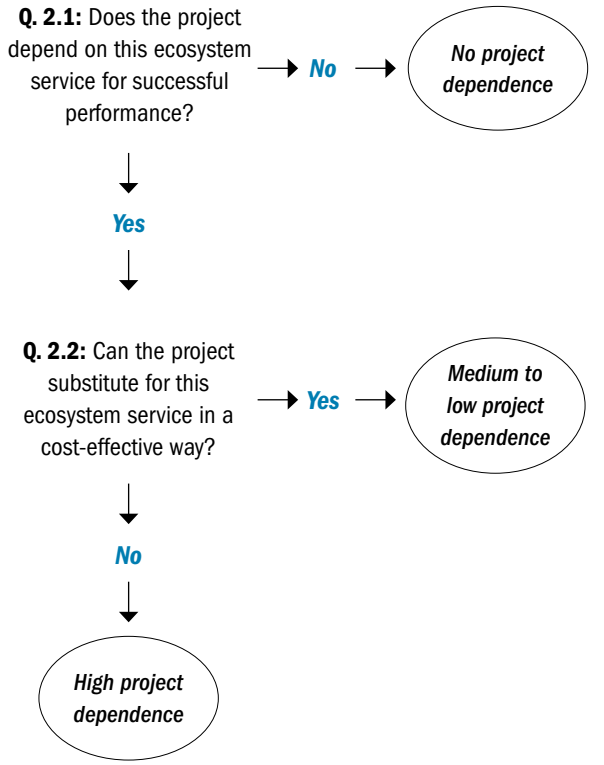
Question 2.2: Can the project substitute for this ecosystem service in a cost-effective way?

The extent to which a project depends on an ecosystem service is determined by the availability of cost-effective substitutes for this ecosystem service.

Based on the answers to these questions, practitioners categorize the ecosystem services in three ways (Figure 3):

- Ecosystem services with **"high project dependence"**. These ecosystem services are priority ecosystem services and need to be addressed in further stages of the ESIA in an integrated way across biophysical and socio-economic disciplines.
- Ecosystem services with **"medium to low project dependence"**. However important to project performance, these ecosystem services can be substituted in a cost-effective way. Consequently, they can be excluded from further stages of the ESIA.
- Ecosystem services with **"no project dependence"**. These ecosystem services are not relevant to project performance and are excluded from further stages of the ESIA.

Figure 3 | **Decision Tree to Evaluate Project Dependence On Ecosystem Services**



Source: WRI, adapted from ESR 2008.

Question 2.3: Which ecosystems supply this ecosystem service to the project (only for ecosystem services with "high project dependence")?

An ecosystem supplies an ecosystem service to the project if it fills two requirements: (1) it has the ecological capacity to supply the ecosystem service (practitioners can use references such as the Burkhard et al. 2009 table in Annex 2 to identify which ecosystems are highly relevant to the supply of each ecosystem service), and (2) the ecosystem location relative to the project allows the project to benefit from the services the ecosystem supplies. For example, a project benefits from the regulation of water flows provided by a forest if the forest is located upstream from the project, but a project benefits from the purification

of effluent discharge by a wetland if the wetland is downstream from its facility.

Annex 3 illustrates a hypothetical but realistic example of Step 2.

Step 3 – Establishing the environmental and social impact assessment Terms of Reference regarding ecosystem services

The terms of reference (ToR) of an ESIA are the written requirements governing ESIA implementation, consultations to be held, data to be produced, and contents of the ESIA report (UNEP 2002). Among other things, ToR often identify the tasks to be carried out, information gaps to be addressed, and studies to be carried out to provide and present the information needed by decision makers regarding the project.

Once ecosystem services have been prioritized, the ESIA ToR need to state explicitly the tasks to be conducted by the ESIA team regarding the ecosystem services to be addressed in further stages of the ESIA: (1) the "priority ecosystem services" requiring an integrated assessment and, (2) the "non-priority ecosystem services" requiring a biophysical assessment watchful of their contribution to well-being and/or project performance.

In the event that more priority ecosystem services are identified for an integrated assessment than are practical to address in the ESIA given time and budget constraints, the number of priority ecosystem services needs to be narrowed down. A second set of selection criteria that could be applied are:

- ***High significance of impact over high project dependence:*** Priority ecosystem services identified because of the significance of project impact should be chosen over the ones identified because of the project dependence.
- ***Ease of establishing effective and efficient measures to mitigate impact and manage dependence on priority ecosystem services:*** Those ecosystem services that will need further data and analysis to apply the mitigation hierarchy and develop effective mitigation measures should be prioritized.
- ***Identified by the affected ecosystem service beneficiaries as most critical:*** The final list of priority ecosystem services should prioritize those ecosystem services pinpointed by the affected beneficiaries because they consider themselves most sensitive and least able to adapt to their changes.

The priority ecosystem services excluded from the final list should be added to "non-priority ecosystem services" in the ToR and addressed accordingly in further stages of the ESIA. Annex 3 presents an example of the second round of selection.

To describe the expectations regarding priority and non-priority ecosystem services in further stages of the ESIA, the ToR could include the following sections dedicated to ecosystem services in the background information and the scope of work:

Background information

The background information regarding ecosystem services summarizes the results from the previous prioritization exercises and covers:

1.1 **Contribution of the project to direct and indirect drivers of ecosystem change.** This section lists the direct and indirect drivers of ecosystem change that are likely to be associated with the project.

1.2 **Priority ecosystem services (because of either high impact or high dependence).** This section should list the priority ecosystem services and a short summary justifying their selection and important issues which need to be addressed across biophysical and socio-economic disciplines in further stages of the ESIA process. The ecosystem services that were prioritized because of both high significance of project impact and high project dependence must be highlighted; these services need to undergo both impact and dependence analyses. The extent to which affected beneficiaries were engaged in prioritizing ecosystem services because of project impact needs to be specified.

1.3 **Non-priority ecosystem services (ecosystem services that scored "medium significance of impact" or priority ecosystem services that didn't make the final list).** This section should provide a list of the ecosystem services with "medium significance of impact" and a short summary reflecting the scoring and assessment process during the ranking exercise. If there has been a second set of selection criteria applied to narrow the number of priority ecosystem services, this section should single out those priority ecosystem services that didn't make the final list and explicitly state the criteria used to downgrade them to non-priority ecosystem services. This section should also make some recommendations regarding the biophysical assessment of impact on these ecosystem services by specifying the biophysical requirements to be met to enhance or at least maintain the contribution of these services to well-being despite of project impact.

1.4 **Delineation of the ecosystem service project area.** The *ecosystem service project area* is the area relevant to the assessment of project impact and dependence on priority ecosystem services. It includes:

- the ecosystems supplying the services identified as priority ecosystem services due to the significance of expected project impact;
- the potentially affected beneficiaries; and
- the ecosystems supplying the services identified as priority ecosystem services because the project is highly dependent on them.

This section should describe how the *ecosystem service project area* was delineated. It should note which ecosystems and beneficiaries were identified as a result of the project's contribution to (1) direct drivers of ecosystem change and, (2) indirect drivers of ecosystem change (including what assumptions were made regarding these indirect drivers), and which ecosystems were identified because of the project dependence on their services.

1.5 **Information gaps.** This section should also note any unanswered questions about the relationships between ecosystem services the project potentially impacts or depends on, the ecosystems that supply them, and the beneficiaries whose well-being may potentially be impacted by the project. It should request that additional information be collected in the impact analysis stage to address these information gaps and clarify these relationships.

Scope of work

Task 1: Establish the Baseline Study—Current Conditions for the Priority Ecosystem Services (exclusively for ecosystem services prioritized because of high significance of project impact).

This section of the ToR specifies key requirements for ESIA practitioners to assess the current contribution of priority ecosystem services to their beneficiaries' well-being (*Step 4* of the ESR for IA). To guide this assessment, the ToR should require the biophysical and socio-economic teams to collect data and information, and engage affected beneficiaries to:

1.1 **Identify the key ecosystems that contribute to the supply of priority ecosystem services.** This more detailed appraisal of the relationship between the priority ecosystem services and these key ecosystems might entail a revision of the *ecosystem service project area*. **Lead:** Biophysical team.

1.2 **Identify the beneficiaries of the priority ecosystem services.** This task seeks to understand how these priority ecosystem services contribute to the beneficiaries' well-being and whether each of them is in sufficient supply relative to demand. This more detailed appraisal of the relationship between the priority ecosystem services and their beneficiaries might entail a revision of the *ecosystem service project area*. **Lead:** Socio-economic team.

1.3 **Identify and characterize the current direct drivers of ecosystem change** with respect to these key ecosystems and their relative importance in driving ecosystem change in these ecosystems. **Lead:** Biophysical team.

1.4 **Identify and characterize the current indirect drivers of ecosystem change** with respect to these ecosystems and their relative importance in accelerating or decelerating change. **Lead:** Socio-economic team.

Task 2: Establish the Baseline Study—Expected Trends for the Priority Ecosystem Services (exclusively for ecosystem services prioritized because of high significance of project impact). This section of the ToR specifies key requirements for ESIA practitioners to assess the foreseeable contribution of priority ecosystem services to the beneficiaries' well-being in the absence of the project (continuation of *Step 4*). To complete this assessment, the ToR should require the biophysical and socio-economic teams to collect data and information, and engage affected beneficiaries to:

2.1 **Predict the supply of priority ecosystem services in the absence of the project** over the temporal scale of the ESIA. **Lead:** Biophysical team.

2.2 **Predict to what extent the supply of priority ecosystem services will meet beneficiaries' demand in the absence of the project** over the temporal scale of the ESIA. **Lead:** Socio-economic team.

Task 3: Conduct Impact Analysis on Priority Ecosystem Services (exclusively for ecosystem services prioritized because of high significance of project impact).

To complete *Step 4*, practitioners need to assess the negative project impact on priority ecosystem services in terms of change in well-being. The ToR should require the biophysical and socio-economic teams to collect data and information, and engage affected beneficiaries to:

3.1 **Predict the supply of priority ecosystem services in the presence of the project** over the temporal scale of the ESIA. **Lead:** Biophysical team.

3.2 **Predict to what extent the supply of priority ecosystem services will meet the beneficiaries' demand in the presence of the project** over the temporal scale of the ESIA, including any increase or decrease in demand for ecosystem services that results from the project's contribution to the well-being of affected beneficiaries. **Lead:** Socio-economic team.

3.3 **Predict the changes in beneficiaries' well-being that results from changes in priority ecosystem services because of the project** over the temporal scale of the ESIA. **Lead:** Socio-economic team.

3.4 **Define what the affected beneficiaries deem to be an acceptable loss of well-being** and start exploring options following the mitigation hierarchy to enhance or at least maintain their well-being at that level. **Lead:** Socio-economic team.

Task 4: Conduct Dependence Analysis on Priority Ecosystem Services (exclusively for ecosystem services prioritized because of high project dependence).

Step 5 assesses the project dependence on priority ecosystem services in terms of change in project performance. To implement *Step 5*, the ToR should require the biophysical and socio-economic teams to collect data and information, and engage third-party beneficiaries to:

4.1 **Predict the supply of priority ecosystem services in the presence of the project** over the temporal scale of the ESIA. **Lead:** Biophysical team.

4.2 **Predict to what extent the supply of priority ecosystem services will meet the project's demand** over the temporal scale of the ESIA, including any increase or decrease in demand for these services that results from the project's development over time. **Lead:** Socio-economic team.

4.3 **Predict changes in project performance as a result of changes in priority ecosystem services** over the lifetime of the project. **Lead:** Socio-economic team.

Task 5: Identify Measures to Mitigate Impact and Manage Dependence on Priority Ecosystem Services (for both ecosystem services prioritized because of high significance of project impact and high project dependence).

To implement *Step 7,* the ToR should require the biophysical and socio-economic teams to collect data and information and engage both affected and third-party beneficiaries to apply the mitigation hiearchy and:

5.1 **Propose biophysical options to enhance or at least maintain the affected beneficiaries' well-being and project performance at acceptable levels** over the temporal scale of the ESIA. **Lead:** Biophysical team.

5.2 **Propose socio-economic options to enhance or at least maintain the affected beneficiaries' well-being and project performance at acceptable levels** over the temporal scale of the ESIA. **Lead:** Socio-economic team.

4. NEXT STEPS

The ESR for IA as presented in this paper is intended to help ESIA practitioners address ecosystem services throughout the ESIA process. Through its framework and detailed instructions on implementation of the framework within the ESIA process, the ESR for IA supports an integrated approach to impact assessment across biophysical and socio-economic disciplines.

This first working paper helps environmental and social impact assessment practitioners systematically address ecosystem services at the scoping stage. It provides clear guidance on how to identify the ecosystem services that need to be included in the ESIA and describes what the ESIA ToR needs to specify to address these services in subsequent ESIA stages.

A second working paper *Ecosystem Services Review for Impact Assessment: Guide to Impact Analysis and Mitigation*, to be released in early 2012, will provide similar detailed guidance to the ESIA team on implementing the ESIA ToR. It will inform the assessment of project impact and dependence on ecosystem services and propose principles to design efficient and effective measures that mitigate negative project impact and manage project dependence on ecosystem services. The two working papers will be road-tested on actual ESIAs being undertaken between January and September 2012. The goals of the road-testing process are to obtain practical feedback that will improve the instructions and associated tools, as well as to establish champion companies and flagship ecosystem service-based ESIAs to promote as success stories.

We invite ESIA practitioners to take part in the road-test. This opportunity is ideal for environmental and social practitioners who work for companies that wish to identify more effective ways to mitigate negative impacts on ecosystem services, meet the International Finance Corporation's new Performance Standards, or establish themselves as leaders in incorporating ecosystem services in environmental and social impact assessment.

This paper is a work in progress. Readers are invited to send comments, ask questions, or discuss issues on the webpage of the guidance note.

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GLOSSARY

An **ecosystem** is a dynamic complex of plant, animal, and micro-organism communities and their nonliving environment interacting as a functional unit (UN 1992).

Ecosystem services are benefits that ecosystems provide to people (MA 2003). They can be classified into four categories that are closely related and dependent on one another:

- *Provisioning services* are the goods or products obtained from ecosystems, such as food, timber, fiber, and freshwater.
- *Regulating services* are the benefits obtained from an ecosystem's control of natural processes, such as climate regulation, disease control, erosion prevention, water flow regulation, and protection from natural hazards.
- *Cultural services* are the nonmaterial benefits obtained from ecosystems, such as recreation, spiritual values, and aesthetic enjoyment.
- *Supporting services* are the natural processes, such as nutrient cycling and primary production, which maintain the other services.

Annex 1 provides a list of 23 ecosystem services with their definitions and some examples.

Human well-being is assumed to have multiple constituents, including the *basic material for a good life*, such as secure and adequate livelihoods, enough food at all times, shelter, clothing, and access to goods; *health*, including feeling well and having a healthy physical environment, such as clean air and access to clean water; *security*, including secure access to natural and other resources, personal safety, and security from natural and human-made disasters; *good social relations*, including social cohesion, mutual respect, and the ability to help others and provide for children; and *freedom of choice and action*, including the opportunity to achieve what an individual values doing and being (MA 2005). **Well-being derived from ecosystem services** are the constituents of well-being to which ecosystem services directly or indirectly contribute.

Ecosystem service beneficiaries, or beneficiaries, are those people who depend on ecosystem services to maintain their basic subsistence, health, income, personal security or culture; this group does not include the project for which the environmental and social impact assessment is carried out. According to the ecosystem service, beneficiaries can be identified at global, regional, and/or local scales. There are two distinct groups of stakeholders to be engaged regarding ecosystem services: **affected ecosystem service beneficiaries,** or affected beneficiaries, are the ones who depend on ecosystem services that might be impacted as a result of the project impact on ecosystems; **third-party ecosystem service beneficiaries**, or third-party beneficiaries, are the ones who may affect project performance as a result of their impact on ecosystem services upon which the project depends.

A **priority ecosystem service** is an ecosystem service that the project either significantly impacts or significantly depends on. Priority ecosystem services need to be addressed across biophysical and socio-economic disciplines in the environmental and social impact assessment process to enhance or at least maintain the well-being of affected beneficiaries or the project performance derived from ecosystem services.

A project **depends on** an ecosystem service if that service functions as an input or process for the project or if the ecosystem service enables, enhances, or influences environmental conditions required for successful project performance.

A project **impacts** an ecosystem service if it affects the quantity, quality, timing, or location of the service.

The **ecosystem service project area** is the area relevant to the assessment of project impact and dependence on priority ecosystem services. It includes the ecosystems supplying the priority ecosystem services and the location of the potentially affected ecosystem service beneficiaries.

A **direct driver** of ecosystem change unequivocally influences ecosystem processes**.** The direct drivers are primarily physical, chemical, and biological factors, and may include land cover change, climate change, air and water pollution, irrigation, use of fertilizers or pesticides, resource consumption, and species introduction or removal (MA 2005).

An **indirect driver** of ecosystem change operates more diffusely, by altering one or more direct drivers. There are five types of indirect drivers of changes in ecosystems and their services: demographic (i.e. population change), changes in economic activity (e.g., globalization, trade, markets), sociopolitical factors (e.g., governance, institutional and legal framework), cultural factors (e.g., beliefs, consumption choices), and technological change (MA 2005).

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ANNEX 1. LIST OF ECOSYSTEM SERVICES WITH DEFINITIONS AND EXAMPLES

Service	Subcategory	Definition	Examples
Provisioning services: The goods or products obtained from ecosystems			
Food	Crops	Cultivated plants or agricultural products harvested by people for human or animal consumption as food	• Grains • Vegetables • Fruits
	Livestock	Animals raised for domestic or commercial consumption or use	• Chickens • Pigs • Cattle
	Capture fisheries	Wild fish captured through trawling and other non-farming methods	• Cod • Crabs • Tuna
	Aquaculture	Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of freshwater or saltwater confinement for purposes of harvesting	• Shrimp • Oysters • Salmon
	Wild foods	Edible plant and animal species gathered or captured in the wild	• Fruits and nuts • Fungi • Bushmeat
Biological raw materials	Timber and other wood products	Products made from trees harvested from natural forest ecosystems, plantations, or non-forested lands	• Industrial roundwood • Wood pulp • Paper
	Fibers and resins	Non-wood and non-fuel fibers and resins	• Cotton, silk, hemp • Twine, rope • Natural rubber
	Animal skins	Processed skins of cattle, deer, pigs, snakes, sting rays, or other animals	• Leather, rawhide, cordwain
	Sand	Sand formed from coral and shells	• White sand from coral and white shells • Colored sand from shells
	Ornamental resources	Products derived from ecosystems that serve aesthetic purposes	• Tagua nut, wild flowers, coral jewelry
Biomass fuel		Biological material derived from living or recently living organisms—both plant and animal—that serves as a source of energy	• Fuelwood and charcoal • Grain for ethanol production • Dung
Freshwater		Inland bodies of water, groundwater, rainwater, and surface waters for household, industrial, and agricultural uses	• 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	• Genes used to increase crop resistance to disease or pests
Biochemicals, natural medicines, and pharmaceuticals		Medicines, biocides, food additives, and other biological materials derived from ecosystems for commercial or domestic use	• Echinacea, ginseng, garlic • Paclitaxel as basis for cancer drugs • Tree extracts used for pest control
Regulating services: The benefits obtained from an ecosystem's control of 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")	• Lakes serve as a sink for industrial emissions of sulfur compounds • Tree and shrub leaves trap air pollutants near roadways
Regulation of 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	• Forests capture and store carbon dioxide • Cattle and rice paddies emit methane
	Regional and local	Influence ecosystems have on local or regional temperature, precipitation, and other climatic factors	• Forests can impact regional rainfall levels
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	• Permeable soil facilitates aquifer recharge • River floodplains and wetlands retain water—which can decrease flooding—reducing the need for engineered flood control infrastructure

ANNEX 1. LIST OF ECOSYSTEM SERVICES WITH DEFINITIONS AND EXAMPLES *(continued)*

Service	Definition	Examples
Regulating services *(continued)*		
Erosion control	Role ecosystems play in retaining and replenishing soil and sand deposits	• Vegetation such as grass and trees prevents soil loss due to wind and rain and prevents siltation of waterways • Coral reefs, oyster reefs, and sea grass beds reduce loss of land and beaches due to waves and storms
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	• 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 that ecosystems have on the incidence and abundance of human pathogens	• Some intact forests reduce the occurrence of standing water—a breeding area for mosquitoes—which lowers the prevalence of malaria
Regulation of soil quality	Role ecosystems play in sustaining soil's biological activity, diversity, and productivity; regulating and partitioning water and solute flow; storing and recycling nutrients and gases; among other functions	• Some organisms aid in decomposition of organic matter, increasing soil nutrient levels • Some organisms aerate soil, improve soil chemistry, and increase moisture retention
Regulation of pests	Influence ecosystems have on the prevalence of crop and livestock pests and diseases	• Predators from nearby forests—such as bats, toads, and snakes—consume crop pests
Pollination	Role ecosystems play in transferring pollen from male to female flower parts	• 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 tsunamis and to maintain natural fire frequency and intensity	• 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	• Hiking, camping, and bird watching • Going on safari • Scuba diving
Ethical and spiritual values	Spiritual, religious, aesthetic, intrinsic, "existence," or similar values people attach to ecosystems, landscapes, or species	• Spiritual fulfillment derived from sacred lands and rivers • People's desire to protect endangered species and rare habitats
Educational and inspirational values	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation	• The structure of tree leaves has inspired technological improvements in solar power cells • School fieldtrips to nature preserves aid in teaching scientific concepts and research skills
Supporting services: The natural processes that maintain the other ecosystem services		
Habitat	Natural or semi-natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances	• Native plant communities often provide pollinators with food and structure for reproduction • Rivers and estuaries provide nurseries for fish reproduction and juvenile development • Large natural areas and biological corridors allow animals to survive forest fires and other disturbances
Nutrient cycling	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems	• Transfer of nitrogen from plants to soil, from soil to oceans, from oceans to the atmosphere, and from the atmosphere to plants
Primary production	Formation of biological material by plants through photosynthesis and nutrient assimilation	• 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	• Transfer of water from soil to plants, plants to air, and air to rain

Source: Adapted from Hanson et al. 2011.

ANNEX 2. INFERRING ECOSYSTEM SERVICES FROM LAND COVER TYPES

	Ecological integrity Σ	Abiotic heterogeneity	Biodiversity	Biotic waterflows	Metabolic efficiency	Exergy capture (radiation)	Reduction of nutrient loss	Storage capacity (SOM)	Provisioning services Σ	Crops	Livestock	Fodder	Capture fisheries	Aquaculture	Wild foods	Timber	Wood fuel	Energy (biomass)	Biochemicals/medicine	Freshwater	Regulating services Σ	Local climate regulation	Global climate regulation	Flood protection	Groundwater recharge	Air quality regulation	Erosion regulation	Nutrient regulation	Water purification	Pollination	Cultural services Σ	Recreation and aesthetic values	Intrinsic value of biodiversity
Continuous urban fabric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Discontinuous urban fabric	7	1	1	1	1	1	1	1	3	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial or commercial units	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Road and rail networks	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Port areas	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	1	1	0
Airports	7	1	1	1	1	1	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mineral extraction sites	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dump sites	8	2	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction sites	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green urban areas	18	3	3	2	1	4	3	2	2	0	0	0	0	0	1	0	1	0	0	0	11	2	1	0	2	1	2	1	1	1	3	3	0
Sport and leisure facilities	16	2	2	2	1	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	9	1	1	0	2	1	1	1	1	1	5	5	0
Non-irrigated arable land	22	3	2	3	4	5	1	4	21	5	5	5	0	0	0	0	0	5	1	0	5	2	1	1	1	0	0	0	0	0	1	1	0
Permanently irrigated land	21	3	2	5	2	5	1	3	18	5	5	2	0	0	0	0	0	5	1	0	5	3	1	1	0	0	0	0	0	0	1	1	0
Ricefields	20	3	2	5	1	5	1	3	7	5	0	2	0	0	0	0	0	0	0	0	4	2	0	0	2	0	0	0	0	0	1	1	0
Vineyards	14	3	2	3	1	3	0	2	5	4	0	0	0	0	0	0	1	0	0	0	3	1	1	0	1	0	0	0	0	0	5	5	0
Fruit trees and berries	21	4	3	4	2	3	2	3	13	5	0	0	0	0	0	4	4	0	0	0	19	2	2	2	2	2	2	1	1	5	5	5	0
Olive groves	17	3	2	3	2	3	1	3	12	4	0	0	0	0	0	4	4	0	0	0	7	1	1	0	1	1	1	1	1	0	5	5	0
Pastures	24	2	2	4	5	5	2	4	10	0	5	5	0	0	0	0	0	0	0	0	8	1	1	1	1	0	4	0	0	0	3	3	0
Annual and permanent crops	18	2	2	3	2	4	2	3	20	5	5	5	0	0	0	0	0	5	1	0	7	2	1	1	1	1	1	0	0	0	1	1	0
Complex cultivation patterns	20	4	4	3	2	4	1	3	9	4	0	3	0	0	0	0	0	0	2	0	5	2	1	1	1	0	0	0	0	0	2	2	0
Agriculture and natural vegetation	19	3	3	3	2	3	2	3	21	3	3	2	0	0	3	3	3	3	1	0	13	3	2	1	2	1	3	0	1	0	5	2	3
Agro-forestry areas	27	4	4	4	3	4	4	4	14	3	3	2	0	0	0	3	3	0	0	0	13	2	1	1	1	1	2	1	1	3	3	3	0
Broad-leaved forest	31	3	4	5	4	5	5	5	21	0	0	1	0	0	5	5	5	0	5	0	39	5	4	3	2	5	5	5	5	5	10	5	5
Coniferous forest	30	3	4	4	4	5	5	5	21	0	0	1	0	0	5	5	5	0	5	0	39	5	4	3	2	5	5	5	5	5	10	5	5
Mixed forest	32	3	5	5	4	5	5	5	21	0	0	1	0	0	5	5	5	0	5	0	39	5	4	3	2	5	5	5	5	5	10	5	5
Natural grassland	30	3	5	4	4	4	5	5	5	0	3	0	0	0	2	0	0	0	0	0	22	2	3	1	1	0	5	5	5	0	6	3	3
Moors and heathland	30	3	4	4	5	4	5	5	10	0	2	0	0	0	1	0	2	5	0	0	20	4	3	2	2	0	0	3	4	2	10	5	5
Sclerophyllous vegetation	21	3	4	2	3	3	4	2	8	0	2	0	0	0	1	0	2	0	3	0	7	2	1	1	1	0	0	0	0	2	6	2	4
Transitional woodland shrub	21	3	4	2	3	3	4	2	5	0	2	0	0	0	1	0	2	0	0	0	3	1	0	0	0	0	0	0	0	2	4	2	2
Beaches, dunes, and sand plains	10	3	3	1	1	1	0	1	2	0	0	0	0	0	0	0	0	2	0	0	6	0	0	5	1	0	0	0	0	0	7	5	2
Bare rock	6	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	1	0	0	0	1	0	4	4	0
Sparsely vegetated areas	9	2	3	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	1	1	0	0	0	0	0	0	0	0
Burnt areas	6	2	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Glaciers and perpetual snow	3	2	1	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5	10	3	3	0	4	0	0	0	0	0	5	5	0
Inland marshes	25	3	2	4	4	4	3	5	7	0	2	5	0	0	0	0	0	0	0	0	14	2	2	4	2	0	0	4	0	0	0	0	0
Peatbogs	29	3	4	4	4	4	5	5	5	0	0	0	0	0	0	0	0	5	0	0	24	4	5	3	3	0	0	3	4	2	8	4	4
Salt marshes	23	2	3	4	3	3	3	5	2	0	2	0	0	0	0	0	0	0	0	0	8	1	0	5	0	0	0	2	0	0	3	3	0
Salines	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	2	0
Intertidal flats	13	2	3	0	2	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	7	1	0	5	0	0	0	1	0	0	4	4	0
Water courses	18	4	4	0	3	3	3	1	12	0	0	0	3	0	4	0	0	0	0	5	10	1	0	2	1	0	0	3	3	0	10	5	5
Water bodies	23	4	4	0	4	4	3	4	12	0	0	0	3	0	4	0	0	0	0	5	7	2	1	1	2	0	0	1	0	0	9	5	4
Coastal lagoons	25	4	4	0	5	5	3	4	16	0	0	0	4	5	4	0	0	3	0	0	5	1	0	4	0	0	0	0	0	0	9	5	4
Estuaries	21	3	3	0	5	5	3	2	17	0	0	0	5	5	4	0	0	3	0	0	9	0	0	3	0	0	0	3	3	0	7	4	3
Sea and ocean	15	2	2	0	3	3	4	1	11	0	0	1	5	5	0	0	0	0	0	0	13	3	5	0	0	0	0	5	0	0	6	4	2

Scale: 0, white = no relevant capacity of the land cover type to provide this particular ecosystem service; 1, light orange = low relevant capacity; 2, orange = relevant capacity; 3, pale green = medium relevant capacity; 4, mid green = high relevant capacity; and 5, dark green = very high relevant capacity.

Source: Adapted from Burkhard et al. 2009.

ANNEX 3. APPLICATION OF STEPS 1, 2, AND 3 OF THE ESR FOR IA TO A CASE STUDY

Description of the African oil project

Characteristics of the project

The hypothetical example is a small oil processing and refining facility (4,000 barrels/day) located on the shores of a large inland lake in Africa. The facility has a 2,000 square meter footprint for the plant itself and pipelines to five production wells situated between 0.5 km and 3 km away. There is one water injection flowline between the facility and the one injection well and one pipeline transferring water from the lake to the facility. After the water and gas are separated from the oil, the oil is refined. Water resulting from the processing is treated and combined with the lake water prior to injections in the wells. Produced gas is both flared and used to produce electricity in a small plant that powers the facility. The refined oil is exported by road tankers to the capital, which entails upgrading of existing roads.

Location of the project

The land cover is mostly grassland with patches of riverine forest. There is a papyrus wetland at the mouth of the river, just before the lake. The biophysical impact area was defined as a 15-km buffer around the facility, the flowlines, and the river that might be affected in case of an oil spill. There are two communities in the impact area located along the lake shores. People are poor and largely depend on fish from the lake. Their fish catch is both consumed locally and exported to the nearest towns. Crops are marginal due to lack of precipitation and sandy soils, but many households keep some chickens. There is neither electricity nor improved water supply infrastructure in the communities. They rely on water from both groundwater and the lake, road infrastructure is minimal. The main morbidity and mortality causes are HIV/AIDS, malaria, and water-borne diseases.

Step 1 – Prioritize ecosystem services because of project impact

Question 1.1: Which drivers of ecosystem change are likely to be associated with the project?

Based on the technical description of the oil processing and refining facility and the knowledge of indirect impacts associated with the oil and gas sector (EBI unknown publication date), the ESIA team identifies the drivers of ecosystem change likely to be associated with the project (Table 1).

Table 1 | **Drivers of Ecosystem Change Likely to Be Associated with the Project**

		Q. 1.1- Which drivers of ecosystem change are likely to be associated with the project? *Y Yes, likely to be associated* *N No, not likely to be associated* *? Don't know*	Comments or supporting information *List the activities or factors associated with the project and likely to lead to this driver of ecosystem change*
Direct drivers of ecosystem change	Change in local land use and cover	Y	• Footprint from facility • Footprint from water pipelines from lake to facility
	Harvest and resource consumption	Y	• Water abstraction for filling wells • Water abstraction for domestic use for staff and maintenance of facility
	Pollution	Y	• Leaking along pipelines • Oil spill
	Introduction of invasive species	N	
	Other direct driver of change (specify)	N	
Indirect drivers of ecosystem change	Demographic change	Y	• Increased accessibility from upgrade of roads and construction of new roads • Job advertisement will attract people to the area
	Economic change	Y	• Increased economic activity from increased accessibility to markets
	Sociopolitical change	?	• Increase in political stakes because of resource extraction (land grabbing, corruption)
	Cultural and religious change	N	
	Scientific and technological change	N	
	Other indirect driver of change (specify)	N	
Well-being of ecosystem service beneficiaries	Change in demand for ecosystem service for basic material for a good life	N	• Very few jobs for local people
	Change in demand for ecosystem service for health	N	
	Change in demand for ecosystem service for security	N	
	Change in demand for ecosystem service for good social relations	N	
	Other change in demand for ecosystem service (specify)	N	

Table 2 | **Potentially Impacted Ecosystems**

Direct drivers of ecosystem change associated with the project	Activities associated with the project	Q. 1.2- Which ecosystems could be impacted?	Comments or supporting information
Change in local land use and cover	• Footprint from facility • Footprint of water pipeline from lake to facility • Conversion to settled areas by newcomers • Conversion to cropland by newcomers	• Grassland • Wetland • Grassland • Grassland	
Harvest and resource consumption	• Water abstraction for filling wells • Water abstraction for domestic use for staff and maintenance of facility • Increase in water consumption by newcomers • Increase in woodfuel consumption by newcomers • Increase in fish consumption by newcomers • Increased export of fish thanks to improved accessibility to markets	• Lake • Lake • Lake • Riverine forest • Lake • Lake	
Pollution	• Leaking along pipelines • Oil spill • More domestic pollution by newcomers	• Grassland • Grassland, river, riverine forest, wetland, lake • Grassland, river, wetland, lake	
Introduction of invasive species			
Other direct driver of change (specify)			

Question 1.2: Which ecosystems could be impacted by the project?

Based on the drivers of ecosystem change likely to be associated with the project, the practitioners identify the ecosystems potentially impacted (Table 2). The ecosystems impacted by the project's own activities (i.e. contribution to direct drivers of change) had been identified by the biophysical specialists during their respective scoping exercises. The socio-economic and biophysical specialists collaborate to predict which ecosystems are likely to be impacted as a result of socio-economic changes associated with the project (i.e. contribution to indirect drivers of ecosystem change or beneficiaries' well-being).

Questions 1.3 and 1.4: Which ecosystem services could be impacted as a result of the project impact on these ecosystems? Who are the potentially affected beneficiaries?

For each of the ecosystems identified as potentially impacted, the ESIA team, led by the biophysical team, identifies the ecosystem services based on the ecological capacity of these ecosystems to supply them (e.g., ecosystem services scoring a relevant capacity of 3 or more for each ecosystem potentially impacted, see Annex 2).

Once the ecosystem services that could be potentially impacted are identified from an ecological point of view, the ESIA team, led by the socio-economic team, ascertains which of them have identifiable beneficiaries (at local, regional, or global scale according to the ecosystem service) since there are no ecosystem services without beneficiaries (Table 3).

Table 3 | **Potentially Impacted Ecosystem Services and Potentially Affected Beneficiaries**

Ecosystems potentially impacted	Q.1.3- Which ecosystem services could be impacted as a result of the project impact on these ecosystems?	Q.1.4- Who are the potentially affected beneficiaries?
Grassland	• Food from livestock	• None
	• Global climate regulation	• Global community
	• Erosion control	• None
	• Nutrient cycling	• None
	• Water purification and waste treatment	• Local communities along the lake shore
	• Recreation and ecotourism	• None
	• Ethical and spiritual values	• Local communities inhabiting the grassland and communities with view of the grassland
Lake	• Food from capture fisheries	• Fishing communities at local level and close to the lake
	• Food from wild foods	• None
	• Freshwater	• Communities who get their drinking water from the lake
	• Recreation and ecotourism	• None
	• Ethical and spiritual values	• Riparian communities and communities with view of the lake
	• Primary production	• Fishing communities at local level and close to the lake
	• Habitat for fish	• Fishing communities at local level and close to the lake
Riverine forest	• Food from wild foods	• None
	• Biological raw materials from timber	• Communities within 3-hour walk from riverine forest
	• Biomass fuel from woodfuel	• Communities within 3-hour walk from riverine forest
	• Biochemicals, natural medicines, and pharmaceuticals	• None
	• Local climate regulation	• None
	• Air quality regulation	• None
	• Erosion control	• None
	• Nutrient cycling	• None
	• Water purification and waste treatment	• Local communities who get their drinking water at the mouth of the river
	• Pollination	• None
	• Recreation and ecotourism	• None
	• Ethical and spiritual values	• Local communities using the riverine forest and communities with a view of the riverine forest
Wetland	• Food from livestock	• None
	• Primary production from fodder	• None
	• Natural hazard mitigation	• None
	• Nutrient cycling	• None
	• Water purification and waste treatment	• Communities who get their drinking water from the lake
	• Pollination	• None
	• Habitat (breeding and nursery grounds for fish)	• Fishing communities at local level and close to the lake
River	• Food from capture fisheries	• None
	• Food from wild foods	• None
	• Freshwater	• None
	• Nutrient cycling	• None
	• Water purification and waste treatment	• Local communities who get their drinking water at the mouth of the river
	• Recreation and ecotourism	• None
	• Ethical and spiritual values	• Local communities with a view of the river

Table 4 | **Prioritization of Ecosystem Services According to the Significance of Project Impact**

Ecosystem services identified as impacted	Potential magnitude of negative impact on ecosystem services (pre-mitigation)	
	Q.1.5- Could the project reduce the benefits that any beneficiaries derive from this ecosystem service? *Y Yes* *N No* *? Don't know*	**Comments or supporting information**
Ecosystem services identified as impacted in Grassland		
Regulation of local, regional, and/or global climate	N	The impacted grassland is not playing a big role in global cimate regulation
Water purification and waste treatment	Y	
Ethical and spiritual values	Y	Lost sense of place
Ecosystem services identified as impacted in Lake		
Food from crops, livestock, capture fisheries, aquaculture, and wild foods	Y	Increased demand for fish because of newcomers and accessibility to markets could lead to the supply not meeting the demand
Freshwater	Y	Pollution could make the water unfit for human consumption
Ethical and spiritual values	Y	Lost sense of place
Habitat	Y	Potential domestic and industrial waste in shallow waters of lake
Primary production	Y	Potential domestic and industrial waste in shallow waters of lake
Ecosystem services identified as impacted in Riverine Forest		
Biological raw material from timber	Y	Increased demand for construction material because of newcomers could lead to the supply not meeting the demand
Biomass fuel	Y	Increased demand for woodfuel because of newcomers could lead to the supply not meeting the demand
Water purification and waste treatment	?	In case of major deforestation
Ethical and spiritual values	Y	Lost sense of place
Ecosystem services identified as impacted in Wetland		
Water purification and waste treatment	Y	Supply of service may no longer meet demand because of increased domestic and industrial pollution
Habitat	Y	Habitat for fish will be insufficient due to increased demand for fish and/or wetland degradation or pollution
Ecosystem services identified as impacted in River		
Water purification and waste treatment	N	
Ethical and spiritual values	Y	Lost sense of place

Questions 1.5 and 1.6: Could the project reduce the benefits that any beneficiaries derive from this ecosystem service? Is this ecosystem service a major contributor to the well-being of any of the potentially affected beneficiaries?

Based on the technical description of the project and knowledge of the environmental and socio-economic context gathered by the various specialists during their own scoping exercises, the ESIA team answers the following questions for each of the ecosystem services identified as potentially impacted (Table 4). The project is expected to have a *high* significance of impact on ecosystem services with "yes" to both questions; *medium* significance with "yes" to the first question and "no" to the second; and *low* significance with "no" to the first question.

Table 4 | **Prioritization of Ecosystem Services According to the Significance of Project Impact *(continued)***

Vulnerability of beneficiaries to negative impact on ecosystem services		**Significance of project impact on this ecosystem service** *2 High significance of project impact* *1 Medium significance of project impact* *0 Low significance of project impact*
Q.1.6- Is this ecosystem service a major contributor to the well-being of any of the potentially affected beneficiaries? *Y Yes* *N No* *? Don't know*	**Comments or supporting information**	
		0
N	There is no source of drinking water directly dependent on this service from grassland	1
Y		2
Y		2
Y		2
?		2
Y	Supports fish production	2
Y	Supports fish production	2
Y		2
Y		2
N	There is no source of drinking water directly dependent on this service from riverine forest	1
?		2
Y	Source of water at the mouth of the wetland in the Lake	2
Y	Supports fish production	2
		0
N		1

In keeping with the precautionary principle, the tool was set up so that impact significance is predicted as *medium* when the ESIA team answers "?" for the first question and "no" to the second. All other combinations (?, ?, or ?, Y, or Y, ?) of "?" are considered as *high* significance of impact.

Step 2 – Assessing project dependence on ecosystem services

Based on the technical description of the project and knowledge of the environmental context gathered by the biophysical specialists during their own scoping exercises, the ESIA team answers three questions to assess project dependence on each of the ecosystem services and identify the ecosystems supplying them.

Questions 2.1 and 2.2: Does the project depend on this ecosystem service for successful performance? Can the project substitute for this ecosystem service in a cost-effective way?

The extent of project dependence will be deemed *high* if the ESIA team answers "yes" to the first question and "no" to the second one; *medium to low* if it answers "yes" to both questions; and *no project dependence* if the answer to the first question is "no". In keeping with the precautionary principle, the tool was set up so that project dependence is deemed *medium* when the ESIA team answers "?" to the first question and "yes" to the second one. In all other combinations (?, N, or Y, ?, or ?, ?) the dependence of the project is considered as *high* (Table 5).

Question 2.3: Which ecosystems supply this ecosystem service to the project (only for ecosystem services with "high project dependence")?

For ecosystem services with high project dependence, the practitioners identify the ecosystems supplying them that might need to be managed to ensure successful project performance (Table 5). Note that an ecosystem supplies an ecosystem service to the project if it fills two requirements: (1) it has the ecological capacity to supply the ecosystem service, and (2) the ecosystem location relative to the project allows the project to benefit from the services the ecosystem supplies.

Table 5 | **Prioritization of Ecosystem Services According to the Extent of Project Dependence**

Ecosystem services	**Q.2.1- Does the project depend on this ecosystem service for successful performance?** *Y Yes* *N No* *? Don't know*	**Q.2.2- Can the project substitute for this ecosystem service in a cost-effective way?** *Y Yes* *N No* *? Don't know*	**Comments or supporting information.** *Be as specific as possible regarding the ecosystem services the project depends on (constant water flows, protection against landslide ..) and its substitutes*	**Extent of project dependence on this ecosystem service** *2 High dependence* *1 Medium to low dependence* *0 No dependence*	**Q.2.3- Which ecosystems supply this ecosystem service to the project (only for ecosystem services with "high project dependence")?**
Provisioning					
Food from crops, livestock, capture fisheries, aquaculture, and wild foods	Y	Y	Can import food from outside the area	1	
Biological raw materials from timber and other wood products, fibers and resins, animal skins, sand, and ornamental resources	N			0	
Biomass fuel	N			0	
Freshwater	Y	N	Needed to fill the wells	2	Lake
Genetic resources	N			0	
Biochemicals, natural medicines, and pharmaceuticals	N			0	
Regulating					
Regulation of air quality	N			0	
Regulation of local, regional, and/or global climate	N			0	
Regulation of water timing and flows	N			0	
Erosion control	N			0	
Water purification and waste treatment	N			0	
Regulation of diseases	Y	Y	Can use malaria prophylaxis	1	
Regulation of soil quality	N			0	
Regulation of pests	N			0	
Pollination	N			0	
Regulation of natural hazards	N			0	
Cultural					
Recreation and ecotourism	Y	N	Possibility of safari/hunting/ leisure fishing	2	Grassland, lake
Ethical and spiritual values	Y	N	Open space	2	Grassland, lake
Educational and inspirational values	Y	N	Open space	2	Grassland, lake
Supporting					
Habitat	Y	N	· To support safari, hunting · To support leisure fishing	2	· Grassland · Lake, wetland
Nutrient cycling	N			0	
Primary production	Y	N	· To support safari, hunting · To support leisure fishing	2	· Grassland · Lake
Water cycling	N			0	

Step 3 – Identification of ecosystem services to be included in the ESIA Terms of Reference

Two categories of ecosystem services need to be included in the ESIA ToR: the priority ecosystem services, which need to be addressed in further stages of the ESIA in an integrated way across biophysical and socio-economic disciplines; and the non-priority ecosystem services, which should also be included in the ToR but which are addressed only by the biophysical team with the aim of maintaining the conditions under which they can contribute to the well-being of the beneficiaries (Table 6).

Because there are many priority ecosystem services, the ESIA team may want to run a second round of selection (Table 7) based on the following criteria:

- **Regarding high significance of impact over high project dependence:** Practitioners can exclude high dependence services that are not absolutely essential to project performance. Among the ecosystem services the project depends on, freshwater is the only one to be essential to project performance and require an integrated dependence analysis. The other ones can be scoped out from further stages of the ESIA process.

Table 6 | **List of Priority and Non-priority Ecosystem Services**

Ecosystems	Candidate ecosystem services for the ToR	Priority ecosystem services because of *impact significance*	Non-priority ecosystem services because of *impact significance*	Priority ecosystem services because of project *dependence*
Grassland	Water purification and waste treatment		√	
	Ethical and spiritual values	√		√
	Recreation and tourism			√
	Educational and spiritual			√
	Habitat			√
	Primary production			√
Lake	Food	√		
	Freshwater	√		√
	Ethical and spiritual values	√		√
	Habitat	√		√
	Primary production	√		√
	Recreation and tourism			√
	Educational and spiritual			√
Riverine forest	Biological raw material	√		
	Biomass fuel	√		
	Water purification and waste treatment		√	
	Ethical and spiritual values	√		
Wetland	Water purification and waste treatment	√		
	Habitat	√		√
River	Ethical and spiritual values		√	
Number of priority and non-priority ecosystem services *before* the second round of selection		11	3	12

- **Regarding the need for an integrated assessment to establish efficient and effective mitigation measures:**
  - There are no effective measures to avoid or effectively minimize impact on the cultural services (ethical and spiritual values) but the no-project option. An in-depth integrated analysis of impact will not help. These services can therefore be downgraded to non-priority ecosystem services. Any supporting service that contributes to these services can also be downgraded to non-priority unless the supporting service is important to maintain another service.
  - The contribution of biological raw material and biomass fuel to well-being can be substituted by tree plantation. There is less of an urgency to do an integrated analysis.
- **Regarding the ranking by the affected beneficiaries of their sensitivity and adaptability to change in ecosystem services:** The supply of freshwater and fish were identified as the top ecosystem services to enhance or at least maintain because the beneficiaries assess their sensitivity and ability to adapt to changes in these two provisioning services to be respectively the highest and the lowest. All ecosystem services that support freshwater and fish supply must also be maintained or ideally enhanced.

Table 7 | **List of Priority and Non-priority Ecosystem Services After Second Round of Selection**

Ecosystems	Ecosystem services to be included in the ToR	Priority ecosystem services because of *impact significance*	Non-priority ecosystem services because of *impact significance*	Priority ecosystem services because of project *dependence*
Grassland	Water purification and waste treatment		√	
	Ethical and spiritual values		√	
	Recreation and tourism			
	Educational and spiritual			
	Habitat			
	Primary production			
Lake	Food	√		
	Freshwater	√		√
	Ethical and spiritual values		√	
	Habitat	√		
	Primary production	√		
	Recreation and tourism			
	Educational and spiritual			
Riverine forest	Biological raw material		√	
	Biomass fuel		√	
	Water purification and waste treatment		√	
	Ethical and spiritual values		√	
Wetland	Water purification and waste treatment	√		
	Habitat	√		
River	Ethical and spiritual values		√	
Number of priority and non-priority ecosystem services *after* the second round of selection		6	8	1

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