WORLD RESOURCES INSTITUTE

WEAVING ECOSYSTEM SERVICES INTO IMPACT ASSESSMENT

Technical Appendix | Version 1.0

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I. Introduction to the technical appendix

This technical appendix is designed for Environmental and Social Impact Assessment (ESIA) practitioners who require a detailed, technical understanding of the Ecosystem Services Review for Impact Assessment (ESR for IA) method. It walks practitioners through each step of the method, and describes the specific output generated through each step. Although this appendix sets out the complete ESR for IA method, it is not meant to stand alone. To understand the context in which the method evolved and the challenges it is designed to address, readers should first consult the Background and Method Overview sections of *Weaving Ecosystem Services Into Impact Assessment: A Step-by-Step Method (Version 1.0)* (Landsberg et al. 2013).

Before delving into the method's implementation, this technical appendix addresses two issues that ESIA practitioners will face early in the ESR for IA process. First, it distinguishes between "intermediate" and "final" ecosystem services—a distinction that is relevant for assessing both project impacts and project dependencies on ecosystem services. Second, it addresses the specificities of stakeholder engagement, answering the practical questions of which stakeholders to engage and how to engage them. These issues while important for practitioners applying the ESR for IA, are less relevant for a broader audience and therefore do not feature as prominently in Landsberg et al. 2013.

Finally, the technical appendix brings the ESR for IA to life through a step-by-step application of its method to an illustrative mining project in the Arctic. The case study is designed to help ESIA practitioners think through and learn from the issues that could arise in a "real life" application of the ESR for IA method.

II. Background to the technical appendix

This section develops topics introduced in Landsberg et al. 2013. To successfully implement the ESR for IA, practitioners need to understand the concepts of intermediate and final ecosystem services and the specificities of the stakeholder engagement process. This section also introduces the hypothetical mining project used to illustrate each step of the method.

Differentiating between intermediate and final ecosystem services

By definition, ecosystem services contribute to human well-being (de Groot et al. 2010). But while some ecosystem services directly contribute to human well-being or project performance, others do so indirectly by supporting other services. For example, livestock production—a final service—typically provides a direct value to human well-being through income, subsistence, and/or culture. In contrast, fodder production—an intermediate service—contributes to human well-being indirectly by supporting livestock production.

Ecosystem services that directly contribute to human well-being or project performance are "final services"; services that indirectly contribute, through supporting other services, are "intermediate services". Although the distinction between intermediate and final services needs to be made on a case-by-case basis, in general all supporting services are intermediate services. Most regulating services also contribute indirectly to well-being. For instance, pollination and pest regulation support food production such as wild food and cultivated crop. Some regulating services, however, directly contribute to well-being or project performance. Water purification provided by a wetland to a downstream wastewater treatment facility is an example of a regulating service that contributes directly to a project's performance.

Understanding the relationships between services that contribute directly and indirectly to human well-being or project performance is essential for assessing and managing project impacts and dependencies on ecosystem services. For example, even if a project is not expected to directly impact a lake important for fish production (i.e., final service), the project may nevertheless affect fish production indirectly by reducing the habitat available for juvenile

fish in a nearby wetland (i.e., intermediate service). Safeguarding the wetland habitat for juvenile fish may be critical to maintaining the income and diet of fishermen downstream.

Similarly, a project that requires constant water flow for its operations depends directly on the river from which it pumps water. It might also depend indirectly on upstream wetlands and forests that regulate the water flow and quantity in the river. If the degradation of these wetlands or forests could jeopardize the availability of water to the project, managing them would be important to ensure project performance.

Identifying and engaging stakeholders

Stakeholder engagement should span the life of the project. Stakeholders include project developers 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 stakeholders have led companies to engage them throughout the entire project lifecycle (i.e., design and planning, construction, operation, and closure), rather than merely at the scoping and review stages of an ESIA. Improved engagement practices include preparing stakeholders before engagement; negotiating agreement between project developers and local communities regarding impact management and community benefits; and promoting participatory monitoring of project impacts by stakeholders themselves (Herbertson et al. 2009).

Who are the relevant stakeholders?

There are three groups of ecosystem services stakeholders:

- **The "affected (ecosystem service) stakeholders".** These are the ecosystem service beneficiaries who may be affected by project impacts on priority ecosystem services. They are identified at local and regional scales,[1] depending on the ecosystem service concerned. Future generations that might be prevented from benefiting from ecosystem services as a result of project impacts should be considered affected stakeholders. They can be individuals, communities, institutions, or companies (exclusive of the project for which the ESIA is conducted—see "project developers"). Affected stakeholders should be engaged early in the ESIA process, starting with the prioritization of ecosystem services (Step 2).
- **The "project developers".** These are the proponents of the project under consideration in the ESIA. Staff members to engage might include analysts, managers, and executive managers (Hanson et al. 2012). Project developers should be engaged as early as possible in the ESIA process, starting with the prioritization of ecosystem services (Step 2).
- **The "third-party actors".** These are the stakeholders who are not affected by the project's impacts on priority ecosystem services but nevertheless drive change in the ecosystems that supply priority ecosystem services. They can be individuals, communities, institutions, or companies (exclusive of the project for which the ESIA is conducted—see "project developers"). Third-party actors might be identified at local and regional scales, depending on the ecosystem service they impact. They can be engaged later in the ESIA process, at the latest during the identification of measures to manage project impacts and dependencies on priority ecosystem services (Step 5).

How to engage them?

Stakeholder consultation should inform most ESR for IA steps to the maximum extent practicable. Therefore, ecosystem services should be integrated into the ESIA's stakeholder engagement process from the outset.

1. The ESR for IA focuses on local and regionally affected beneficiaries because it would be difficult to assess project impacts on ecosystems in terms of implications for the well-being of global beneficiaries.

Integrating ecosystem services into the ESIA's stakeholder engagement process does not overly complicate the process because the ESR for IA emphasizes final ecosystem services (services that contribute *directly* to people's well-being or project performance) and avoids technical language.[2] Ideally the Ecosystem Service lead[3] (ES lead) would be part of the team conducting the stakeholder engagement and contribute to the design of the stakeholder consultation tools. If this is impractical, the ES lead should inform the consultation team of the linkages between ecosystems, priority ecosystem services, people, and the project prior to initiating the stakeholder engagement. For example, the ES lead would explain the links between regulating services (e.g., erosion control) and supporting services (e.g., nutrient cycling) to crop production. The social practitioners would then elicit from local farmers the importance of crop production to their income and sustenance, and from the larger community the importance of crop calendars to cultural and religious events.

Engaging stakeholders around ecosystem services relies on standard stakeholder engagement processes and tools and should abide by the same best practice standards (e.g., IFC 2012, Vanclay 2003), such as sensitivity to gender and vulnerable groups (e.g., the elderly, female-headed households, orphans, poor people). The ESIA team should also pay special attention to where ecosystem service beneficiaries access an ecosystem service. Multiple communities may extract drinking water from a river whose flow is impacted by a project, but a group that lives in the downstream, water-scarce watershed would probably be impacted differently than a group that lives in the upper, more water-rich watershed, since the latter would be more likely to have access to an alternative water source.

Presenting the case study: the Viva mining project

The ESR for IA is illustrated here through its application to a hypothetical project (see Boxes 2 to 4, 6 to 11, 13 to 18).

The proposed Viva project is a mining project in the Arctic that would include an open mine pit, a processing plant, a port, a slurry pipeline, and a new access road (Figure 1). The mine site and processing plant would be close to the ice cap and require excavating ice. The slurry pipeline would transport a high-quality ore from the processing plant to the port, from where it would be shipped to markets by bulk carriers. The processing plant would pump water from a nearby glacial lake to process the ore and facilitate its transportation.

The access road would be for project use only. A no-hunting security zone would be established around the road and all other project facilities.

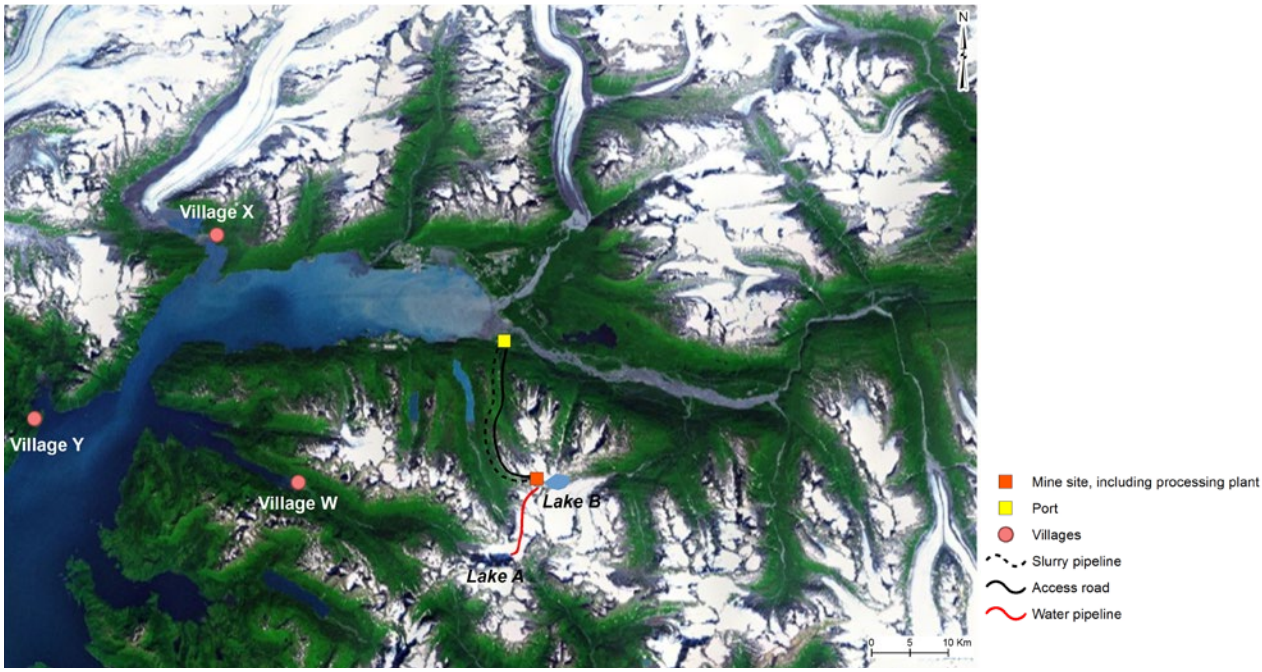
The project production capacity is 18 million tons of ore concentrate per year with a 33 year life-time (3 years of construction, 25 years of operation and 5 years of decommissioning).

There has been no prior industrial development in the area. Local residents are settled in three villages (villages W, X, Y). Life in these poor rural communities revolves around hunting (reindeer and seal) and fishing. To keep a professional hunting license, hunters cannot earn more than 40 percent of their income outside of hunting. The area also attracts recreational hunters from elsewhere in the province. The tundra and fjords have been focal points for cultural practices for generations.

2. Studies on the public understanding of the concept "ecosystem services" suggest that this terminology can alienate and confuse stakeholders and therefore be an obstacle to gathering information on their importance to people's well-being (Resource Media 2012, Metz and Weigel 2010, COI and DEFRA 2007).

3. The ecosystem service lead has responsibility for guiding, coordinating, and integrating the analyses of the environmental and social practitioners of the ESIA team. For more on who should conduct the ESR for IA, see Landsberg et al. 2013.

Figure 1 | **Sketch of the Viva project**



Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

III. Impact assessment steps

The objectives of the impact assessment are threefold: (1) to identify the ecosystem services for which project impacts could lead to a loss in well-being, (2) to assess how project impacts on ecosystems might affect the benefits that affected stakeholders derive from them, and (3) to provide measures to at least achieve no loss in the benefits that affected stakeholders derive from impacted ecosystems.

Figure 2 depicts the conceptual framework linking project impacts on ecosystems, ecosystem services, and ecosystem service benefits to affected stakeholders. The conceptual framework explicitly differentiates between ecosystem, ecosystem service supply, ecosystem service use, and ecosystem service benefit (see Box 1 for definitions of these terms). This differentiation enables the ES lead to understand the various relationships between them (see Box 1 for a brief description of these relationships).

Project impacts could lead to changes in the type or condition of ecosystems, and therefore their supply of ecosystem services. The ESR for IA goes beyond predicting project impacts on ecosystem service supply. Instead, it forecasts how project-induced changes in ecosystem service supply could lead to changes in ecosystem service benefits by extrapolating the relationships between ecosystem service use and benefit that are established during the baseline assessment (black boxes in Figure 2).

In some cases, practitioners might want to address a project's cumulative impacts on ecosystems and the services and benefits they provide. While the ESR for IA does not comprehensively address such impacts on ecosystem services—it focuses instead on discrete project-related changes—Annex 1 provides some preliminary guidance for adapting the ESR for IA to address cumulative impacts.

1 DEFINITIONS OF, AND RELATIONSHIPS BETWEEN, ECOSYSTEM SERVICE SUPPLY, USE, AND BENEFIT

- **Ecosystem service supply.** Ecosystem service supply is the maximum level of ecosystem service that the ecosystem can provide without undermining its future provisioning capacity, regardless of whether people actually use or value the service (adapted from UNEP-WCMC 2011, Kareiva et al. 2011).

- **Ecosystem service use.** Ecosystem service use is the level of ecosystem service actually consumed or enjoyed by beneficiaries (adapted from Boyd and Banzhaf 2007). Use can be consumptive (e.g., agriculture crops for food, water for drinking) or non-consumptive (e.g., recreational and spiritual appreciation of a landscape or wildlife, pollination of crops by bees).

- **Ecosystem service benefit.** Ecosystem service benefit is the gain in human well-being or project performance derived from the use of an ecosystem service, often in combination with other inputs such as labor and capital (adapted from van Oudenhoven et al. 2012).

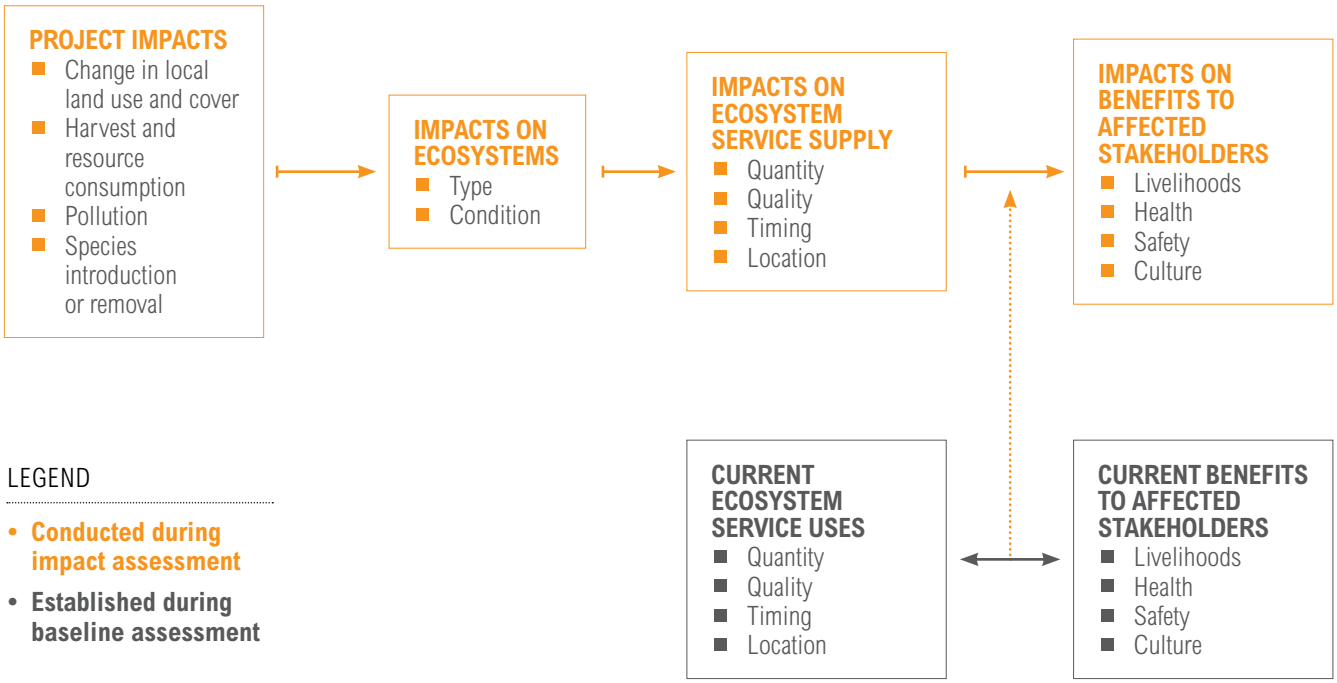
While the relationships between ecosystem service supply, use, and benefit are context-specific, they can be generalized as follows:

- **Relationship between ecosystem and ecosystem service supply:** Ecosystem service supply is determined by the ecosystem type and condition, and it is modeled based on ecological production functions (Kareiva et al. 2011, NRC 2005). For example, the type and condition of a savanna determines its herbivore carrying capacity; the type and condition of a wetland determines its maximum contaminant absorption; the type and condition of agricultural land determines its inherent maximum productivity and crop yields; the type and condition of vegetation cover determines its maximum soil retention; and the type and condition of a forest determines its maximum sustainable timber yield. As a function of ecosystem type and condition, changes in ecosystem service supply can be linear (e.g., decrease in freshwater quality directly relates to the increased pollution of a river); or non-linear, where small ecosystem change may have disproportionate effects on ecosystem service supply (e.g., small additional nutrient loading leads to algal blooms and fish kills).

- **Relationship between ecosystem service supply and use:** The relationship (or absence thereof) between ecosystem service supply and use depends on whether the use is consumptive or non-consumptive. When non-consumptive, ecosystem service use equates with ecosystem service supply (e.g., the decrease in flooding events experienced by floodplain households is equal to the maximum flood protection that the wetland, based on its type and condition, can provide). When consumptive, ecosystem service use does not always have a direct relationship with ecosystem service supply: if the level of use is below the level of supply, the ecosystem service is being underexploited. Conversely, if the level of use exceeds the level of supply, the ecosystem service is being overexploited. In the latter case, the level of use undermines the capacity of the ecosystem to supply the service in the future, and is therefore unsustainable. When dealing with consumptive use, maximum sustainable use is determined by ecosystem service supply, which in turn depends on the type and condition of ecosystem.

- **Relationship between ecosystem service use and benefit:** The relationship between ecosystem service use and benefit can be linear or non-linear. In a linear relationship, the benefit is proportional to the use (e.g., the more fish caught, the higher the income; the more floodwater stored, the more the avoided real property damage). In a non-linear relationship, use and benefit are not proportional (e.g., the cleaner the water, the healthier the population up to a certain water quality level beyond which an increase in water quality leads to negligible gain in health).

Figure 2 | **From project impacts on ecosystems to project impacts on benefits to affected stakeholders**



Impact Step 1 – Identify ecosystem services relevant to project impact

An ecosystem service is considered relevant to assessing project impacts if (1) an ecosystem is potentially impacted; (2) a service could be provided by this impacted ecosystem; and (3) there are beneficiaries of the impacted service. Relevant ecosystem services are included in the ESIA terms of reference.

Sub-step I-1.1: Identify ecosystems the project could impact

The ES lead identifies the ecosystems[4] that could undergo changes beyond natural variation as a result of the project. This includes the ecosystems that could be subject to direct and indirect project impacts. Direct project impacts are impacts that are direct consequences of project activities or decisions (TBC 2012). Indirect impacts are project-induced changes that are not a direct result of project activities. They are often produced some distance away from the project or result from complex pathways (EC 1999). Indirect impacts include growth-inducing impacts such as in-migration and increased economic activity resulting from improved access to markets.

To identify directly impacted ecosystems, the ES lead reviews the ecosystems identified by the environmental practitioners. He[5] can also overlay a project design map on a land cover map or satellite image to assess what ecosystems are likely to be directly impacted by project activities. If mapping and satellite imagery are not available, then the ES lead lists the project activities and identifies the potentially affected ecosystems based on site knowledge.

4. When the environmental practitioners are using finer units of analysis than ecosystems (e.g., habitat or land cover/use classes), the ES lead can use them as well, as long as he is able to link these units to the supply of ecosystem services in sub-step 1.2.

5. For the sake of clarity and brevity, the ES lead is referred to as "he" throughout this document. In practice, of course, the ES lead may be male or female.

To identify ecosystems indirectly impacted by the project, the ES lead works with the ESIA team to predict how social and other project-induced changes might lead to additional changes in ecosystems. For example, a project that builds a new road to connect its facilities to the existing road network would have direct impacts on the ecosystems located within and immediately adjacent to the path of the road. The project might also have indirect impacts on nearby ecosystems if the road provides access to previously inaccessible ecosystems. In this case, the indirectly impacted ecosystems would be within reasonable walking distance from the road, where people might hunt, harvest timber, or convert forest to agriculture. In many cases a project's indirect impacts are much larger than its direct impacts.

At this stage, it is not necessary to assess the extent to which the project could affect particular ecosystems. The ES lead only establishes which ecosystems might be exposed to some impact, whether positive or negative. It is also important to identify the causal links between a project and ecosystem change.

In addition to directly and indirectly affected ecosystems, the ES lead also identifies those ecosystems that would be partially or wholly subject to land acquisition or land-use restrictions as a result of the project. Even though these ecosystems might not be physically altered by the project, people might not be able to benefit from some of their ecosystem services following implementation of the project.

The output of sub-step I-1.1 is a list of the ecosystems that are expected to undergo changes as a result of the project (see Box 2).

2 IMPACT ASSESSMENT SUB-STEP 1.1 FOR THE VIVA PROJECT

Based on the description of the project's activities, expected in-migration of people, and the existing land cover map, the following ecosystems, or parts thereof, were identified as potentially impacted: the tundra (with a specific potential impact on reindeer population as a result of in-migration induced hunting), the fjord (with a specific potential impact on fish population as a result of in-migration induced fishing), lakes A and B, and the ice cap.

It should be noted that even though the mine will produce air pollution, the atmosphere is not an ecosystem, and air quality issues, and the human health consequences, should therefore independently be addressed by the air specialist.

See output table on page 9.

2 OUTPUT TABLE | IMPACT ASSESSMENT SUB-STEP 1.1 FOR THE VIVA PROJECT

SUB-STEP 1.1: IDENTIFY ECOSYSTEMS THE PROJECT COULD IMPACT		
Enter project activities	**Associate each project activity with one or more impacts on ecosystem**	**For each impact on ecosystem, enter the potentially impacted ecosystem(s) or parts thereof**
Construction of mine pit and processing plant	Removal of ice	Ice cap
Construction of road	Fragmentation of habitat	Tundra
Construction of port	Land cover and use change	Tundra
		Fjord
Tailing deposit	Lake filled up with submarine tailings	Lake B
Process water	Water abstraction	Lake A
Discharge of partially treated effluent	Water pollution	Fjord
Security zone around mine, processing plant, and port, and along road and slurry pipeline	Loss of access	Tundra
		Fjord
Operation of mine	Visual and noise disturbance from industrial activities	Tundra
		Fjord
	Air pollution	N/A (atmosphere is not an ecosystem; impact will be covered by air specialist)
Enter project-induced changes	**Associate each project-induced change with one or more impacts on ecosystem**	**For each impact on ecosystem, enter the potentially impacted ecosystem(s) or parts thereof**
Project-related in-migration	Hunting	Reindeer
	Fishing	Trout
	Land cover and use change	Tundra

Sub-step I-1.2: Identify ecosystem services the project could impact

Once potentially impacted ecosystems are identified, the ES lead infers which ecosystem services could be supplied by them. For each ecosystem identified in sub-step 1.1, he reviews Table A-1 in Annex 2[6] to identify potential ecosystem services (see Annex 3 for examples of table associating ecosystem services and habitat or land cover classes). Alternatively, the ES lead can use various computer-based tools[7] to map ecosystem services associated with specific ecosystems.

The output of sub-step I-1.2 is a list of ecosystem services that may be affected by the project. This list should be considered preliminary and should be double-checked through subsequent field visits and stakeholder engagement.

6. There are other lists of ecosystem services (e.g., Haines-Young and Potschin 2013, de Groot et al. 2010). If used as starting points, these lists need to be reviewed and adapted to the local context.

7. Various mapping tools are reviewed in BSR 2011, and Center for Ocean Solutions 2011.

Sub-step I-1.3: Identify potentially affected ecosystem service beneficiaries and benefits

For each ecosystem service identified in sub-step 1.2, the ES lead, with support from social practitioners, determines whether there are any beneficiaries who could be affected by project-related changes, and establishes which benefits they derive from potentially affected ecosystem services.

IDENTIFYING POTENTIALLY AFFECTED BENEFICIARIES

Ecosystem service beneficiaries are those individuals and communities that depend on ecosystem services to maintain their well-being. Beneficiaries also include institutions and companies (other than the one for which the ESIA is conducted) whose performance depends on an ecosystem service. Depending on the nature of the ecosystem service, beneficiaries can be identified at local, regional, and/or global scales. The ESR for IA focuses on local and regional beneficiaries because of the difficulty of assessing the implications of project impacts on ecosystems for the well-being of global beneficiaries.

Standard stakeholder mapping can identify the beneficiaries of those ecosystem services that contribute to subsistence, income, or culture. It is less effective at identifying the beneficiaries of ecosystem services when: (1) the services contribute to people's health and safety, such as protection from flooding or landslides; or (2) they contribute indirectly to people's well-being, such as water purification provided by a wetland, which improves the quality of downstream drinking water; or fish breeding nurseries, which support fish populations used for food.

The ES lead identifies all ecosystem service beneficiaries who could be affected (positively or negatively) by the project by systematically going through the list of ecosystem services established in sub-step 1.2.

Beneficiaries of ecosystem services could be *negatively* affected by project-related changes in any of the following ways:

- The project physically restricts beneficiaries from accessing an ecosystem and the services it provides (e.g., railway infrastructure prevents livestock keepers from grazing their animals in dry season pastures, resulting in loss of income).
- The project diminishes the supply of an ecosystem service by degrading the ecosystem that provides it. A reduction in ecosystem service supply makes it more difficult for beneficiaries to derive benefits from the ecosystem, resulting in increased costs or lowered benefits (e.g., nutrient runoff from an agricultural project leads to eutrophication of a freshwater lake and related decline in fish stocks. Fishing communities relying on the lake for subsistence have to increase their fishing effort to maintain the same level of benefit or accept a lower quantity of fish for self-consumption or market sales).
- The project increases the use of an ecosystem service either directly (because it depends on the service for its own performance) or indirectly (by increasing the use of this ecosystem service by others). An increase in use is detrimental to communities that already rely on an ecosystem if it competes with or prevents their use of ecosystem services (e.g., a tea factory's large use of biomass energy negatively affects a local community that sources its fuelwood from the same woodland).
- The project's impacts on an ecosystem service trigger a regulatory response from local or national government, which results in restricted access of beneficiaries to the ecosystem service (e.g., as a result of the project, water toxicity exceeds the legal limit for human consumption, leading to a health-related regulatory ban).

Ecosystem service beneficiaries could be *positively* affected by the project's impacts on an ecosystem service in any of the following ways:

- The project increases the supply of an ecosystem service as a by-product of its operations (e.g., a soil carbon project is conducted through sustainable land management practices and these practices increase agricultural yields).
- The project decreases some beneficiaries' dependence on, and therefore use of, an ecosystem service. A decrease in the use of the service increases the supply of the service available to other users (e.g., an irrigation project upgrades farmers to drip irrigation, which leaves more water for downstream users).
- The project's impacts on an ecosystem service bring to an end a regulatory response from local or national government that had restricted access to the ecosystem service (e.g., as a result of

an urban water treatment facility project, water quality increases sufficiently in a downstream river to allow the government to lift a ban on aquatic activities).

If the project affects an intermediate service (i.e., a service that contributes indirectly to human well-being), the ES lead will not be able to identify beneficiaries of this service without first identifying the final services they support. In this case, only the final services are identified as relevant (see Glossary for definitions of intermediate and final services). If such a final service had not been identified as being potentially impacted in sub-step 1.2, the ES lead adds it to the list of relevant services.

An ecosystem service can contribute to the well-being of numerous beneficiaries and do so in a variety of ways. When beneficiaries are thought to have different levels of dependence on a service, the ES lead treats them separately. Differentiation among beneficiaries will allow for the prioritization of ecosystem services according to each beneficiary's level of dependence, which will be determined in Step 2.

IDENTIFYING POTENTIALLY AFFECTED BENEFITS

When identifying ecosystem service beneficiaries, the ES lead also identifies the benefits they derive from affected ecosystems. Ecosystem service benefits typically fall into one of the following categories of well-being (MA 2005):

- Basic material for a good life (e.g., secure and adequate livelihoods, enough food at all times, shelter, clothing, access to goods);
- Health (e.g., clean air and access to clean water);
- Security (e.g., secure access to natural and other resources, personal safety, security from natural and human-made disasters); and
- Good social relations (e.g., social cohesion, mutual respect, ability to help others and provide for children).

An ecosystem service can provide multiple benefits to a single beneficiary. If these benefits are not expected to contribute equally to the beneficiary's well-being, the ES lead differentiates among the benefits to be able to prioritize ecosystem services with regard to each benefit (see Step 2).

3 IMPACT ASSESSMENT SUB-STEPS 1.2 AND 1.3 FOR THE VIVA PROJECT

The five ecosystems identified in sub-step 1.1 were ecologically associated with 13 specific ecosystem services: the tundra potentially supplies five ecosystem services; the fjord, four ecosystem services; lakes A and B, the river outflowing from Lake A, and the ice cap, one ecosystem service each.

A sixth ecosystem, the river outflowing from Lake A, was added to the list of potentially impacted ecosystems. While no persons were identified as benefiting directly from the freshwater provided by Lake A, it was established that hunters and village W benefit from its outflow river. Indeed, the river is a source of water for the reindeer populations and of piped water for local communities. Unlike reindeer, the river had not been identified in sub-step 1.1 as potentially impacted by the project. The river, freshwater, village W, and domestic water were therefore added to the list of potentially impacted ecosystems, services, beneficiaries, and benefits.

Recreational and professional hunters were expected to depend on reindeer meat to differing degrees; this difference is acknowledged by differentiating recreational and professional hunters with regard to reindeer meat. (In contrast, recreational and professional hunters were expected to enjoy aesthetic value equally.) Similarly, income, health (protein intake), and social cohesion derived from reindeer meat by recreational hunters were differentiated (some of these benefits are expected to be more important than others to their well-being).

No local or regional beneficiaries could be identified for water cycling; therefore, water cycling was not included in the list of relevant services.

See output table on pages 12 and 13.

When no ecosystem service beneficiaries can be identified for a service identified in sub-step 1.2, it should not be included in the list of relevant services. Where the ES lead is unsure whether an ecosystem service has beneficiaries or not, he should use the precautionary principle and include that ecosystem service in the list of relevant services.

The output of sub-step I-1.3 is a list of relevant ecosystem services, and potentially affected beneficiaries and benefits (see Box 3). This list will be revisited during Step 2 when stakeholders are engaged.

3 OUTPUT TABLE | IMPACT ASSESSMENT SUB-STEPS 1.2 AND 1.3 FOR THE VIVA PROJECT

SUB-STEP 1.2: IDENTIFY ECOSYSTEM SERVICES THE PROJECT COULD IMPACT		SUB-STEP 1.3:
Select from the pre-populated list the ecosystem services that are ecologically associated with each impacted ecosystem	**Comments or supporting information**	**Identify the potentially affected beneficiaries**
Impacted ecosystem: Tundra		
Food from crops, livestock, capture fisheries, aquaculture, and wild foods	Reindeer meat	Professional hunters from villages W, X, and Y and their households
		Recreational hunters from the province and their households
Biological raw materials from timber and other wood products, fibers and resins, animal skins, sand, and ornamental resources	Fur from reindeer	Professional hunters from villages W, X, and Y and their households
		Recreational hunters from the province and their households
	Bones from reindeer	Professional hunters from villages W, X, and Y and their households
		Recreational hunters from the province and their households
Recreation and ecotourism	Aesthetic value	Professional hunters from villages W, X, and Y and recreational hunters from the province
Educational and inspirational values	Cultural heritage and identity	Communities in the province
Impacted ecosystem: Fjord		
Food from crops, livestock, capture fisheries, aquaculture, and wild foods	Trout meat	Professional fishermen from villages W, X, and Y and their households
Food from crops, livestock, capture fisheries, aquaculture, and wild foods	Seal meat	Professional seal hunters from villages W, X, and Y and their households
Biological raw materials from timber and other wood products, fibers and resins, animal skins, sand, and ornamental resources	Fur from seal	Professional seal hunters from villages W, X, and Y and their households
Educational and inspirational values	Cultural heritage and identity	Communities in the province
Impacted ecosystem: Lake A		
Freshwater		Intermediate service to wild foods and biological raw material from reindeer; see their affected stakeholders
		Intermediate service to freshwater from river outflowing from Lake A; see their affected stakeholders
Impacted ecosystem: Lake B		
Freshwater		Intermediate service to wild foods and biological raw material from reindeer; see their affected stakeholders
Impacted ecosystem: Ice cap		
Water cycling		No beneficiaries identified
Impacted ecosystem: River outflowing from Lake A		
Freshwater	As a result of impact on Lake A	Village W

IDENTIFY POTENTIALLY AFFECTED BENEFICIARIES AND BENEFITS		LIST OF RELEVANT ECOSYSTEM SERVICES
Identify the potentially affected benefits	**Comments or supporting information**	**List the ecosystem services for which beneficiaries were identified**
Income	Based on census data, employment statistics, anthropological study, tourism data	Reindeer meat
Protein intake		
Ability to help others		
Protein intake		
Ability to help others		
Income		Fur from reindeer
Sense of identity (traditional clothes)		
Sense of identity (traditional clothes)		
Sense of identity (artisanal crafts)		Bones from reindeer
Sense of identity (artisanal crafts)		
Spiritual fulfillment		Aesthetic value
Social cohesion		Cultural heritage and identity
Income	Based on census data, employment statistics, and anthropological study	Trout meat
Protein intake		
Income		Seal meat
Protein intake		
Income		Fur from seal
Social cohesion		Cultural heritage and identity
Intermediate service to wild foods and biological raw material from reindeer; see their benefits		
Intermediate service to freshwater from river outflowing from Lake A; see their benefits		
Intermediate service to wild foods and biological raw material from reindeer; see their benefits		
Domestic water	Based on public infrastructure data	Freshwater

Impact Step 2 – Prioritize relevant ecosystem services according to project impact

Ecosystem services affected by the project are prioritized when all three of the following criteria are met: (1) the project might affect the ability of others to benefit from the service; (2) the affected service is important to beneficiaries' well-being; and (3) beneficiaries do not have viable alternatives for that service (Figure 3).

Non-priority ecosystem services are not carried forward for further assessment in the ESR for IA. However, environmental practitioners on the ESIA team might assess impacts on non-priority ecosystem services from an ecological or biodiversity point of view. In this case, they assess environmental impacts without considering the implications in terms of specific benefits. For example, if project impacts on freshwater quality do not interfere with its drinkability, the ES lead will not select freshwater as a priority ecosystem service nor assess the project's impacts on people's health. Environmental practitioners might nevertheless assess project impacts on water quality in terms of freshwater biodiversity. As new information arises through ESIA baseline data collection and impact analysis, reclassification of non-priority services may be warranted.

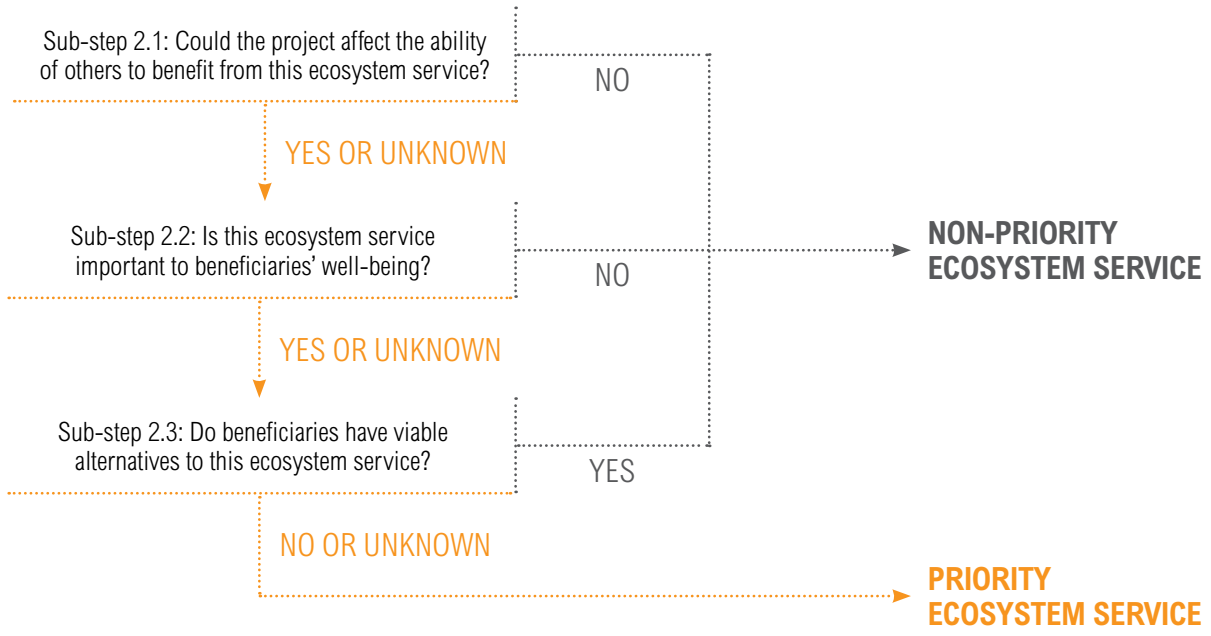
The ES lead can use the Impact Prioritization Spreadsheet (see Box 4) to prioritize ecosystem services according to project impacts on beneficiaries.

The prioritization exercise is summarized in the ESIA report.

Sub-step I-2.1: Identify ecosystem services for which project impacts could affect the ability of others to derive benefits

A project affects the ability of others to benefit from a service when its impacts interfere with beneficiaries' current or foreseeable use of that service. For example, the discharge of project effluent could affect downstream water users if water quality falls below certain quality standards. Conversely, the project will not affect the recreational benefits of the river as long as hikers do not perceive a change in water smell, color, or quantity.

Figure 3 | **Decision tree to prioritize relevant ecosystem services according to potential project impacts on beneficiaries**



For each of the relevant services identified in Step 1, the ES lead, in consultation with the rest of the ESIA team, assesses whether project impacts could affect the ability of others to derive benefits. Impacts on an ecosystem service might lead to changes in a benefit when:

- *The project's impacts on this service push it across a sustainability threshold*. A project might affect the ability of others to benefit from an ecosystem service by pushing it across a sustainability threshold. The project would turn the supply of this service from "adequate" to "inadequate" relative to demand, whether in quantity, quality, timing, or location. A shrimp farm project that converts a large area of mangrove to raise shrimp, for example, substantially decreases breeding grounds for fish and may render the current level of fishing unsustainable in relation to the reproduction rate, undermining the sustainability of the benefits fishermen accrue from fishing.
- *The project's impacts on this service trigger a regulatory response*. A project might affect the ability of others to benefit from an ecosystem service by changing its legal status or access. For example, an oil spill could lead to a ban on professional and recreational fishing.
- *This ecosystem service is already in short supply relative to demand*. A project is more likely to affect the ability of others to benefit from a service when the demand for this service already outstrips the supply. For instance, in a water-stressed watershed, any water abstraction by the project during the dry months could sharply reduce the benefits derived by other water users.
- *Any change in this service precludes others from benefiting from it*. A project would affect the benefits others derive from an ecosystem service when these benefits require the service to stay unchanged. This scenario is most likely to arise in connection with cultural services. For indigenous communities, for example, a pristine natural environment can be an essential component of cultural heritage. Any construction, however small, could damage indigenous communities' sense of place and belonging.
- *The project's impacts on this service are perceived by others as affecting their ability to benefit from it*. A project is more likely to be perceived as responsible for affecting the ability of others to benefit from an ecosystem service when it causes a relatively large share of total ecosystem change in the area. A project planned on the shore of a lake in an undeveloped area, for example, could trigger fears from local communities that it will pollute the lake and decrease the availability of fish even if the project treats its effluent. As a potential source of grievance and possibly conflict, perceived impacts should be addressed with the same importance as real impacts (IFC 2009, Vanclay 2003).

If the ES lead is unsure of the project's implications for benefits associated with any particular ecosystem service, he should invoke the precautionary principle and include the ecosystem service in the output of sub-step 2.1.

The output of sub-step I-2.1 is a shortlist of the ecosystem services identified in Step 1 for which project impacts could affect others' ability to benefit.

Sub-step I-2.2: Identify ecosystem services that are important to beneficiaries' well-being

A project is more likely to affect ecosystem service beneficiaries if it impacts a service that they identify as important to their well-being.

For each ecosystem service shortlisted in sub-step 2.1, the ES lead determines, subject to validation by affected stakeholders, which ones are likely to be important to beneficiaries' well-being. Various approaches can be used to assess importance to well-being. The 2008 Toolkit for Identification of High Conservation Values in Indonesia, for example, proposes the following as one of the criteria for identifying "Natural Areas Critical for Meeting the Basic Needs of Local People": "forest or other natural ecosystems are determined to be very important if it is used by one or more members of a community to meet at least 50% of one or more basic needs" (IndRI et al. 2008). If the ES lead defines his own criteria to measure importance, he should document them.

The ES lead should engage beneficiaries to validate his preliminary selection of ecosystem services and benefits based on their contribution to well-being. There should not be any minimum threshold regarding the number of beneficiaries: if even a single family considers an ecosystem service important, that service should be included in the output of sub-step 2.2. This conservative approach ensures that minority groups are not overlooked.

Where the ES lead is unable to determine whether a benefit derived from a particular ecosystem service is important to well-being, he should use the precautionary principle and include that ecosystem service in the output of sub-step 2.2.

The output of sub-step I-2.2 is a shortlist of the ecosystem services identified in sub-step 2.1 that provide benefits important to affected stakeholders' well-being.

Sub-step I-2.3: Identify ecosystem services for which beneficiaries have no viable alternatives

Beneficiaries will feel project impacts on an ecosystem service more acutely if they have no viable alternatives to that service, leaving them unable to adapt.

Through stakeholder engagement, beneficiaries select from the ecosystem services shortlisted in sub-step 2.2 those services for which they cannot get the same benefit over time[8]—without unacceptable physical, economic, or psychological burden—from either:

- Non-ecosystem based solutions (e.g., a farmer can replace his agricultural income lost as a result of the project with employment income from working on another farm or receive rental income from the project for the temporary use of his land); or
- The same service supplied by another ecosystem (e.g., women can fetch freshwater from another river in the area). An alternative service is considered "viable" only if the ES lead can establish beyond a reasonable doubt that all the additional following criteria are met: (1) its supply can meet the needs of the affected beneficiaries; (2) the increased use of the alternative service does not compete with existing uses; and (3) the beneficiaries have formal or informal access to the service.

8. If beneficiaries are foregoing long-term benefits as a result of a project's impacts on ecosystems, temporary alternative benefits are not considered viable alternatives even if all other criteria are met.

4 OUTPUT TABLE | IMPACT ASSESSMENT STEP 2 FOR THE VIVA PROJECT

FROM STEP 1			SUB-STEP 2.1: COULD THE PROJECT AFFECT THE ABILITY OF OTHERS TO BENEFIT FROM THIS ECOSYSTEM SERVICE?	
Relevant ecosystem services	**Potentially affected beneficiaries**	**Potentially affected benefits**	**Y Yes N No ? Unknown**	**Comments or supporting information**
Impacted ecosystem: Tundra				
Reindeer meat	Professional hunters from villages W, X, and Y and their households	Income	?	Change in reindeer population is likely to be beyond natural variation within hunting areas, which will be reflected in smaller hunting quotas. There is no discarded meat. Any decrease in number of animals will impact the benefits derived from reindeer meat.
		Protein intake	?	
		Ability to help others	?	
	Recreational hunters from the province and their households	Protein intake	?	
		Ability to help others	?	

For example, local fishermen have a viable alternative to the loss of a fishing ground if they are able to fish in an area: (1) that is the same distance from their landing sites; (2) that supplies the fish of interest to local fishermen; (3) that does not show signs of overfishing; and (4) to which they have fishing rights.

Where the ES lead is unable to determine whether beneficiaries have a viable alternative to a particular ecosystem service, he should use the precautionary principle and consider that ecosystem service as a priority ecosystem service.

The output of sub-step I-2.3 is a shortlist of the ecosystem services identified in sub-step 2.2 for which beneficiaries do not have viable alternatives. These services are the priority ecosystem services on which the impact assessment will be conducted. Sub-step 2.3 also produces a list of affected stakeholders and benefits (see Box 4).

4 IMPACT ASSESSMENT STEP 2 FOR THE VIVA PROJECT

Step 1 identified 10 relevant ecosystem services. Using the Impact Prioritization Spreadsheet, six of these services were prioritized: reindeer meat, aesthetic value from the tundra, cultural heritage and identity from the tundra, seal meat, fur from seal, and cultural heritage and identity from the fjord.

It should be noted that the benefits derived from "reindeer meat" were prioritized for professional and recreational hunters independently. All the benefits professional hunters derive from reindeer meat were prioritized (i.e., income, protein intake, and ability to help others). In contrast, reindeer meat was prioritized for its contribution to recreational hunters' ability to help others (sharing reindeer meat is an important tradition), but not for its contribution to their protein intake; recreational hunters reported that reindeer meat does not contribute significantly to their diet.

See output table below and on pages 18 and 19.

	SUB-STEP 2.2: IS THIS ECOSYSTEM SERVICE IMPORTANT TO BENEFICIARIES' WELL-BEING?		SUB-STEP 2.3: DO BENEFICIARIES HAVE VIABLE ALTERNATIVES TO THIS ECOSYSTEM SERVICE?		PRIORITY ECOSYSTEM SERVICES
	Y Yes N No ? Unknown	Comments or supporting information	Y Yes N No ? Unknown	Comments or supporting information	1 Priority ecosystem services 0 Non-priority ecosystem services
	Y	Professional hunters get at least 60% of their income from hunting.	N	Professional hunters cannot get more than 40% of their income from sources other than hunting.	1
	Y	Reindeer meat is the only source of meat professional hunters provide to their families.	N	Professional hunters are poor and cannot afford to buy the same quality of food.	1
	Y	Sharing of traditional foods is a main component of indigenous culture and well-being.	N		1
	N	Reindeer meat is one of the sources of meat recreational hunters consume.			0
	Y	Sharing of traditional foods is a main component of local culture and well-being.	N		1

4 OUTPUT TABLE | IMPACT ASSESSMENT STEP 2 FOR THE VIVA PROJECT (CONT.)

FROM STEP 1			SUB-STEP 2.1: COULD THE PROJECT AFFECT THE ABILITY OF OTHERS TO BENEFIT FROM THIS ECOSYSTEM SERVICE?	
Relevant ecosystem services	**Potentially affected beneficiaries**	**Potentially affected benefits**	**Y Yes N No ? Unknown**	**Comments or supporting information**
Impacted ecosystem: Tundra (continued)				
Fur from reindeer	Professional hunters from villages W, X, and Y and their households	Income	?	Change in reindeer population is likely to be beyond natural variation within hunting areas, which will be reflected in smaller hunting quotas.
		Sense of identity (traditional clothes)	?	
	Recreational hunters from the province and their households	Sense of identity (traditional clothes)	?	The fur of most animals is used. Any decrease in number of animals will impact the benefits derived from reindeer fur.
Bones from reindeer	Professional hunters from villages W, X, and Y and their households	Sense of identity (artisanal crafts)	N	Change in reindeer population is likely to be beyond natural variation within hunting areas, which will be reflected in smaller hunting quotas.
	Recreational hunters from the province and their households	Sense of identity (artisanal crafts)	N	Not all antlers are used for artisanal crafts. A decrease in number of animals is unlikely to decrease the availability of antlers for artisanal crafts.
Aesthetic value	Professional hunters from villages W, X, and Y and recreational hunters from the province	Spiritual fulfillment	Y	Any change in the landscape will interfere with the aesthetic value enjoyed by the hunters during hunts.
Cultural heritage and identity	Communities in the province	Social cohesion	Y	Any change in the landscape will interfere with the importance of wilderness to indigenous identity.
Impacted ecosystem: Fjord				
Trout meat	Professional fishermen from villages W, X, and Y and their households	Income	Y	The change in trout population is expected to be within natural variation because project impacts on fish habitat are very local. However, preferred fishing grounds might not be accessible anymore because of project activities.
		Protein intake	Y	
Seal meat	Professional seal hunters from villages W, X, and Y and their households	Income	?	Level of seal catch is unknown but might be close to maximum yield, which means that a decrease in seal would translate into greater competition among professional fishermen/hunters (or overhunting).
		Protein intake	?	
Fur from seal	Professional seal hunters from villages W, X, and Y and their households	Income	?	The fur of most seals is sold. A decrease in seal would translate into greater competition among professional fishermen/hunters (or overhunting).
Cultural heritage and identity	Communities in the province	Social cohesion	Y	The area has always been untouched. Constructing a port and having boats use it will change this essential characteristic.
Impacted ecosystem: River outflowing from Lake A				
Freshwater	Village W	Domestic water	N	This river represents less than 5% of the source of piped paper for the settlements downstream.

SUB-STEP 2.2: IS THIS ECOSYSTEM SERVICE IMPORTANT TO BENEFICIARIES' WELL-BEING?		SUB-STEP 2.3: DO BENEFICIARIES HAVE VIABLE ALTERNATIVES TO THIS ECOSYSTEM SERVICE?		PRIORITY ECOSYSTEM SERVICES
Y Yes N No ? Unknown	Comments or supporting information	Y Yes N No ? Unknown	Comments or supporting information	1 Priority ecosystem services 0 Non-priority ecosystem services
?	The use of fur is not known.	Y	Can be replaced by seal fur provided that increased seal hunting would still be sustainable.	0
?		Y		0
?		Y		0
				0
				0
Y	Hunting in the Arctic is about the relationship between the hunter and the wilderness.	N	Hunters are limited to hunting areas close enough to the water to be able to transport dead animals without motorized vehicles.	1
Y	Hunting as well as consumption of traditional foods are considered important to indigenous identity.	N	Hunters have traditionally hunted in these areas. Alternatives don't have the same traditions.	1
N	Fishing is a secondary complement to reindeer hunting. People fish on their way to hunting grounds.			0
N				0
Y	Seal catch is an important complement to income from reindeer.	N	Fjord is close enough to allow fishermen to return home every day from fishing/seal hunts. Alternatives are less accessible and more expensive.	1
N	Most seal meat is sold to local markets.			0
Y	Main source of income for professional hunters.	N	Fur from seal cannot be substituted by fur from reindeer because the quota doesn't allow an increase in the number of reindeer hunted.	1
Y	The fjord is fully part of the experience of hunting in the wild. Fishermen take pride in safe navigation in a difficult and poorly mapped area.	N	Alternatives don't have the same reputation and traditions.	1
				0

Impact Step 3 – Define the scope and information needs of the ecosystem service impact assessment

Now that the priority ecosystem services have been identified, Step 3 lays the foundation for focused baseline data collection (Step 4) and impact assessment (Step 5) by determining where to collect data and which data to collect.

Sub-step I-3.1: Delineate the ecosystem service impact assessment area

The ecosystem service impact assessment area is the area relevant to assessing project impacts on affected stakeholders' well-being. It includes the ecosystems the project impacts as well as the places where affected stakeholders access priority ecosystem services.

For each priority ecosystem service identified in Step 2, the ES lead identifies the areas:

- *Where the impacted ecosystems relevant to the supply of priority ecosystem services, or parts thereof, are located.* The ES lead identifies the ecosystems that supply each priority ecosystem service by reviewing the output of Step 2 (see Box 4).
- *Where affected stakeholders access priority ecosystem services.* The ES lead engages affected stakeholders and identifies where they access priority ecosystem services (this may have occurred in Step 2 as part of the prioritization-related stakeholder engagement). Beneficiaries do not always access ecosystem services locally, i.e., within the ecosystem that supplies them. Recognizing the spatial relationships between where ecosystem services are supplied and where they are accessed ensures that the ES lead does not overlook parts of the impact assessment area (see Box 5 on these spatial relationships).

While intermediate services affected by a project are not prioritized in Step 1, the ecosystem service impact assessment area also includes the ecosystem that supplies these impacted intermediate services along with the ecosystems that supply the priority ecosystem services they support. For example, a project that deforests an upper watershed would directly affect the regulation of water flow and timing by the upper watershed and, indirectly, the provision of freshwater in downstream rivers. The priority ecosystem service is freshwater and the impact assessment area includes (1) the impacted forest (i.e., ecosystem supplying regulation of water flow and timing); (2) the impacted rivers (i.e., ecosystems supplying freshwater); and (3) the abstraction points (i.e., where people access freshwater).

The output of sub-step I-3.1 is the delineation of the geographic scope of the ecosystem service impact assessment (see Box 6).

5 SPATIAL RELATIONSHIPS BETWEEN AREAS WHERE ECOSYSTEM SERVICES ARE ACCESSED AND SUPPLIED

Ecosystem services can be classified into five categories according to the relationship between where they are accessed and supplied (adapted from Balmford et al. 2008):

- Local ecosystem services: when beneficiaries access the ecosystem service within the ecosystem that supplies it (e.g., soil production);
- Omnidirectional neighborhood ecosystem services: when beneficiaries access the ecosystem service within a buffer area surrounding the ecosystem supplying it (e.g., pollination of crops by species from a nearby forest);
- Directional neighborhood ecosystem services: when beneficiaries access the ecosystem service within a buffer area surrounding the ecosystem supplying it, but only in a given direction (e.g., protection of settlements behind mangroves);
- Long-distance directional ecosystem services: when beneficiaries access the ecosystem service far from the ecosystem supplying it, with services flowing in specific directions (e.g., water provisioning flowing downstream); and
- Globally distributed ecosystem services: when beneficiaries access the ecosystem service anywhere irrespective of where the ecosystem supplying it is located (e.g., carbon sequestration by forests, ethical value of protecting endangered species).

Sub-step I-3.2: Identify indicators of project impact on ecosystem services

At this stage, the ESIA team has probably not systematically collected all the data required to assess project impacts on ecosystem services. Now that the team knows where to collect the data, sub-step 3.2 establishes the indicators that they will use for that collection. The contribution of individual practitioners during Steps 4 and 5 will be guided by the indicators identified during this sub-step.

The ES lead identifies indicators of ecosystem service benefit, use, and supply in a specific order to ensure that attention remains focused on the ways people benefit from ecosystems:

1. *Indicator of ecosystem service benefit*. For each benefit derived from priority ecosystem services, the ES lead, with input from affected stakeholders, chooses a socio-economic indicator that best captures the gain in well-being derived from an ecosystem service. The indicator of benefit can be monetary or non-monetary. For example, the ES lead, with input from fishermen who could be affected by the impacts of an oil and gas project on local fisheries, might identify three indicators to depict the contribution of fish to the fishermen's well-being: annual income from fish, nutritional status of fishermen's children, and fishermen's social standing.

6 IMPACT ASSESSMENT SUB-STEP 3.1 FOR THE VIVA PROJECT

The ES lead identified the ecosystem service impact assessment area related to the six priority ecosystem services (i.e., reindeer meat, aesthetic value from the tundra, cultural heritage and identity from the tundra, seal meat, seal fur, and cultural heritage and identity from the fjord). The ES lead first listed the parts of the impacted ecosystems that are relevant to the supply of priority ecosystem services, and the locations where affected stakeholders access priority services. Based on this list, he then sketched a map for each priority ecosystem service.

Although residents throughout the province value the cultural heritage and identity associated with the tundra and the fjord, the ES lead might focus only on the areas where the project facilities are visible in order to keep the geographic scope manageable.

See output table below and output maps on page 22.

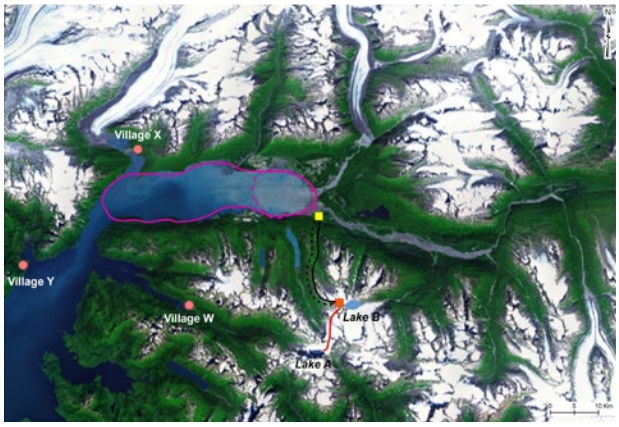
6 OUTPUT TABLE | IMPACT ASSESSMENT SUB-STEP 3.1 FOR THE VIVA PROJECT

Priority ecosystem services	Where the impacted ecosystems relevant to the supply of priority ecosystem services, or parts thereof, are located	Where affected stakeholders access priority ecosystem services
Reindeer meat	Part of the tundra affected by the project and its buffer zone	Tundra hunting grounds close to tundra affected by the project
Aesthetic value of the tundra	Part of the tundra affected by the project and its buffer zone	Tundra hunting grounds from where project facilities are visible (based on a viewshed analysis)
Cultural heritage and identity from the tundra	Part of the tundra affected by the project and its buffer zone	Whole province
Seal meat	Part of the fjord where port is located and where effluent is diluted	Fjord hunting grounds close to port
Fur from seal	Part of the fjord where port is located and where effluent is diluted	Fjord hunting grounds close to port
Cultural heritage and identity from the fjord	Part of the fjord where port is located and where effluent is diluted	Whole province

6 OUTPUT MAPS | IMPACT ASSESSMENT SUB-STEP 3.1 FOR THE VIVA PROJECT

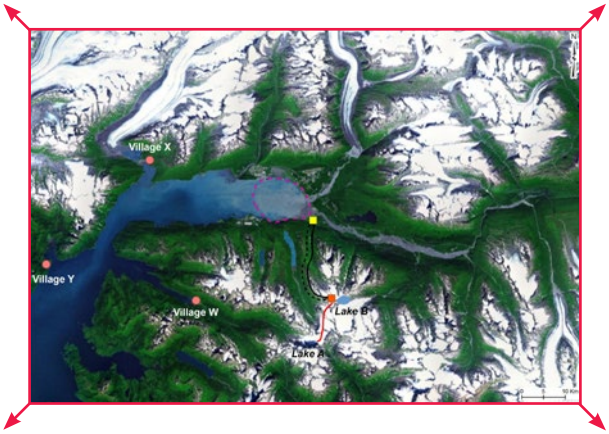
REINDEER MEAT

SEAL MEAT



AESTHETIC VALUE FROM THE TUNDRA

CULTURAL HERITAGE AND IDENTITY FROM THE FJORD



CULTURAL HERITAGE AND IDENTITY FROM THE TUNDRA

- Mine site, including processing plant
- Port
- Villages
- Slurry pipeline
- Access road
- Water pipeline
- Impacted ecosystems relevant to the supply of priority ecosystem service
- Where affected stakeholders access priority ecosystem services

Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

2. *Indicator of ecosystem service use*. For each indicator of ecosystem service benefit, the ES lead, with input from affected stakeholders, selects a socio-ecological indicator[9] that reflects the way stakeholders actually enjoy or consume an ecosystem service. In the example cited above, annual income from fish would link to the annual quantity of fish sold, the nutritional status of fishermen's children to the annual quantity of fish they consume, and the social standing of fishermen to the size of their catch.

3. *Indicator of ecosystem service supply*. For each indicator of ecosystem service use, the ES lead chooses a socio-ecological indicator that communicates the maximum level of ecosystem service that the ecosystem can provide without undermining its future provisioning capacity. The total annual quantity of fish sold and consumed, for example, can be associated with the total annual maximum sustainable fish yield. (This means that there might be tradeoffs between these two uses: if the quantity of fish is diminished, fishermen might have to choose between sale and consumption.) The ES lead and ecologists would link the number, size, and diversity of the fishermen's catch to the total number, size, and diversity of fish species that can be sustainably caught.

The output of sub-step I-3.2 is a list of indicators of ecosystem benefit, use, and supply for each priority ecosystem service identified in Step 2 (see Box 7).

7 IMPACT ASSESSMENT SUB-STEP 3.2 FOR THE VIVA PROJECT

The ES lead identified monetary and non-monetary indicators of benefits. The indicators revealed tradeoffs between different uses of reindeer meat by professional hunters (who must decide whether to sell, eat, or share the meat), and between professional and recreational hunters (who compete over the total annual maximum sustainable harvesting of reindeer meat).

Unlike benefits derived from reindeer meat, seals contribute two, non-competitive sources of income through their fur and their meat.

See output table on pages 24 and 25.

9. More than one indicator of ecosystem service use would be required in two scenarios. First, when the project impacts multiple ecosystem service characteristics (e.g., quantity, quality, timing, and location) important to delivering the benefit to affected stakeholders, more than one indicator of use would be required. For example, when a project is anticipated to affect the quantity and timing of freshwater flows downstream, the ES lead would identify both the average volume of river water withdrawn by beneficiaries per day during average flows, and the average volume of river water withdrawn by beneficiaries per day during low flows. Second, more than one indicator of ecosystem service use would be required when the project impacts a single ecosystem service characteristic important to affected stakeholders in multiple ways. For example, when a hydrocarbon project is expected to affect water quality through oil leakages and domestic pollution from in-migration, the ES lead would choose two water quality indicators: one to measure the concentration of oil-related pollutants and one to measure the concentration of domestic waste-related pathogens.

7 OUTPUT TABLE | IMPACT ASSESSMENT SUB-STEP 3.2 FOR THE VIVA PROJECT

FROM STEP 2			SUB-STEP 3.2:
Priority ecosystem services	**Affected stakeholders**	**Affected benefits**	**Indicators of ecosystem service benefit**
Impacted ecosystem: Tundra			
Reindeer meat	Professional hunters from villages W, X, and Y and their households	Income	Annual income from reindeer meat sale for all professional hunters
		Protein intake	Protein intake by professional hunters' households
		Ability to help others	Number of meals to which professional hunters' households contributed reindeer meat/year
	Recreational hunters from the province and their households	Ability to help others	Number of meals to which recreational hunters' households contributed reindeer meat/year
Aesthetic value	Professional hunters from villages W, X, and Y and recreational hunters from the province	Spiritual fulfillment	Self reported satisfaction with hunting experience
Cultural heritage and identity	Communities in the province	Social cohesion	Percentage of people in the communities that identify the tundra as important to their community
Impacted ecosystem: Fjord			
Seal meat	Professional seal hunters from villages W, X, and Y and their households	Income	Annual income from seal meat sale for all professional hunters
Fur from seal	Professional seal hunters from villages W, X, and Y and their households	Income	Annual income from seal fur sale for all professional hunters
Cultural heritage and identity	Communities in the province	Social cohesion	Percentage of people in the communities that identify the fjord as important to their community

IDENTIFY INDICATORS OF PROJECT IMPACT ON ECOSYSTEM SERVICES		
Indicators of ecosystem service use	**Indicators of ecosystem service supply**	**Comments or supporting information**
Quantity of reindeer meat sold by all professional hunters/year	Number of reindeer available for hunting/year within hunting grounds	The more reindeer meat sold, the more income gained
Quantity of reindeer meat consumed by all professional hunters' households/year		The more reindeer meat eaten, the higher the protein intake (up to a certain level)
Quantity of reindeer meat contributed by all professional hunters' households/year		The more reindeer meat given, the more contribution to traditional events, the more integrated the professional hunter's household
Quantity of reindeer meat contributed by all recreational hunters' households/year		The more reindeer meat given, the more contribution to traditional events, the more integrated the recreational hunter's household
Area of undisturbed natural areas viewed when hunting	Area of undisturbed natural areas within view of hunting grounds	The more undisturbed the tundra, the greater the pleasure from hunting
Perceived wilderness of the tundra	Wilderness of the tundra	The wilder the tundra is perceived, the more vibrant the cultural pride
Quantity of seal meat sold by all professional seal hunters/year	Number of seals available for hunting/year within hunting areas of the fjord	The more seal meat sold, the more income gained
Quantity of seal skin sold by all professional seal hunters/year		The more seal fur sold, the more income gained
Perceived wilderness of the fjord	Wilderness of the fjord	The wilder the fjord is perceived, the more vibrant the cultural pride

Impact Step 4 – Establish the baseline for priority ecosystem services

In Step 4, the ES lead compiles the data collected by the ESIA team from within the impact assessment area for the indicators identified in Step 3. The ES lead assesses the relationship between current ecosystem service use and benefit, and characterizes the sustainability of current use in order to predict impact and assess significance in Step 5. The main output is an ecosystem service baseline assessment to be included in the ESIA report.

Sub-step I-4.1: Assess current ecosystem service use and benefit

The ES lead establishes the current levels of use and benefit for each indicator identified in sub-step 3.2. Information on current levels of ecosystem service use and benefit can come from stakeholder engagement, livelihood surveys, agricultural census, health surveys, cultural studies, and other sources.

As shown in Figure 2, sub-step 4.1 establishes the relationships between current levels of ecosystem service use and benefit. The ES lead will use these relationships in Step 5 to extrapolate how project impacts on ecosystem service supply might alter the benefits affected stakeholders derive from the service.

The output of sub-step I-4.1 is a characterization of the current uses of, and the benefits derived from, priority ecosystem services (see Box 8).

Sub-step I-4.2: Assess sustainability of current ecosystem service use and benefit

Affected stakeholders' use of an ecosystem service does not provide information about the sustainability of use, and therefore the sustainability of benefit, over time. Knowing the sustainability of current use and benefit is important to assess the significance of project impacts (see sub-step 5.3) and to identify mitigation measures sensitive to current trends (see sub-step 6.1).

Addressing ecosystem services in ESIA is about addressing the social implications of environmental impacts. It requires identifying the environmental impacts that need further consideration because of their social, economic, or cultural importance; understanding how people benefit from their environment in the absence of the project; and predicting how the project could affect these benefits.

To assess the sustainability of current use, the ES lead can use a combination of the following approaches:

- Infer qualitatively from ecosystem condition whether current level of use is undermining the ecosystem's capacity to maintain this level of use over time;
- Establish the current ecosystem service supply based on an ecological production function and compare it to current use (i.e., current use is sustainable if it is less than or equal to supply); or
- Discuss past trends with stakeholders to determine if current use is:
  - Sustainable: Over the recent past,[10] affected stakeholders have maintained steady levels of use without making additional efforts in terms of time, distance, or technology and have not seen signs of ecosystem degradation (e.g., equal abundance of medicinal plants in the area, steady fishing effort); or event occurrence has remained constant (e.g., equal number and magnitude of landslides).
  - Unsustainable: Over the recent past, affected stakeholders have maintained current use but with additional efforts in terms of time, distance, or technology and have observed signs of ecosystem degradation (e.g., having to travel further distances to harvest a medicinal plant; use of smaller-mesh fishing net); or they have experienced a noticeable change in event occurrence (e.g., increased incidence or magnitude of landslides).
  - Highly unsustainable: Over the recent past, affected stakeholders have registered a decrease in use of an ecosystem service despite making additional efforts in terms of time, distance, or technology; or they have experienced a dramatic change in event occurrence.

The output of sub-step I-4.2 is an assessment of the sustainability of current ecosystem service uses and benefits (see Box 8).

8 IMPACT ASSESSMENT STEP 4 FOR THE VIVA PROJECT

The ES lead established the baseline for the indicators of ecosystem service use and benefit identified in sub-step 3.2. For example, he established that:

- Provincial hunting statistics and socio-economic surveys show that, in an average year, 85 professional hunters shoot 2,000 reindeer or 100,000 kg of reindeer meat, leading to an annual income of $700,000; private consumption of 20,000 kg of meat; and a donation of 10,000 kg.
- 80% of interviewed professional hunters are satisfied with their hunting experience.
- 95% of the people surveyed in the province see the tundra ecosystem as important to their community.

The ecological studies undertaken as part of the ESIA and the fact that hunters have not seen variations in their catch or their hunting effort led the ES lead to consider the level of use regarding reindeer meat as sustainable. On the other hand, the reports by hunters of changes in their seal catch provided grounds for the ES lead to regard the sustainability of seal meat as unknown.

See output table on pages 28 and 29.

10. The ES lead might have to define "recent past" differently according to the ecosystem service under consideration since ecosystem services work over different temporal scales, from the annual production of crops to the long cycles of soil formation and climate regulation.

8 OUTPUT TABLE | IMPACT ASSESSMENT STEP 4 FOR THE VIVA PROJECT

FROM STEP 2			SUB-STEP 4.1:
Priority ecosystem services	**Affected stakeholders**	**Affected benefits**	**Current ecosystem service benefits**
Impacted ecosystem: Tundra			
Reindeer meat	Professional hunters from villages W, X, and Y and their households	Income	Annual income from reindeer meat sale for all professional hunters: $700,000/year ($8,000/hunter/year)
		Protein intake	Protein intake by all professional hunters' households: Good
		Ability to help others	Number of meals to which professional hunters' households contributed reindeer meat: 2,500 meals/year (30 meals/hunter's household/year)
	Recreational hunters from the province and their households	Ability to help others	Number of traditional meals to which recreational hunters' households contributed reindeer meat: 10,000 meals/year (17 meals/hunter's household/year)
Aesthetic value	Professional hunters from villages W, X, and Y and recreational hunters from the province	Spiritual fulfillment	Self-reported satisfaction with hunting experience: 30% are very satisfied; 50% are satisfied; 20% are not satisfied
Cultural heritage and identity	Communities in the province	Social cohesion	Percentage of people in the communities that identify the tundra as important to their community: 95%
Impacted ecosystem: Fjord			
Seal meat	Professional seal hunters from villages W, X, and Y and their households	Income	Annual income from seal meat sale for all professional seal hunters: $600,000/year ($13,300/hunter/year)
Fur from seal	Professional seal hunters from villages W, X, and Y and their households	Income	Annual income from seal fur sale for all professional seal hunters: $76,000/year ($1,700/hunter/year)
Cultural heritage and identity	Communities in the province	Social cohesion	Percentage of people in the communities that identify the fjord as important to their community: 85%

ASSESS CURRENT ECOSYSTEM SERVICE USE AND BENEFIT		SUB-STEP 4.2: ASSESS SUSTAINABILITY OF CURRENT ECOSYSTEM SERVICE USE AND BENEFIT	
Current ecosystem service uses	**Comments or supporting information**	**Sustainable Unsustainable Highly unsustainable Unknown**	**Comments or supporting information**
Quantity of reindeer meat sold by all professional hunters: 70,000 kg/year (800 kg/hunter/year)	Labor statistics	Sustainable	Hunters did not report variations in their catch of reindeer over the years. Ecological studies conducted as part of the ESIA suggest that more reindeer could be sustainably caught.
Quantity of reindeer meat consumed by all professional hunters' households: 20,000 kg/year (230 kg/hunter's household/year)	Health statistics		
Quantity of reindeer meat given by all professional hunters' households: 10,000 kg/year (115 kg/hunter's household/year)	From stakeholder engagement		
Quantity of reindeer meat given by all recreational hunters' households: 47,500 kg/year (85 kg/hunter's household/year)	From stakeholder engagement	Sustainable	
Area of undisturbed natural areas viewed when hunting: 100% of area within view of hunting grounds is undisturbed natural areas	From stakeholder engagement	Sustainable	No expected change in the naturalness of the tundra.
Perceived wilderness of the tundra: 100% agree with "the tundra is wild"	From stakeholder engagement	Sustainable	There has been no change in the wilderness of the tundra. There is no expectation of change except by the project.
Quantity of seal meat sold by all professional seal hunters: 20,000 kg/year (440 kg/hunter/year)	Labor statistics	Unknown	Seal hunters did report significant variations in their catch on a year-to-year basis. Record of seal catch shows unexplained variation over the years.
Quantity of seal skin sold by all professional seal hunters: 1,900 skins/year (40 skins/hunter/year)	Labor statistics		
Perceived wilderness of the fjord: 100% agree with "the fjord is wild"	From stakeholder engagement	Sustainable	There has been no change in the wilderness of the fjord. There is no expectation of change except by the project.

Impact Step 5 – Assess project impacts on priority ecosystem services

In Step 5, the ES lead assesses how a project's direct and indirect impacts affect ecosystems, their supply of ecosystem services, and the benefits to affected stakeholders based on the analyses conducted by the ESIA team for the indicators identified in Step 3. Based on the relationships between the levels of ecosystem service use and benefit established during the baseline assessment (Step 4), the ES lead infers changes in ecosystem service benefits from changes in ecosystem service supply.

The ecosystem service impact assessment is included in the ESIA report.

Sub-step I-5.1: Predict project impacts on ecosystem service supply

The ES lead predicts how the project could affect ecosystem service supply, either because it would alter the condition or type of ecosystems or change the accessibility of ecosystem services to affected stakeholders (Figure 4).

For each indicator of ecosystem service supply identified in sub-step 3.2, the ES lead in consultation with environmental practitioners can either:

- Infer the predicted changes in ecosystem service supply qualitatively from the extent of changes in the ecosystem, based on expert knowledge; or
- Model the predicted changes in supply quantitatively, based on ecological production functions.

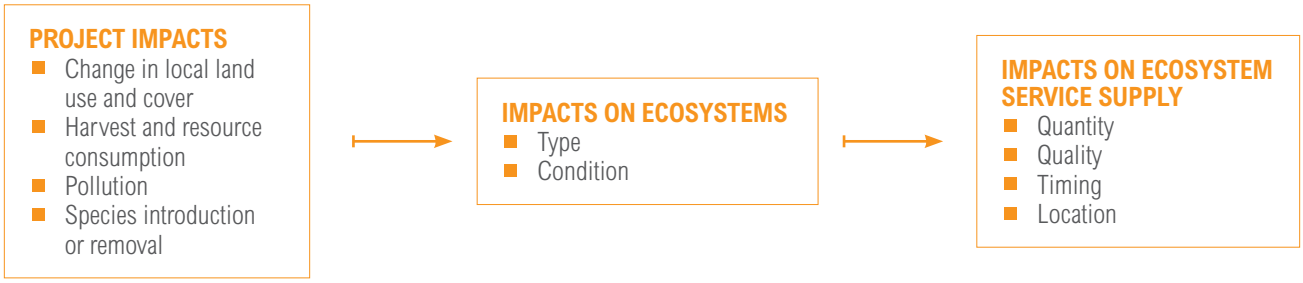
The output of sub-step I-5.1 is a prediction of how ecosystem service supply could be affected by the project for each priority ecosystem service (see Box 9).

Sub-step I-5.2: Predict project impacts on ecosystem service benefits

The ES lead predicts how impacts on ecosystem service supply predicted in sub-step 5.1 could affect the ecosystem service benefits to affected stakeholders.

In sub-step 4.1, the ES lead established the relationship between ecosystem service use and benefit, allowing him to understand how a change in ecosystem service use can lead to a change in ecosystem service benefit. In sub-step 5.2, he approximates ecosystem service use and supply so that he can extrapolate how project-induced changes in ecosystem service supply could translate to a change in ecosystem service benefit (Figure 5). For example, the ES lead established during baseline that 2,000 reindeer contribute to an income of $700,000, a consumption of 20,000 kg of meat, and donation of 10,000 kg of meat. If the ES lead predicts that the project would lead to a loss in the tundra's capacity to support 200 reindeer, he can approximate that this could translate into a 10 percent loss in income, meat consumption, and donation if the hunters distributed the loss equally among the benefits they derive from reindeer meat.

Figure 4 | **From project impacts on ecosystems to project impacts on ecosystem service supply**



When one ecosystem service provides multiple conflicting benefits, the ES lead might need to engage stakeholders to understand how they would allot limited ecosystem service supply among different benefits.

The output of sub-step I-5.2 is an explanation of how ecosystem service benefits could be affected by the project for each priority ecosystem service (see Box 9).

Sub-step I-5.3: Assess significance of project impacts on affected stakeholders

The ES lead determines the significance of project impacts according to the magnitude of impacts on ecosystem service benefits and the sensitivity of affected stakeholders to the changes in those benefits.

The ES lead assesses, with the social practitioners, impact magnitude on ecosystem service benefit according to the size, frequency, duration, reversibility, and intensity of impact on the ecosystem service benefit. He also accounts for the sustainability of current ecosystem service benefit (established in sub-step 4.2) in assessing magnitude.

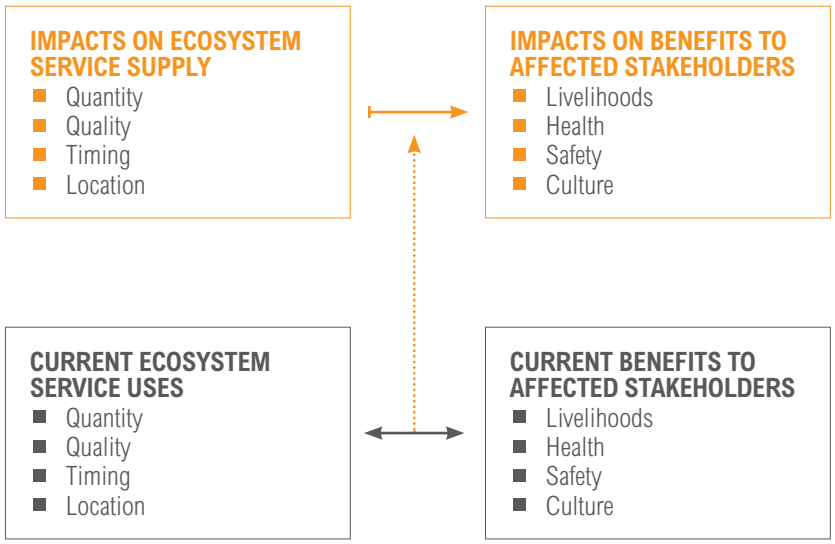
9 IMPACT ASSESSMENT SUB-STEPS 5.1 AND 5.2 FOR THE VIVA PROJECT

The ES lead predicted impacts on the indicators of supply and benefit identified in sub-step 3.2. It should be noted that project impacts on ecosystem service supply and benefits are not necessarily proportionate. For example, the Viva project's impacts on the wilderness of the tundra were expected to be negligible relative to the whole ecosystem. However, a small change in the tundra wilderness was deemed to have a disproportionate effect on communities' social cohesion given the premium their culture places on the tundra's wildness.

Regarding competition between their different uses of reindeer meat, professional hunters told the ES lead that they would prioritize earning an income, over providing meat for their family, over sharing with community members if their reindeer catch dropped. The ES lead therefore predicted that a loss in reindeer meat would mostly be experienced by the hunters' families through a sharp decline in their ability to help others.

See output table on pages 32 and 33.

Figure 5 | **From project impacts on ecosystem service supply to project impacts on benefits to affected stakeholders**



LEGEND

- Conducted during impact assessment
- Established during baseline assessment

9 OUTPUT TABLE | IMPACT ASSESSMENT SUB-STEPS 5.1 AND 5.2 FOR THE VIVA PROJECT

FROM STEP 2			SUB-STEP 5.1: PREDICT PROJECT IMPACTS ON ECOSYSTEM SERVICE SUPPLY	
Priority ecosystem services	**Affected stakeholders**	**Affected benefits**	**Predicted impacts on ecosystem service supply**	**Comments or supporting information**
Impacted ecosystem: Tundra				
Reindeer meat	Professional hunters from villages W, X, and Y and their households	Income	Number of reindeer available for hunting/year within hunting grounds: ↓ (moderate decrease in number of reindeer)	The disturbance of reindeer habitat as a result of the project's footprint is expected to lower reindeer density in hunting grounds. With a predicted decline in the density of reindeer and restricted access around the project's facilities in the hunting grounds, the number of reindeer available to hunters is expected to decrease.
		Protein intake		
		Ability to help others		
	Recreational hunters from the province and their households	Ability to help others		
Aesthetic value	Professional hunters from villages W, X, and Y and recreational hunters from the province	Spiritual fulfillment	Area of undisturbed natural areas within view of hunting grounds: ↘ (minor decrease in visual naturalness)	The visual impact of the project is assessed based on a viewshed analysis of the project by geographical information system (GIS). The area of the hunting grounds visually disturbed is estimated to be small relative to the total acreage of the hunting grounds.
Cultural heritage and identity	Communities in the province	Social cohesion	Wilderness of the tundra: ≈ (no change in wilderness)	The impact on the wilderness of the tundra is estimated to be negligible because the project's footprint would be small and localized relative to the total area of tundra.
Impacted ecosystem: Fjord				
Seal meat	Professional seal hunters from villages W, X, and Y and their households	Income	Number of seals available for hunting/year within hunting areas of the fjord: ≈ (no change in number of seals)	Port activities are not expected to affect seal population.
Fur from seal	Professional seal hunters from villages W, X, and Y and their households	Income		
Cultural heritage and identity	Communities in the province	Social cohesion	Wilderness of the fjord: ↘ (minor decrease in wilderness)	The project and its infrastructure will infringe upon the wilderness of the fjord, but only slightly.

SUB-STEP 5.2: PREDICT PROJECT IMPACTS ON ECOSYSTEM SERVICE BENEFITS	
Predicted impacts on ecosystem service benefit	**Comments or supporting information**
Annual income from reindeer meat sale for all professional hunters: ≈ (no change in income)	Professional hunters said they would prioritize (1) getting income, (2) having meat in their diet, and (3) sharing with other families.
Protein intake by all professional hunters' households: ↘ (minor decrease in protein intake)	
Number of meals to which professional hunters' households would contribute reindeer meat: ↓↓ (major decrease in the number of meals to which households can contribute)	
Number of traditional meals to which recreational hunters' households would contribute reindeer meat: ↘ (minor decrease in the number of meals to which households can contribute)	Recreational hunters said they would prioritize sharing reindeer meat over self-consumption.
Self-reported satisfaction with hunting experience: ↓↓ (major loss in satisfaction from hunting)	Hunters said they would not enjoy the same relationship with nature in areas where the project can be seen. The change in supply disproportionately affects the aesthetic value. Nature and hunters are not setting the rules of the game anymore. There will be constraints related to hunting resulting from the presence of the project.
Percentage of people in the communities that identify the tundra as important to their community: ↓↓ (major loss in communities' identification with the tundra)	Even though the change in wilderness is minor, it disproportionately affects the tundra's cultural value. The communities are likely to transfer what is going on at the mining site to the whole tundra and see it as "spoiled".
Annual income from seal meat sale for all professional seal hunters: ≈ (no change in income)	
Annual income from seal fur sale for all professional seal hunters: ≈ (no change in income)	
Percentage of people in the communities that identify the fjord as important to their community: ↓ (moderate loss in communities' identification with the fjord)	The change in supply disproportionately affects the cultural value of the fjord to the communities.

The ES lead engages affected stakeholders to evaluate their sensitivity to the predicted impacts on ecosystem service benefits. The less numerous and diversified the assets of stakeholders, the less likely they are to be able to adapt successfully to a change in this benefit, whether it is a loss or a gain. Asset assessment includes assessments of (DFID 1999):

- Human capital: Health, knowledge, skills, information, ability to labor.
- Social capital: Social resources (relationships of trust, membership of groups, networks, access to wider institutions).
- Physical capital: Basic infrastructure (for water supply distribution and sanitation, energy, transport, communications), housing, and the means and equipment of production.
- Financial capital: financial resources available (regular remittances or pensions, savings, supplies of credit).
- Natural capital: Natural resources (land, soils, vegetation, water, wildlife, fisheries, biodiversity).

The ES lead uses Table 1 or 2 to determine the significance of ecosystem service benefit loss or gain respectively.

The output of sub-step I-5.3 is the assessment of impact significance on affected stakeholders for each benefit derived from priority ecosystem services (see Box 10) and identification of the ecosystem services for which project impacts need to be mitigated.

Table 1 | **Assessment of significance of loss in ecosystem service benefit brought by a project**

		SENSITIVITY OF AFFECTED STAKEHOLDERS TO LOSS IN ECOSYSTEM SERVICE BENEFIT		
		Low Strong and diversified asset portfolio; high ability to adapt to loss in ecosystem service benefit and maintain overall well-being.	**Medium** Medium-size and moderately diversified asset portfolio; ability to partially adapt to loss in ecosystem service benefit and maintain overall well-being.	**High** Small and concentrated asset portfolio; limited ability to adapt to loss in ecosystem service benefit and maintain overall well-being.
MAGNITUDE OF LOSS IN ECOSYSTEM SERVICE BENEFIT	**Negligible** Loss in ecosystem service benefit remains within the range commonly experienced by affected stakeholders. Loss in ecosystem service benefit categorized as "negligible" by affected stakeholders.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
	Low Relatively small loss in ecosystem service benefit from baseline conditions. The loss in ecosystem service benefit is for a short duration or occurs with low frequency. Loss in ecosystem service benefit categorized as "low" by affected stakeholders.	NEGLIGIBLE	MINOR	MODERATE
	Medium Relatively large loss in ecosystem service benefit from baseline conditions. The loss in ecosystem service benefit is of medium duration or occasional frequency. Loss in ecosystem service benefit categorized as "medium" by affected stakeholders.	MINOR	MODERATE	MAJOR
	High Loss in ecosystem service benefit dominates over baseline conditions. The loss in ecosystem service benefit is of long duration, even irreversible, or frequent. Loss in ecosystem service benefit categorized as "high" by affected stakeholders.	MODERATE	MAJOR	MAJOR

Source: Adapted from ERM 2012.

10 IMPACT ASSESSMENT SUB-STEP 5.3 FOR THE VIVA PROJECT

Six of the project impacts on ecosystem service benefits were rated as minor or higher and need to be mitigated in Step 6: professional hunters' loss in (1) income, (2) children's nutrition, and (3) ability to help others derived from reindeer meat; (4) loss in aesthetic fulfillment from the tundra by both professional and recreational hunters; (5) loss in cultural heritage and identity by the communities in the province from the tundra; and (6) loss in cultural heritage and identity by the communities in the province from the fjord.

It should be noted that the significance of impacts on the "ability to help others" on professional and recreational hunters was assessed as "major" and "negligible" respectively because of their different sensitivity to the loss in benefit. Recreational hunters with more diversified capital were deemed less vulnerable to the loss in benefit.

See output table on pages 36 and 37.

Table 2 | **Assessment of significance of gain in ecosystem service benefit brought by a project**

		SENSITIVITY OF AFFECTED STAKEHOLDERS TO GAIN IN ECOSYSTEM SERVICE BENEFIT		
		Low Small and concentrated asset portfolio; limited ability to capture gain in ecosystem service benefit and improve overall well-being.	**Medium** Medium-size and moderately diversified asset portfolio; ability to partially capture gain in ecosystem service benefit and improve overall well-being.	**High** Strong and diversified asset portfolio; high ability to capture gain in ecosystem service benefit and improve overall well-being.
MAGNITUDE OF GAIN IN ECOSYSTEM SERVICE BENEFIT	**Negligible** Gain in ecosystem service benefit remains within the range commonly experienced by affected stakeholders. Gain in ecosystem service benefit categorized as "negligible" by affected stakeholders.	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE
	Low Relatively small gain in ecosystem service benefit from baseline conditions. The gain in ecosystem service benefit is for a short duration or occurs with low frequency. Gain in ecosystem service benefit categorized as "low" by affected stakeholders.	NEGLIGIBLE	MINOR	MODERATE
	Medium Relatively large gain in ecosystem service benefit from baseline conditions. The gain in ecosystem service benefit is of medium duration or occasional frequency. Gain in ecosystem service benefit categorized as "medium" by affected stakeholders.	MINOR	MODERATE	MAJOR
	High Gain in ecosystem service benefit dominates over baseline conditions. The gain in ecosystem service benefit is of long duration or frequent. Gain in ecosystem service benefit categorized as "high" by affected stakeholders.	MODERATE	MAJOR	MAJOR

Source: Adapted from ERM 2012.

10 OUTPUT TABLE | IMPACT ASSESSMENT SUB-STEP 5.3 FOR THE VIVA PROJECT

FROM STEP 2			FROM SUB-STEP 5.2	SUB-STEP 5.3:
Priority ecosystem services	**Affected stakeholders**	**Affected benefits**	**Predicted impacts on ecosystem service benefit**	**Magnitude of impact on ecosystem service benefit**
Impacted ecosystem: Tundra				
Reindeer meat	Professional hunters from villages W, X, and Y and their households	Income	Annual income from reindeer meat sale for all professional hunters: ≈ (no change in income)	Low
		Protein intake	Protein intake by all professional hunters' households: ↘ (minor decrease in protein intake)	Medium
		Ability to help others	Number of meals to which professional hunters' households would contribute reindeer meat: ↓↓ (major decrease in the number of meals to which households can contribute)	High
	Recreational hunters from the province and their households	Ability to help others	Number of traditional meals to which recreational hunters' households would contribute reindeer meat: ↘ (minor decrease in the number of meals to which households can contribute)	Low
Aesthetic value	Professional hunters from villages W, X, and Y and recreational hunters from the province	Spiritual fulfillment	Self-reported satisfaction with hunting experience: ↓↓ (major loss in satisfaction from hunting)	High
Cultural heritage and identity	Communities in the province	Social cohesion	Percentage of people in the communities that identify the tundra as important to their community: ↓↓ (major loss in communities' identification with the tundra)	Medium
Impacted ecosystem: Fjord				
Seal meat	Professional seal hunters from villages W, X, and Y and their households	Income	Annual income from seal meat sale for all professional seal hunters: ≈ (no change in income)	Negligible
Fur from seal	Professional seal hunters from villages W, X, and Y and their households	Income	Annual income from seal fur sale for all professional seal hunters: ≈ (no change in income)	Negligible
Cultural heritage and identity	Communities in the province	Social cohesion	Percentage of people in the communities that identify the fjord as important to their community: ↓ (moderate loss in communities' identification with the fjord)	Medium

ASSESS SIGNIFICANCE OF PROJECT IMPACTS ON AFFECTED STAKEHOLDERS			
Comments or supporting information	Sensitivity of affected stakeholders to impacts on ecosystem service benefit	Comments or supporting information	Significance of impact
The professional hunters will prioritize selling reindeer meat so the magnitude of impact on income should be low over the life of the project. However, the smallest change in income from hunting has disproportionate consequences as professional hunters cannot earn more than 40% of income from activities other than hunting. Any small loss in income from hunting would have repercussions on total income.	High	Professional hunters are among the poorest in the local communities.	Moderate
The loss in food and protein intake would be small but sustained for the life of the project. Reindeer meat is likely to be replaced by cheap, low quality food. For the households' children, this might have irreversible health consequences.	High	Professional hunters' households cannot afford to buy meat regularly. Their most reliable source of animal protein is the meat from their catch.	Major
The inability to help others and to partake of reindeer meat will curtail social relationships. The duration will be the life of the project, with possible irreversible consequences in terms of social capital.	High	Professional hunters' households enjoy a high social status despite being poor. Sharing reindeer meat is their only means to help others.	Major
Recreational hunters have the means to help others in ways other than sharing their reindeer catch.	Low	Recreational hunters have social capital built outside of sharing reindeer meat.	Negligible
The impact on spiritual fulfillment will be experienced every time hunters hunt in view of the project.	High	Hunters would go further away to hunt in pristine areas. However, current hunting grounds are close and allow them to return home in the evenings. Having to travel farther would impact family life.	Major
The impact on cultural heritage and identity will be probably experienced most acutely during construction after which people might get used to the changes.	High	Local communities have seen a disintegration of their society and are very vulnerable to change to their environment, which has contributed to social cohesion for thousand of years.	Major
	High		Negligible
	High		Negligible
The impact on cultural heritage and identity will probably be experienced forever, possibly with a peak during construction.	High	Local communities have seen a disintegration of their society and are very vulnerable to change to their environment, which has contributed to social cohesion for thousand of years.	Major

Impact Step 6 – Mitigate project impacts on priority ecosystem services

The ESR for IA aims to mitigate project impacts on the benefits provided by ecosystems to at least achieve no loss in these benefits by affected stakeholders.

The ES lead identifies ecosystem service-specific mitigation measures to supplement those identified by environmental practitioners. While part of a loss in ecosystem service benefit might be mitigated by implementing the mitigation hierarchy on environmental impacts, measures generated in this manner are likely to fall short of achieving no loss of ecosystem service benefit because environmental practitioners do not explicitly consider affected stakeholders in mitigating environmental impacts. For example, environmental practitioners could propose a wetland offset in another watershed to ensure no loss of biodiversity. This offset measure would not, however, address the loss in benefits to affected stakeholders.

Ecosystem service mitigation measures inform project design and operations and are incorporated into the environmental and social management plans.

Sub-step I-6.1: Mitigate loss and enhance gain in ecosystem service benefit

For the losses and gains in ecosystem service benefits rated as minor or higher in Step 5, the ES lead develops mitigation measures that achieve no loss of ecosystem service benefit by affected stakeholders, and, if possible, produce a net gain. This means that, at a minimum, mitigation measures should protect affected stakeholders from experiencing any loss in well-being as a result of the project's impacts on ecosystems.

Ecosystem service mitigation measures should reflect the characteristics of the original benefit derived from ecosystem services. Among others, these measures need to exhibit the intra- and inter-generational equity patterns of the ecosystem service benefit mitigated (see Vanclay 2003). For example, paying cash compensation to individual homeowners whose houses become more prone to flooding following implementation of a project does not necessarily compensate for the loss of protection provided to the whole community now and in the future by wetlands that are degraded or destroyed. The ES lead should endeavor to identify technically and financially feasible mitigation options that will ensure that the whole community continues to receive flood protection now and in the future, for example through the construction of a substitute green infrastructure or man-made levees.

The ES lead reviews the mitigation measures identified by the environmental practitioners and assesses whether these measures would be sufficient to at least achieve no loss in ecosystem service benefit. If they are judged insufficient, the ES lead proceeds to the ecosystem service mitigation hierarchy (Figure 6). If the loss in ecosystem service cannot be fully mitigated through avoidance, minimization, and restoration of project impacts on supply, the ES lead would turn to safeguarding the ecosystem service benefits through offset measures (adapted from BBOP 2013):

1. *Avoidance measures:* These measures avoid project impacts on ecosystems so that the capacity of ecosystems to supply services, and the benefits associated with these services, are left unchanged. They include changes in project location, design, and operations.

2. *Minimization measures:* These measures reduce the duration, intensity, and/or extent of project impacts on ecosystems so that impacts on ecosystem service supply and benefits are kept to a minimum. They include changes in project location, design, and operations.

3. *Restoration measures:* These measures restore the capacity of impacted ecosystems to provide ecosystem service supply and benefits. If there is an unacceptable time lag between when affected stakeholders experience a loss in benefit and when the ecosystem service supply and benefits are restored, restoration measures may need to be accompanied by temporary offset measures.

11 IMPACT ASSESSMENT STEP 6 FOR THE VIVA PROJECT

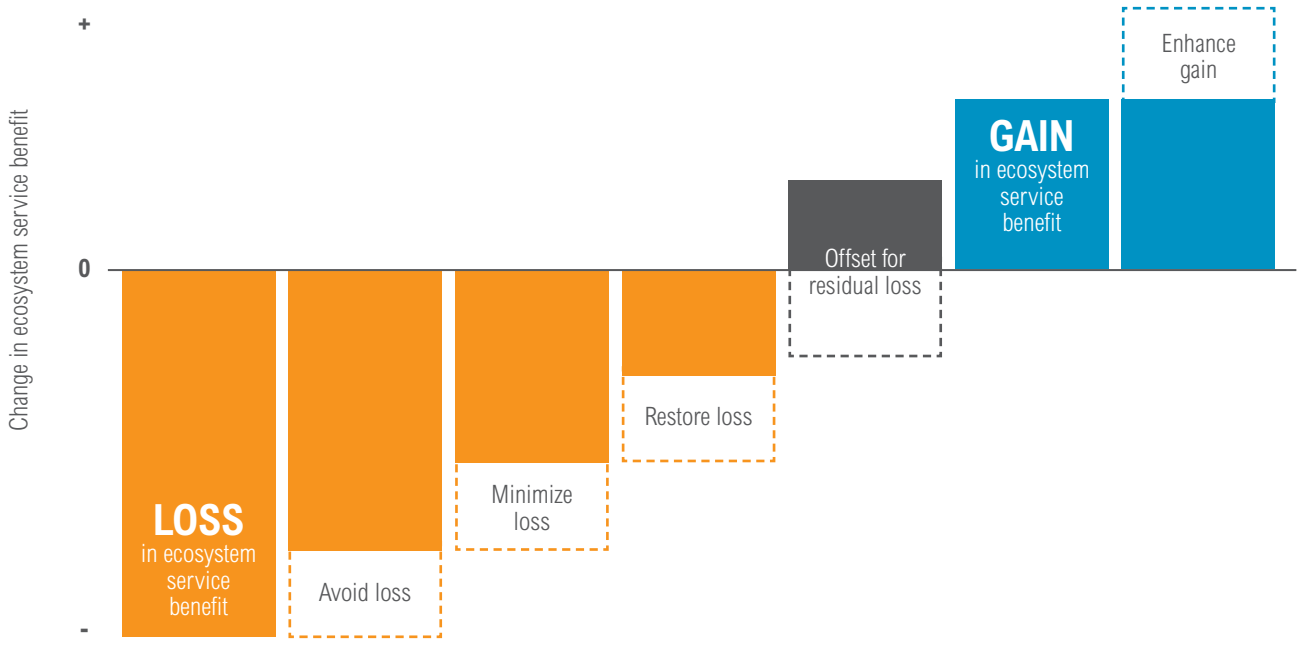
Based on the significance of project impacts on ecosystem service benefits (see Box 10), project impacts on six ecosystem service benefits needed to be mitigated:

- Three benefits derived from reindeer meat: professional hunter households' loss in annual income, protein intake, and number of meals to which they can contribute reindeer meat;
- One benefit derived from the aesthetic value from the tundra: loss in professional and recreational hunters' satisfaction with their hunting experience;
- One benefit derived from the cultural heritage and identity from the tundra: decrease in the percentage of people in the communities of the province who identify the tundra as important to their community; and
- One benefit derived from the cultural heritage and identity from the fjord: decrease in the percentage of people in the communities of the province who identify the fjord as important to their community.

The measures that the ES lead identified to achieve no loss in ecosystem service benefits were identified by avoiding, minimizing, restoring, and offsetting project impacts in that order. For example, when identifying measures to mitigate the loss in satisfaction with hunting that the hunters would experience because project activities compromise the wild condition of traditional hunting areas, no avoidance measure was identified. The ES lead proposed minimization measures such as scheduling project-related road transportation in a manner that would reduce the impact on the experience of hunters. Because a combination of avoidance and minimization measures was expected to be insufficient, the ES lead proposed restoring the hunting areas as part of project decommissioning and closure. Because the ES lead projected that the hunters would still experience a residual loss in satisfaction with their hunting experience despite the avoidance, minimization, and restoration measures, he recommended that affected hunters be permitted to use the project's private roads in order to expand their range and access new hunting grounds.

See output table on pages 40 and 41.

Figure 6 | **Mitigating and enhancing project impacts on ecosystem service benefits**



Source: Adapted from Rio Tinto 2008.

11 OUTPUT TABLE | IMPACT ASSESSMENT STEP 6 FOR THE VIVA PROJECT

FROM STEP 2			FROM SUB-STEP 5.2	FROM SUB-STEP 5.1	FROM SUB-STEP 1.1
Priority ecosystem services	**Affected stakeholders**	**Affected benefits**	**Predicted impacts on ecosystem service benefit**	**Predicted impacts on ecosystem service supply**	**Project impacts on ecosystem**
Impacted ecosystem: Tundra					
Reindeer meat	Professional hunters from villages W, X, and Y and their households	Income	Annual income from reindeer meat sale for all professional hunters: ≈ (no change in income)	Number of reindeer available for hunting/year within hunting grounds: ↓ (moderate decrease in number of reindeer)	Fragmentation of habitat, land cover and use change
		Protein intake	Protein intake by all professional hunters' households: ↘ (minor decrease in protein intake)		Loss of access around mine, processing plant, and port, and along road and slurry pipeline
		Ability to help others	Number of meals to which professional hunters' households would contribute reindeer meat: ↓↓ (major decrease in the number of meals to which households can contribute)		Increased hunting by newcomers
Aesthetic value	Professional hunters from villages W, X, and Y and recreational hunters from the province	Spiritual fulfillment	Self-reported satisfaction with hunting experience: ↓↓ (major loss in satisfaction from hunting)	Area of undisturbed natural areas within view of hunting grounds: ↘ (minor decrease in visual naturalness)	Fragmentation of habitat
					Loss of access around mine, processing plant, and port, and along road and slurry pipeline
					Visual and noise disturbance from industrial activities
Cultural heritage and identity	Communities in the province	Social cohesion	Percentage of people in the communities that identify the tundra as important to their community: ↓↓ (major loss in communities' identification with the tundra)	Wilderness of the tundra: ≈ (no change in wilderness)	Fragmentation of habitat
					Loss of access around mine, processing plant, and port, and along road and slurry pipeline
					Visual and noise disturbance from industrial activities
Impacted ecosystem: Fjord					
Cultural heritage and identity	Communities in the province	Social cohesion	Percentage of people in the communities that identify the fjord as important to their community: ↓ (moderate loss in communities' identification with the fjord)	Wilderness of the fjord: ↘ (minor decrease in wilderness)	Land cover and use change
					Water pollution
					Loss of access around mine, processing plant, and port, and along road and slurry pipeline
					Visual and noise disturbance from industrial activities

SUB-STEP 6.1: MITIGATE LOSS AND ENHANCE GAIN IN ECOSYSTEM SERVICE BENEFIT				
Avoidance measures	**Minimization measures**	**Restoration measures**	**Offset measures**	**Enhancement measures**
		Restoration of the hunting areas as part of project decommissioning and closure	Discuss the possibility of having the "40-60% rule" more flexible so that if hunters earn less from hunting because of project impacts on availability of reindeer, their total income is not affected.	N/A
			Permit use of the project's private roads so hunters can access new, wild hunting grounds for reindeer	N/A
	Give priority to locals in granting hunting licenses Propose seasonal hunting licenses for newcomers			N/A
		Restoration of the hunting areas as part of project decommissioning and closure	Permit use of the project's private roads so hunters can access new, wild hunting grounds	N/A
				N/A
	Road transportation scheduled to be respectful of the whereabouts of hunters to minimize impacting their hunting experience			N/A
		Restoration of the hunting areas as part of project decommissioning and closure	Government to set up land use plan for tundra, including areas to be left untouched for current and future generations to enjoy	N/A
				N/A
				N/A
		Restoration of the fjord as part of project decommissioning and closure	Government to set up land use plan for fjords, including areas to be left untouched for current and future generations to enjoy	N/A
	Treat more effluent discharge			N/A
				N/A
	Use ships that are known to be quiet and ban use of fog horn except in emergency situations			N/A

4. *Offset measures:* These measures compensate for any residual loss in ecosystem service benefit. They include:
   - Restoring ecosystems that are not impacted by the project but that supply the same ecosystem service to the same affected stakeholders[11] (e.g., creation of community woodlots to compensate for restricted access of local communities to forests due to the project, increasing agricultural yield outside of wetlands to slow down wetland conversion to crops);
   - Compensating with man-made substitutes (e.g., wastewater treatment facility to substitute for converted wetland, pharmaceutical medicine to substitute for disease control by undisturbed forests, cash compensation for residual income loss from impacted fisheries); and
   - Increasing the benefit accrued from one unit of ecosystem service supply (e.g., investment in plant to process coffee so that the income per kilo of coffee increases).
5. *Enhancement measures:* These measures increase the benefits people derive from ecosystem services whose supply the project increases (e.g., reforestation efforts by a dam to control sedimentation in parts of the watershed are undertaken where more people would benefit from forest services because of their relative location).

Once ecosystem service-specific mitigation measures are identified, the ES lead ensures there are no conflicts between these mitigation measures and the ones identified independently by the environmental and social practitioners.

If affected stakeholders still experience a loss in ecosystem service benefit even after implementing the ecosystem service mitigation hierarchy, the ES lead engages them to determine whether the loss is acceptable to them. If the loss in benefit is deemed unacceptable by affected stakeholders, the benefit derived from this priority ecosystem service is irreplaceable to their well-being and alternatives for the project should be considered.

The output of sub-step I-6.1 is a list of measures to mitigate loss and enhance gain in ecosystem service benefit (see Box 11).

While part of a loss in ecosystem service benefit might be mitigated by implementing the mitigation hierarchy on environmental impacts, measures generated in this manner are likely to fall short of achieving no loss of ecosystem service benefit because environmental practitioners do not explicitly consider affected stakeholders in mitigating environmental impacts.

11. Tallis et al. 2012 delineates areas "that provide a specific ecosystem service to a specific beneficiary (individual or group of people)" or "servicesheds." It ensures that the ecosystem service offset benefits negatively affected stakeholders.

IV. Dependence assessment steps

Ecosystem services can contribute to project performance in multiple ways (Box 12). The ESR for IA dependence assessment focuses on a project's operational dependencies on ecosystem services.

The contribution of an ecosystem service to project operational performance depends on the extent to which the supply of that service meets the level required by the project to meet its performance goals. Wetlands, for example, can contribute significantly to treating project effluents. A project with an annual budget for treating its wastewater to meet local water quality standards might factor into its budget the free-of-charge contribution to effluent treatment of a nearby wetland. If the wetland is degraded over the project life, however, it might not be able to treat wastewater to the extent originally estimated and the project might therefore need to treat more of its effluent at the project site, which would increase project costs. In this case, wetland degradation could lead to an increase in the project's wastewater treatment expenditures.

The objectives of the dependence assessment are threefold: (1) to identify which ecosystem services might put project operational performance at risk, (2) to assess how ecosystem change over the life of the project might lead to loss in operational performance, and (3) to provide measures to manage operations dependent on ecosystems to achieve planned performance.

Figure 7 depicts the conceptual framework linking causes of ecosystem change (both external and related to the project), future ecosystem service supply, and loss in operational performance. Loss in operational performance is the loss in ecosystem service benefits the project might experience as a result of ecosystem change. The dependence conceptual framework explicitly differentiates between ecosystem, ecosystem service supply, ecosystem service use, and ecosystem service benefit/operational performance in order to reflect the various relationships between them (see Box 1 for definitions of these terms and a brief description of their relationships).

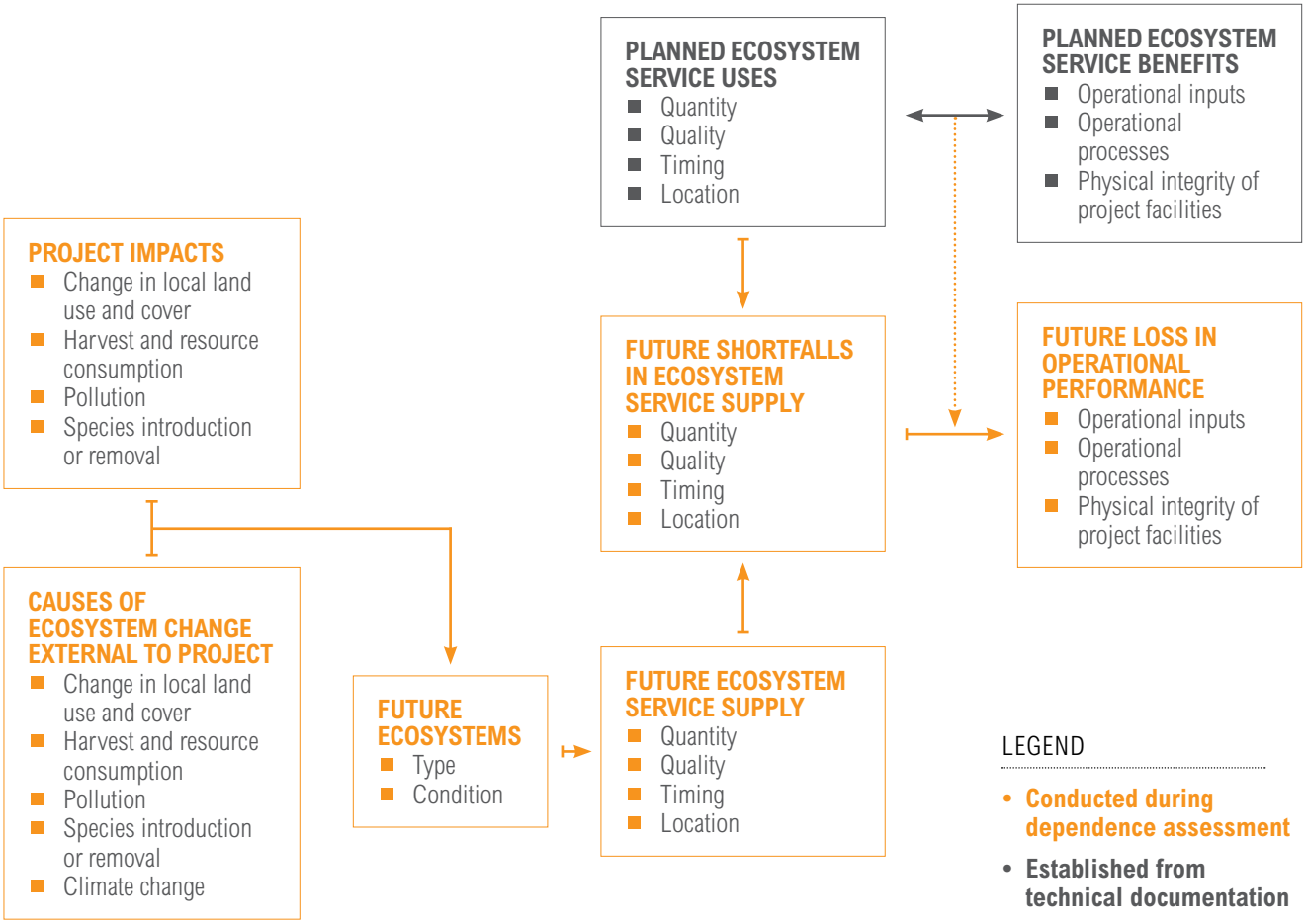
12 TYPES OF PROJECT DEPENDENCE ON ECOSYSTEM SERVICES

Some of the ways in which ecosystem services may contribute to project performance include (adapted from Hanson et al. 2012):

- Operations: as an input or process for project operations or influencing the physical integrity of project facilities (e.g., provision of freshwater for industrial and agricultural processes, purification of input water of beverage company, protection of project facilities from flooding);
- Regulatory and legal compliance: by minimizing compliance costs related to legal and regulatory requirements (e.g., contribution of effluent treatment by wetlands to compliance with water quality standards);
- Reputation: by contributing to the project's reputation as an environmentally friendly or sustainable business (e.g., project's cleaning of invasive species supporting social license to operate);
- Market and product development: by improving the project's market or product potential (e.g., eco-labeling, new environmental markets, or new revenue streams); or
- Financing: by helping the project meet minimum lending requirements or access more favorable lending terms as a result of its management of environmental risks (e.g., projects in area of water scarcity face greater scrutiny by global investment banks).

The ESR for IA assesses how ecosystem type and condition can change over the life of the project, and consequently affect the future supply of ecosystem services. It then determines the extent to which the future supply of this service meets a project's planned ecosystem service use. A project's *planned ecosystem service use* is the level of ecosystem service the project intends to consume or enjoy over its lifespan to achieve its operational performance.

Figure 7 | **From causes of ecosystem change to loss in project operational performance**



The ESR for IA goes beyond establishing whether there is a shortfall in ecosystem service supply or not: it forecasts the future loss in operational performance associated with future shortfalls in ecosystem service supply based on the relationships between planned ecosystem service uses and benefits (black boxes in Figure 7). A project's *planned ecosystem service benefit* is the gain in operational performance the project expects to derive from ecosystem service use over its life, and that project developers factored into its operational performance targets.

Dependence Step 1 – Identify ecosystem services relevant to project dependence

An ecosystem service is relevant to project performance if (1) the service supports project operations and (2) the service can be directly linked to specific benefits to the project. Relevant ecosystem services are included in the ESIA terms of reference.

Sub-step D-1.1: Identify which ecosystem services support project operations

ESIAs do not generally consider the dependence of projects on ecosystem services. As a consequence, the ESIA team may not have identified the services on which the project depends for its operations.

To identify the services on which a project depends for its operations, the ES lead reviews the project documentation and selects from a list of ecosystem services (see Table A-1 in Annex 2 for a standard list of ecosystem services)[12] those services that are operational inputs, contribute to operational processes, or influence the physical integrity of project facilities.

Feasibility studies and risk assessments may have identified the project's dependence on some ecosystem services contributing to operational inputs, such as freshwater. Other types of dependence, such as the dependence of agricultural yield on bee pollination or of industrial complexes on natural flood protection, are less likely to have been identified and addressed in these studies.

The ES lead should also consider the project's future dependence on ecosystem services. Stricter environmental regulations, for example, could increase the quantity of effluent a project has to treat. The project could plan to depend on a larger area of wetland to increase the amount of effluents treated for free. Similarly, expansion of project activities could entail an increase in water consumption, to which the project needs to ensure access.

The output of sub-step D-1.1 is a list of ecosystem services that support project operations.

Sub-step D-1.2: Identify the benefits the project derives from ecosystem services

For each ecosystem service identified in sub-step 1.1, the ES lead determines which benefits the project plans to derive from it. Ecosystem service benefits to operational performance typically relate to avoided costs for:

- Operational input (e.g., tourism operations depend on roaming wildlife);
- Operational process (e.g., a coffee plantation's yield relies on pollination provided at no cost by neighboring forests; a hydropower plant relies on erosion control by vegetation to minimize costs related to managing reservoir siltation); and
- Physical integrity of project facilities (e.g., coral reefs help protect hotels from beach erosion).

If the ES lead cannot identify benefits derived from an ecosystem service without first identifying the services it supports—that is, if a service contributes indirectly to project performance—then the ecosystem service identified in sub-step 1.1 is an intermediate service (see Glossary for definitions of intermediate and final services). In this case, only the final services are considered as relevant. If a final service on which the project depends was not identified in sub-step 1.1, the ES lead adds it to the list of relevant services.

An ecosystem service can provide multiple benefits to the project. Since these benefits might not contribute equally to the project's operational performance, the ES lead differentiates among the benefits in order to prioritize ecosystem services with regard to each benefit in Step 2.

The output of sub-step D-1.2 is a list of relevant ecosystem services and a characterization of the benefits that the project derives from them (see Box 13). This list will be revisited during Step 2 when project developers are engaged.

13 DEPENDENCE ASSESSMENT STEP 1 FOR THE VIVA PROJECT

The ES lead selected three ecosystem services relevant to project operations: freshwater, dilution of residual contaminants from effluent discharge, and tailing pond. The project does not benefit from any actual ecosystem process in the tailing pond as the pond is merely a natural, sealed receptacle for tailings. However, increased sedimentation in the pond, which is likely to happen along with increased snowmelt, might curtail its capacity to store tailings, and therefore increase the project's storage costs. As a consequence, the ES lead decided to consider tailing pond as a relevant ecosystem service.

Freshwater contributed both to domestic and processing water. These two benefits were differentiated so they can be prioritized independently in Step 2.

See output table on page 46.

12. There are other lists of ecosystem services (e.g., Haines-Young and Potschin 2013, de Groot et al. 2010). If used as starting points, these lists need to be reviewed and adapted to the local context.

13 OUTPUT TABLE | DEPENDENCE ASSESSMENT STEP 1 FOR THE VIVA PROJECT

	SUB-STEP 1.1: IDENTIFY WHICH ECOSYSTEM SERVICES SUPPORT PROJECT OPERATIONS		SUB-STEP 1.2: IDENTIFY THE BENEFITS THE PROJECT DERIVES FROM ECOSYSTEM SERVICES	LIST OF RELEVANT ECOSYSTEM SERVICES
List of ecosystem services	**Does the project depend on this ecosystem service for its operations?**	**Comments or supporting information**	**How does the project benefit from this service?**	**List the ecosystem services for which benefits were identified**
Provisioning				
Food from crops, livestock, capture fisheries, aquaculture, and wild foods	N			
Biological raw materials from timber and other wood products, fibers and resins, animal skins, sand, and ornamental resources	N			
Biomass fuel	N			
Freshwater	Y		Free processing water for production plant; Free domestic water for staff	Freshwater
Genetic resources	N			
Biochemicals, natural medicines, and pharmaceuticals	N			
Regulating				
Regulation of air quality	N			
Regulation of local, regional, and/or global climate	N			
Regulation of water timing and flows	N			
Erosion control	Y	Avoided sedimentation in tailing pond	Intermediate service to tailing pond; see its benefits	
Water purification and waste treatment	Y	Dilution of residual contaminants from effluent	Avoided effluent treatment costs	Dilution of residual contaminants from effluent
Regulation of diseases	N			
Regulation of soil quality	N			
Regulation of pests	N			
Pollination	N			
Regulation of natural hazards	N			
Cultural				
Recreation and ecotourism	N			
Ethical and spiritual values	N			
Educational and inspirational values	N			
Supporting				
Habitat	N			
Nutrient cycling	N			
Primary production	N			
Water cycling	N			
Other				
Storage space	Y	Tailing storage	Free sealed storage of tailings	Tailing storage

Dependence Step 2 – Prioritize relevant ecosystem services according to project dependence

Ecosystem services on which the project depends are prioritized when two criteria are met: (1) there could be changes in the quantity, quality, timing, or location of the services over the life of the project with implications for operational performance; and (2) the project has no alternatives to this service (Figure 8).

Non-priority ecosystem services do not need to be considered further in the ESR for IA. As new information arises through the dependence analysis, reclassification of non-priority services may be warranted. Project developers might also consider monitoring those services for which the project has no alternatives in order to have early warning of any changes in the service that might put operational performance at risk.

The ES lead can use the Dependence Prioritization Spreadsheet to automatically prioritize ecosystem services according to operational risks to project performance.

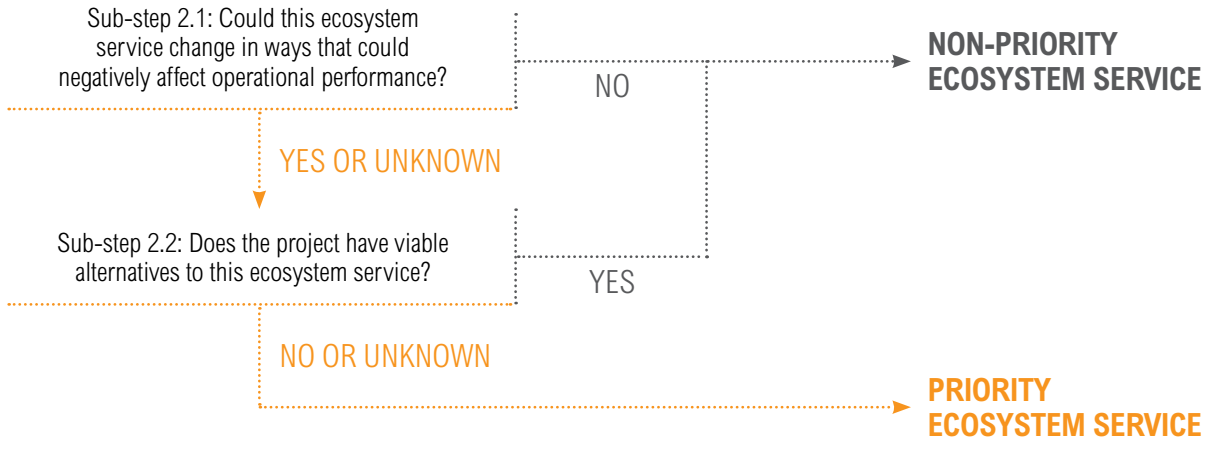
The prioritization exercise is summarized in the ESIA report.

Sub-step D-2.1: Identify ecosystem services expected to change in ways that could negatively affect operational performance

When changes in ecosystems and the services they provide to the project diminish the benefits the project expects to derive, the project's operational performance can be at risk.[13] Such changes might be driven by causes external to the project, the project's own impacts, or a combination of both. For example, a biofuel project in a floodplain could accelerate the conversion of wetlands to sugarcane in its watershed, thereby putting its facilities at increased risk of flooding.

For each of the relevant services identified in Step 1, the ES lead assesses whether changes in ecosystem services could affect the ability of the project to achieve planned performance.

Figure 8 | **Decision tree to prioritize ecosystem services according to operational risks to project performance**



13. The ESR for IA focuses on achieving planned operational performance related to ecosystem services. Therefore, it focuses on those ecosystem services for which future supply might fall short of planned use.

Changes in an ecosystem service might lead to a loss in operational performance when:

- *Changes in this service over the life of the project could push it across a sustainability threshold.* Changes in an ecosystem service are more likely to lead to a loss in benefit to the project if large changes in the service are expected, or if the service is already close to a sustainability threshold. Economic development and demographic change in an area, for example, might be expected over the life of a project, possibly resulting in substantial deforestation with associated loss in protection from landslides that could be costly to the project.
- *Changes in this service over the life of the project could trigger a regulatory response.* Changes in an ecosystem service are likely to lead to a loss in benefit to the project if they lead to a change in its legal status or access. For example, excessive water abstraction in a watershed might force the government to instigate a system of water permits.
- *This ecosystem service is already in scarce supply relative to demand.* Even small changes in an ecosystem service whose supply already fails to meet current demand are likely to translate into a loss of benefit to the project. A fish processing facility might see a sharp drop in performance, for example, if targeted fisheries are already overfished.
- *Any change in this service precludes the project from achieving operational performance.* If project operations depend on the quantity, quality, timing, or location of the service remaining constant, any change in this ecosystem service will affect the project. Undisturbed natural environment, for example, is an essential selling point for high-end tourism operators and even minor alterations to a pristine environment can have consequences for the operators' business success.

If the ES lead is unable to determine whether ecosystem service change would be sufficient to adversely affect project operational performance, he should use the precautionary principle and include that ecosystem service in the output of sub-step 2.1.

The output of sub-step D-2.1 is a shortlist of ecosystem services identified in Step 1 that can reasonably be expected to change to put operational performance at risk.

Sub-step D-2.2: Identify ecosystem services for which the project has no viable alternatives

The ES lead, in consultation with the project developers, reviews the ecosystem services shortlisted in sub-step 2.1 to determine whether the project can get the same benefit, in a cost-effective way, from:

- non-ecosystem based solutions (e.g., using solar power instead of fuelwood to dry coffee beans); or
- the same service supplied by another ecosystem (e.g., sourcing fuelwood to dry coffee beans from savanna or bushland instead of forest). In addition to cost-effectiveness, an alternative service is considered "viable" if practitioners can establish beyond a reasonable doubt that (1) its supply can meet the needs of the project; (2) the increased use of the alternative service by the project does not compete with existing uses; and (3) the project has legal access to the alternative service.

If the ES lead cannot determine whether the project has a viable alternative to a particular ecosystem service, he should exercise the precautionary principle and consider the ecosystem service as a priority ecosystem service.

The output of sub-step D-2.2 is a shortlist of the ecosystem services identified in sub-step 2.1 for which the project has no viable alternatives. These services are the priority ecosystem services on which the dependence assessment will be conducted. Sub-step 2.2 also produces a list of benefits the project derives from priority services (see Box 14).

14 DEPENDENCE ASSESSMENT STEP 2 FOR THE VIVA PROJECT

The ES lead deemed that freshwater availability would not be a source of operational risk to the project. He estimated that there will be plenty of water available even with additional industrial development as climate change models predict water availability, which is already abundant, to increase, rather than decrease. Tailing pond was also left out after sub-step 2.1 as the ES lead and ecologist estimated that the size of the lake would not, even with high sedimentation rates, change to a point where the project would need to relocate part of its tailing. The ES lead and hydrologist did, however, prioritize dilution of residual contaminants from effluent discharge. This is an ecosystem service for which the project has no viable alternatives, and development in the fjord could possibly affect its dilutive capacity over the life of the project.

The spreadsheet allows the ES lead to prioritize relevant ecosystem services on a benefit-by-benefit basis as the project could have viable alternatives to some but not all benefits derived from a single ecosystem service. For example, if freshwater had made it to sub-step 2.2, the ES lead and project developers would have assessed the alternatives available to the project for domestic use and processing water independently, as the smaller quantity involved with domestic water uses would make it much easier to find a cost-effective alternative.

See output table below.

14 OUTPUT TABLE | DEPENDENCE ASSESSMENT STEP 2 FOR THE VIVA PROJECT

FROM STEP 1		SUB-STEP 2.1: COULD THIS ECOSYSTEM SERVICE CHANGE IN WAYS THAT COULD NEGATIVELY AFFECT OPERATIONAL PERFORMANCE?		SUB-STEP 2.2: DOES THE PROJECT HAVE VIABLE ALTERNATIVES TO THIS ECOSYSTEM SERVICE?		PRIORITY ECOSYSTEM SERVICES
Relevant ecosystem services	**Benefits to the project**	**Y Yes N No ? Unknown**	**Comments or supporting information**	**Y Yes N No ? Unknown**	**Comments or supporting information**	**1 Priority ecosystem services 0 Non-priority eecosystem services**
Freshwater	Free processing water for production plant	N	Global warming is expected to melt the ice cap, increasing water availability.			0
	Free domestic water for staff	N				0
Dilution of residual contaminants from effluent	Avoided effluent treatment costs	?	The area of dilution would be able to dilute the project's discharge if no other project is discharging there. Any other industrial developments discharging in the fjord could affect the dilution capacity for the project.	N	Without access to "dilution" in the bay the project would need to invest in additional effluent treatment.	1
Tailing storage	Free sealed storing of tailings	N	The size of the lake is not expected to change over time.			0

Dependence Step 3 – Define the scope and information needs of the ecosystem service dependence assessment

Now that the priority ecosystem services are identified, Step 3 establishes the geographical area in which to conduct the dependence assessment and determines which changes to predict in order to understand the operational risks to project performance in the next step.

Sub-step D-3.1: Delineate the ecosystem service dependence assessment area

The dependence assessment area is the area relevant to predicting the loss in operational performance as a result of ecosystem change. It includes the places where the project accesses priority ecosystem services and the ecosystems that are relevant to the supply of these priority services. It should be noted that this may differ from the ecosystem service impact assessment area.

For each priority ecosystem service identified in Step 2, the ES lead identifies the areas:

- *Where the project accesses priority ecosystem services*. Together with the project developers, the ES lead identifies where the project will access priority ecosystem services.
- *Where the ecosystems relevant to the supply of priority ecosystem services to the project, or parts thereof, are located*.[14] The ES lead identifies the ecosystems, or parts thereof, supplying a priority ecosystem service to the project by identifying ecosystems that (1) have the ecological capacity to supply the priority ecosystem service (practitioners can use references in Annex 3 to identify which ecosystems are likely to supply each ecosystem service); and (2) are in a location relative to the project that allows the project to benefit from the services they supply (i.e., there is functional connectivity between the ecosystem and the project). For example, a project may benefit both from a wetland upstream from its facility, which helps ensure a supply of clean freshwater, and from a wetland downstream from its facility, which helps treat its subsequent effluents. As this example demonstrates, the ES lead will sometimes have to identify the ecosystems that supply priority ecosystem services to a project at a distance from where the project accesses them. The spatial relations between where the ecosystem service is supplied and where the project accesses it can be classified into five categories (Box 5).

The output from sub-step D-3.1 is the delineation of the geographic scope of the ecosystem service dependence assessment (see Box 15).

15 DEPENDENCE ASSESSMENT SUB-STEP 3.1 FOR THE VIVA PROJECT

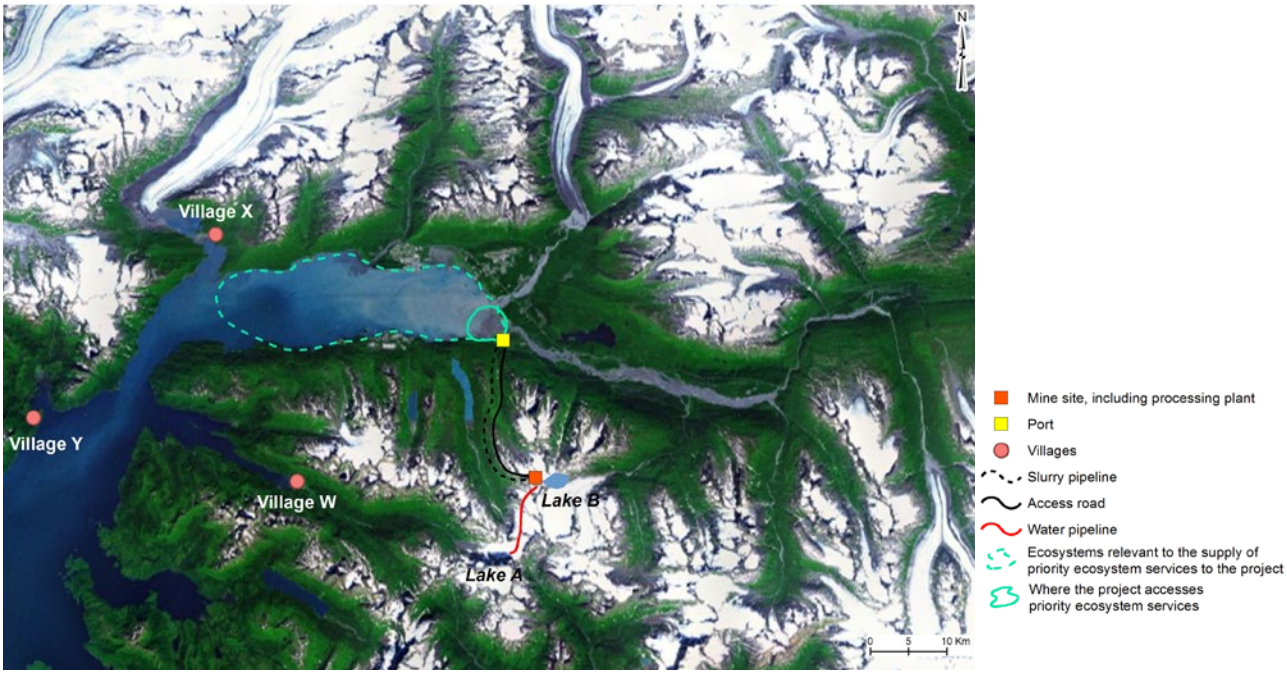
The ES lead identified the ecosystem service dependence assessment area related to the only ecosystem service prioritized (i.e., dilution of residual contaminants from effluent). The ES lead first identified where the project accesses dilution of residual contaminants from effluent and the ecosystem relevant to the supply of that service to the project. In collaboration with the hydrologist, he then produced a map that delineates the area of the fjord that will contribute to the dilution of effluent over the life of the project.

See output table and map on page 51.

14. If the prediction of future ecosystem service supply requires the ES lead to predict supply of an intermediate service, then the ES lead also includes the ecosystem that supplies the intermediate service in the dependence assessment area. For example, the ES lead would need to predict the erosion control provided by upstream riverine vegetation to predict the turbidity of irrigation water. The ES lead can refer to the output of sub-step 1.1 to identify any intermediate service that indirectly contributes to project operational performance.

15 OUTPUT TABLE AND MAP | DEPENDENCE ASSESSMENT SUB-STEP 3.1 FOR THE VIVA PROJECT

Priority ecosystem services	Where the project accesses priority ecosystem services	Where the ecosystems relevant to the supply of priority ecosystem services to the project, or parts thereof, are located
Dilution of residual contaminants from effluent	Where the project discharges effluent	Part of the fjord diluting the effluent



Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

Sub-step D-3.2: Identify indicators of project dependence on ecosystem services

Now that the ESIA team knows where to collect data to assess project dependencies on ecosystem services, sub-step 3.2 establishes which data to collect through the selection of indicators. An early identification of indicators will guide the contributions of individual practitioners to the ecosystem service dependence assessment conducted in Step 5. Sub-step 3.2 also establishes the relationships between planned ecosystem service uses and benefits (Figure 7). The ES lead will use these relationships in Step 5 to extrapolate the loss in operational performance from ecosystem service supply shortfalls.

To focus data collection and analysis on the specific ways in which the project expects to benefit from ecosystems, the ES lead, for each benefit identified in Step 2, reviews the project documentation and engages project developers to establish the planned levels[15] of ecosystem service benefit and use necessary to achieve operational performance over the life of the project (see Glossary for definitions of planned ecosystem service benefit and use). The technical plans for an oil project, for example, would specify the quantity of freshwater required to fill emptied wells and the level of turbidity that can safely be handled by the well pipelines. If the levels of benefits and uses planned for some ecosystem

15. The ES lead might have to specify multiple planned levels of use for a single ecosystem service benefit if project performance depends on multiple characteristics (e.g., quantity, quality, timing, location) of a single ecosystem service. For example, an orchard yield depends on both the quantity and timing of pollination from an adjacent forest. The ES lead would identify the planned minimum number of bees required to achieve planned yield and the periods of the year when the bees are required.

services (e.g., protection from landslides, pollination) are not specified in the technical documentation, the ES lead and project developers make, and document, their assumptions about planned ecosystem service benefits and uses.

Once planned ecosystem service benefits and uses are established for each priority ecosystem service, the ES lead identifies:

1. *Indicators of ecosystem service supply*. For each planned ecosystem service use, the ES lead identifies a socio-ecological indicator that conveys information on the maximum level of ecosystem service the ecosystem will be able to provide to the project without undermining its future provisioning capacity. For example, in the case of the aforementioned oil and gas project, the ES lead would identify the maximum quantity and the maximum turbidity of freshwater available to the project, considering expected ecosystem change over the life of the project.

2. *Indicators of loss in operational performance*. For each planned ecosystem service benefit, the ES lead selects a socio-economic indicator that best captures how shortfalls in ecosystem service supply could lead to loss in operational performance. The indicator of loss in operational performance can be monetary or non-monetary. In the case of the oil and gas project mentioned above, the ES lead would assess how a predicted increase in water turbidity might lead to an increase in the cost of pump maintenance.

The output of sub-step D-3.2 is a description of planned ecosystem service benefits and uses, and a list of indicators of supply and loss in operational performance for each priority ecosystem service (see Box 16). These indicators will guide data collection and analyses during later steps.

16 DEPENDENCE ASSESSMENT SUB-STEP 3.2 FOR THE VIVA PROJECT

Since the volume of effluent to be diluted was specified in the project documentation, the ES lead easily established planned ecosystem service use. The ES lead could not find data on the savings in effluent treatment costs, however, and extrapolated from the differential costs incurred by mining projects that did not benefit from partial effluent treatment by an ecosystem.

Knowing that the project plans to dilute 5 million m^3 of effluent in the fjord, the ES lead and the hydrologist identified, as an indicator of ecosystem service supply, the maximum volume of effluent that the fjord can dilute without being adversely affected. The ES lead then identified the indicator of loss in operational performance: the change in volume of effluent that the fjord can safely dilute over the life of the project would be related to a change in effluent treatment savings.

See output table below.

16 OUTPUT TABLE | DEPENDENCE ASSESSMENT SUB-STEP 3.2 FOR THE VIVA PROJECT

FROM STEP 2		SUB-STEP 3.2: IDENTIFY INDICATORS OF PROJECT DEPENDENCE ON PRIORITY ECOSYSTEM SERVICES				
Priority ecosystem services	**Benefits to the project**	**Planned ecosystem service benefits**	**Planned ecosystem service uses**	**Indicators of ecosystem service supply**	**Indicators of loss in operational performance**	**Comments or supporting information**
Ecosystem: Fjord						
Dilution of residual contaminants from effluent	Avoided effluent treatment costs	≈ $200,000 savings in effluent treatment/year	5 million m^3 of effluent diluted/year	Volume of effluent that can be diluted/year	Additional cost in effluent treatment/year	The higher the dilution of effluent in the fjord, the higher the savings in effluent treatment (up to a certain level).

Dependence Step 4 – Establish the baseline for priority ecosystem services

Establishing a baseline is not relevant to the dependence assessment as it focuses on predicting ecosystem change expected in the presence of the project.

Dependence Step 5 – Assess project dependencies on priority ecosystem services

In Step 5, the ES lead assesses how the project's own impacts and other causes of ecosystem change (e.g., other projects' impacts, other people's use of ecosystem services, climate change) could affect ecosystem, ecosystem service supply, and operational performance, based on the analyses conducted by the ESIA team for the indicators identified in Step 3. The ecosystem service dependence assessment is included in the ESIA report.

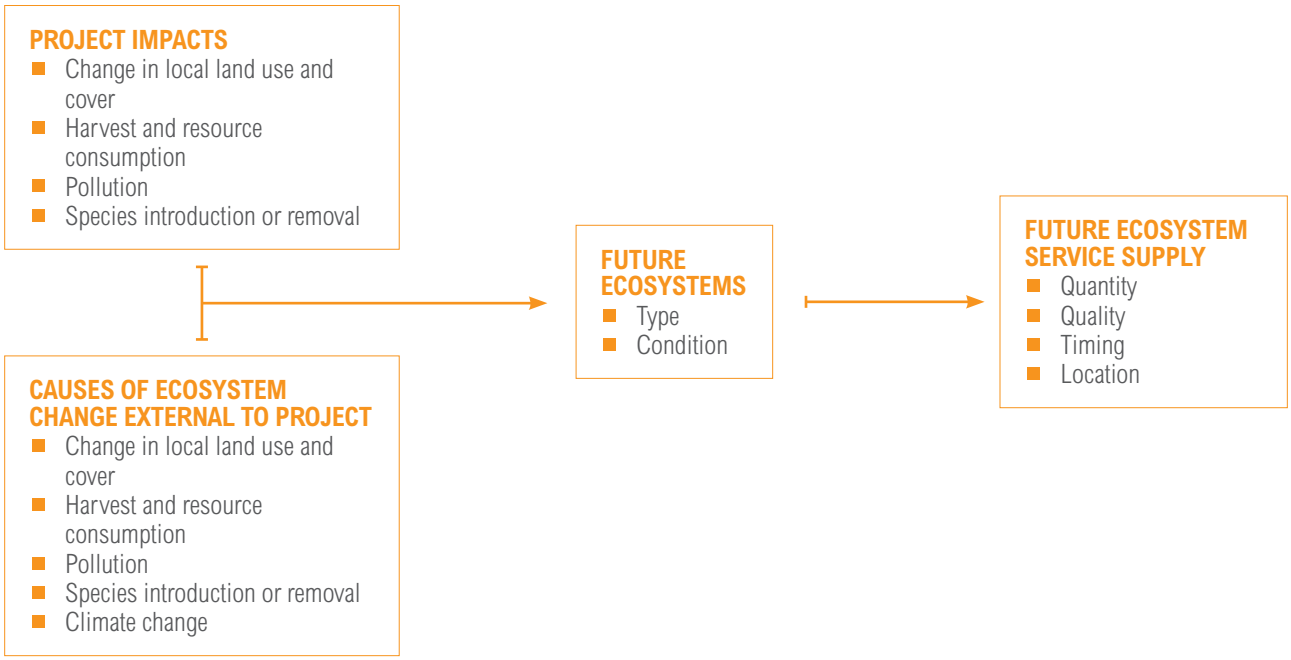
Sub-step D-5.1: Predict ecosystem service supply over the life of the project

The ES lead forecasts likely ecosystem service supply over the project's lifetime based on predicted ecosystem changes. Ecosystem changes may be driven by causes external to the project or by the project itself (Figure 9).

In many cases, the ES lead can predict the major causes of ecosystem change external to the project based on the extrapolation of current trends. Five causes of ecosystem change are considered to have the greatest impact on the supply of ecosystem services: (1) changes in local land use and land cover; (2) unsustainable harvest and resource consumption; (3) pollution; (4) introduction of invasive species; and (5) climate change (Ash et al. 2010). The ES lead identifies which causes are relevant to each priority ecosystem service by studying recent trends in its supply. Either he will be able to project current trends into the future, or current trends will need to be adjusted to reflect changes in socio-economic factors such as:

- Major demographic changes (e.g., in- or out-migration that has a large effect on the rate of land use change and resource harvesting);
- Major economic changes (e.g., increased market access through improved road infrastructure that can incentivize increased crop production or natural resource harvesting);
- Major changes in technology (e.g., shift from shallow wells to piped drinking water supplies, which generally increases per capita water demand);

Figure 9 | **From causes of ecosystem change to future ecosystem service supply**



- Major regulatory changes (e.g., strict implementation of a ban on consumption of wildlife, which could decrease consumption of bushmeat).

Regarding the project's own impacts on priority ecosystem services, the ES lead reviews sub-step 1.1 of the impact assessment to check whether any project impact would affect an ecosystem on which the project depends. If so, he predicts how its impacts, in combination with other causes of ecosystem change, would affect ecosystems and ecosystem service supply.

For each indicator of priority ecosystem service supply identified in sub-step 3.2, the ES lead models the future ecosystem service supply based on ecological production functions. In case there are no sufficient data or budget to quantify supply, the ES lead can go to sub-step 5.2 and assess future ecosystem service supply relative to planned ecosystem service use.

The output from sub-step D-5.1 is the future supply of priority ecosystem services over the lifetime of the project (see Box 17).

17 DEPENDENCE ASSESSMENT STEP 5 FOR THE VIVA PROJECT

The ES lead lacked data to predict future dilution capacity based on changes in the fjord over the project's life. He predicted, based on the high likelihood of other actors discharging effluents into the fjord, that the volume of effluent diluted by the fjord could be lower than assumed in the project documentation. As a consequence of this change in the fjord dilutive capacity, he predicted that there could be an additional cost of $5,000-$20,000 a year compared to the planned budget to treat project effluent.

While the exact increase in effluent treatment costs was unknown, the project developers requested the ES lead to conduct Step 6 and manage project dependence on the dilution service provided by the fjord.

See output table on page 55.

Sub-step D-5.2: Predict loss in operational performance related to ecosystem services

In sub-step 5.2, the ES lead predicts how future ecosystem service supply (sub-step 5.1) could lead to loss in operational performance (Figure 10). Where future supply of priority ecosystem services is anticipated to be less than planned project use, associated ecosystem service benefits could be lower than assumed in the project plans and the project could experience a loss in operational performance related to this benefit.

If the ES lead was able to model future ecosystem service supply in sub-step 5.1, he compares future ecosystem service supply to planned ecosystem service use and ascertains whether there is, and the extent of, a shortfall in ecosystem service supply. If the ES lead could not model future supply, he infers from the ecosystem type and condition expected over the life of the project whether the future ecosystem service supply could be lower or higher than planned ecosystem service use, based on the ESIA team's expert knowledge. Ideally, he is able to qualify supply shortfalls as minor, moderate, or major in order to predict the extent of loss in operational performance.

After the ES lead establishes the shortfall in ecosystem service supply, he predicts the associated loss in operational performance by extrapolating the relationships between planned ecosystem service uses and benefits established in sub-step 3.2.

When one ecosystem service provides multiple conflicting benefits to the project, the ES lead might need to engage project developers to understand how they would allot limited ecosystem service supply among different benefits.

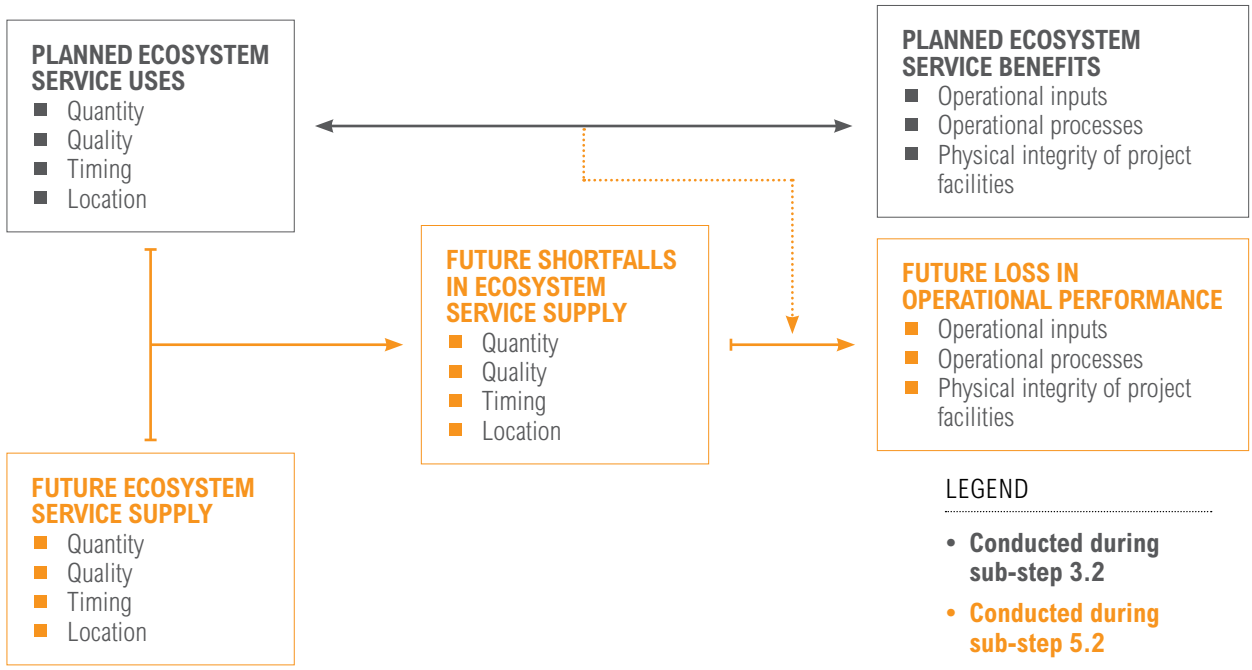
The ES lead identifies the ecosystem services expected to change in ways that would lead to loss in operational performance. The project's dependence on these services needs to be managed in Step 6.

The outputs of sub-step D-5.2 are the predicted loss in operational performance and the identification of the priority ecosystem services on which project dependence needs to be managed (see Box 17).

17 OUTPUT TABLE | DEPENDENCE ASSESSMENT STEP 5 FOR THE VIVA PROJECT

FROM STEP 3		SUB-STEP 5.1: PREDICT ECOSYSTEM SERVICE SUPPLY OVER THE LIFE OF THE PROJECT		SUB-STEP 5.2: PREDICT LOSS IN OPERATIONAL PERFORMANCE RELATED TO ECOSYSTEM SERVICES			
Planned ecosystem service benefits	**Planned ecosystem service uses**	**Future ecosystem service supply**	**Comments or supporting information**	**Future shortfall in ecosystem service supply**	**Comments or supporting information**	**Future loss in operational performance**	**Comments or supporting information**
Ecosystem: Fjord							
≈ $200,000 savings in effluent treatment/year	5 million m^3 of effluent diluted/year	Volume of effluent that can be diluted/year: No data available to model supply		125,000-500,000 m^3 of effluent not diluted	Expected increase in development on the coast of the fjord over the life of the project that will increase the effluent to be diluted.	Additional cost in effluent treatment/ year: $5,000-$20,000/year	The project is likely to have to treat more of its effluent before discharge into the fjord to meet local water quality guideline values for marine water.

Figure 10 | **From future ecosystem service supply to future loss in operational performance**



Dependence Step 6 – Manage project dependencies on priority ecosystem services

The ESR for IA provides measures to manage operations that depend on ecosystems to achieve planned performance, when applicable. These measures inform project design and operations and are incorporated into the environmental and social management plans.

In case the project, through its own impacts on ecosystems, undermines its operational performance, part of the loss in operational performance might be managed by measures identified to mitigate environmental impacts. When ecosystem change is driven by factors other than the project, the standard ESIA is unlikely to have identified measures to manage loss in operational performance.

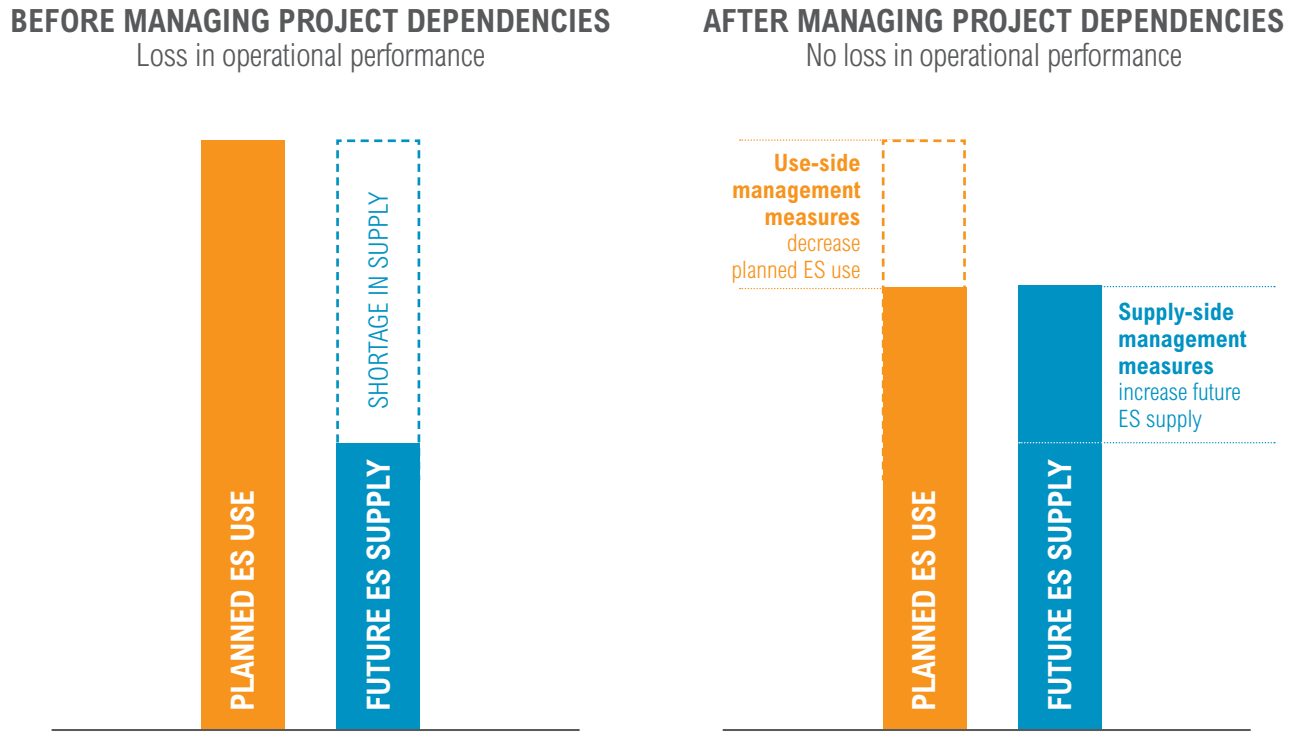
Sub-step D-6.1: Manage operational performance related to ecosystem services

For the ecosystem services shortlisted in sub-step 5.2, the ES lead identifies measures to close the gap between future ecosystem service supply to the project and planned ecosystem service use.

The ES lead reviews the mitigation measures identified by the environmental practitioners and proposed in the risk assessment and determines whether they would be sufficient to achieve planned operational performance. If they are deemed insufficient, he identifies measures to increase the future supply of priority ecosystem service to the project and, in collaboration with the project developers, to decrease planned ecosystem service use (Figure 11):

- *Supply-side management measures*. These measures aim at increasing the supply of priority ecosystem services to the project (e.g., restoration of riverine forest and/or incentives to farmers to terrace their fields in order to decrease dam reservoir siltation). The ES lead reviews the causes of ecosystem change responsible for future ecosystem service supply (see sub-step 5.1) and identifies measures that would avoid or minimize them.

Figure 11 | **Managing project dependencies on ecosystem services (ES) to ensure planned operational performance**



- *Use-side management measures*. These measures change project design and operations to avoid or minimize the project's dependence on the ecosystem service to achieve operational performance (e.g., use of more resource-efficient technologies to decrease the amount of water needed, building of a wastewater treatment facility to decrease the amount of effluent to be treated by the wetland).

Management measures are selected according to their cost-effectiveness. In some circumstances, the project developers might choose a less cost-effective supply-side measure over a use-side measure because the increase in ecosystem service supply might also benefit others and support the project's "social license to operate". In this case, the ecosystem restored should be added to the list of impacted ecosystems in sub-step 1.1 and feed into the ESR for IA impact assessment to assess the potential gains in well-being of people who would benefit from the restored ecosystem.

The ES lead continues to identify cost-effective management measures until the project achieves planned project performance or, at a minimum, a level of performance acceptable to the project developers. If cost-effective measures to manage project dependence on priority ecosystem services are exhausted and the level of project performance remains unacceptable to the project developers, the feasibility of the project as presented in the ESIA should be questioned.

The output of sub-step D-6.1 is a list of cost-effective measures to manage project dependence on priority ecosystem services and achieve planned operational performance or a level of operational performance acceptable to the project developers (see Box 18).

18 DEPENDENCE ASSESSMENT STEP 6 FOR THE VIVA PROJECT

The ES lead and project developers identified measures to decrease the vulnerability of the project to changes in the capacity of the fjord to dilute effluent by increasing the project's own treatment of effluent discharge. Project developers also decided to compare the costs and benefits of expanding the project's waste treatment infrastructure versus constructing a wetland.

Decreasing the level of pollution by other actors was also identified as an option to preserve the fjord's capacity to treat the project's effluent over the lifetime of the project.

See output table below.

18 OUTPUT TABLE | DEPENDENCE ASSESSMENT STEP 6 FOR THE VIVA PROJECT

FROM STEP 3		FROM SUB-STEP 5.2	SUB-STEP 6.1: MANAGE OPERATIONAL PERFORMANCE RELATED TO ECOSYSTEM SERVICES			
Priority ecosystem services	**Planned ecosystem service benefits**	**Loss in operational performance**	**Use-side measures**	**Comments and supporting information**	**Supply-side measures**	**Comments or supporting information regarding supply-side measures**
Ecosystem: Fjord						
Dilution of residual contaminants from effluent discharge	≈ $200,000 savings in effluent treatment/ year	$5,000-$20,000/year	Construct a wetland to treat effluent before discharging into fjord Increase capacity of project's effluent treatment		Project's own pollution: None	The project is already using state-of-the-art mining processes regarding minimization of pollution.
					Other developments' pollution: Work with government to ensure that there are regulations regarding the maximum contaminant concentration in effluent discharge.	Current regulations target contaminant concentration in marine water. If one company overpollutes, it affects all. Having regulations that apply to each project is fairer.

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ANNEX 1 | PRELIMINARY THOUGHTS FOR ASSESSING PROJECT CUMULATIVE IMPACTS ON PRIORITY ECOSYSTEM SERVICES

A project's cumulative impact on an ecosystem service is the total impact on the ecosystem service that results from the incremental impacts of the project when added to past, present, or reasonably foreseeable changes in ecosystem services unrelated to the project (adapted from EC 1999). Changes unrelated to the project may be driven by other projects, the activities of ecosystem service beneficiaries, the actions of institutions with a management mandate on the ecosystem service, or climate change.

When considering project cumulative impacts, the ES lead makes some adjustments to Steps 4 and 5. After conducting sub-steps 4.1 and 4.2, he conducts an additional sub-step, sub-step 4.3, and then moves to sub-step 5.1b, instead of sub-step 5.1, and sub-steps 5.2 and 5.3.

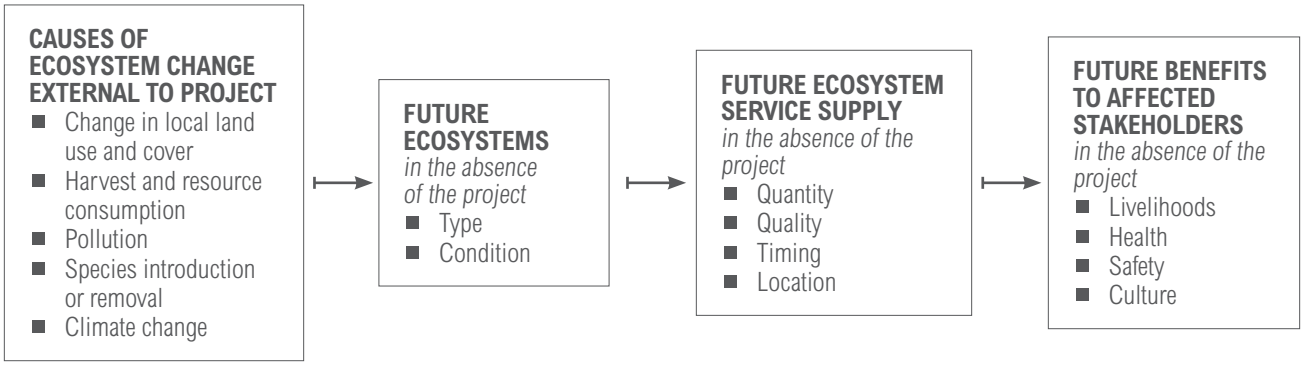
Sub-step I-4.3: Predict ecosystem service benefits in the absence of the project

The ES lead predicts the likely supply of priority ecosystem services in the absence of the project given predicted causes of ecosystem change external to the project (Figure A-1).

Five causes of ecosystem change generally have the greatest impact on ecosystem service supply: (1) changes in local land use and land cover; (2) unsustainable harvest and resource consumption; (3) pollution; (4) introduction of invasive species; and (5) climate change (Ash et al. 2010). The ES lead identifies which of these are relevant to each priority ecosystem service by studying recent trends in supply. Either the ES lead will be able to project current trends into the future, or current trends will be adjusted to reflect changes in socio-economic factors such as:

- Major demographic changes (e.g., in- or out-migration that has a large effect on the rate of land use change and resource harvesting);
- Major economic changes (e.g., increased market access through improved road infrastructure that can incentivize increased crop production or natural resource harvesting);
- Major changes in technology (e.g., shift from shallow wells to piped drinking water supplies, which generally increases per capita water demand);
- Major regulatory changes (e.g., strict implementation of a ban on consumption of wildlife, which could decrease consumption of bushmeat).

Figure A-1 | **From causes of ecosystem change external to the project, to future benefits to affected stakeholders**



Sub-step I-5.1b: Predict project cumulative impacts on ecosystem service supply

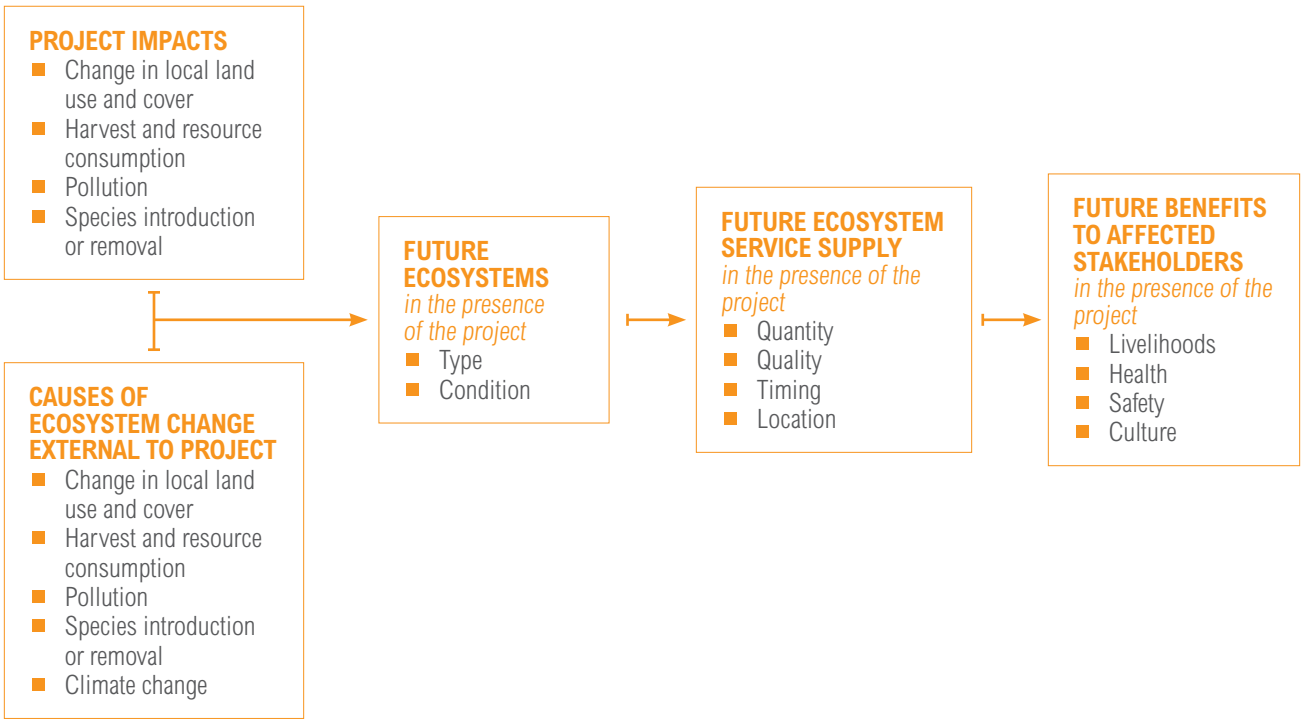
The ES lead first predicts how the combination of the project's impacts and the causes of ecosystem change external to the project would affect ecosystems (Figure A-2).

For each indicator of priority ecosystem service supply identified in sub-step 3.2, the ES lead with the support of environmental practitioners can either:

- Infer the future ecosystem service supply qualitatively from the expected type and condition of each ecosystem over the life of the project, based on expert knowledge; or
- Model the future ecosystem service supply quantitatively, based on ecological production functions.

Once future supply in the presence of the project is established, the ES lead compares it to the baseline (sub-step 4.3) to assess the project's cumulative impacts on ecosystem service supply.

Figure A-2 | **From causes of ecosystem change external to the project and project impacts, to future benefits to affected stakeholders**



ANNEX 2 | INDICATIVE LIST OF ECOSYSTEM SERVICES

Table A-1 | **Indicative 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, stingrays, 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 fowers, coral jewery
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 ■ Paclitaxe as basis for cancer drugs ■ Tree extracts used for pest control

Table A-1 | **Indicative list of ecosystem services with definitions and examples (cont.)**

SERVICE	SUBCATEGORY	DEFINITION	EXAMPLES
Regulating services: The contributions to human well-being arising 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 sufur 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
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

Table A-1 | **Indicative list of ecosystem services with definitions and examples (cont.)**

SERVICE	SUBCATEGORY	DEFINITION	EXAMPLES
Regulating services: The contributions to human well-being arising from an ecosystem's control of natural processes (cont.)			
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 contributions of ecosystems to human well-being			
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. 2012.

ANNEX 3 | INFERRING ECOSYSTEM SERVICES FROM HABITAT OR LAND COVER

Ecosystem services can be associated with habitat classes (Table A-2) or with more discrete land cover classes (Table A-3).

Table A-2 | Ecosystem services by habitat type

KEY: ● = High Importance ○ = Medium / Low Importance

ECOSYSTEM SERVICES	FORESTS	WETLANDS, RIVERS, AND LAKES	POLAR	DESERTS	DEEP WATER	NEAR SHORE/ TRANSITION ZONE
Provisioning						
Crops						
Livestock	○	○	○	○		
Capture fisheries		●	●		●	●
Aquaculture		●	○		○	●
Wild foods	●	●	●	●	○	●
Timber and other wood fibres	●	●	●	○		○
Fibres and resins	●	●	○	○		○
Animal skins	●	○	●	○		
Sand, gravel, etc.		○	●	●		●
Ornamental resources	●	○	○	○	○	●
Biomass fuel	●	○	○			○
Freshwater	●	●	●	○		○
Genetic resources	●	●	●	●	●	●
Biochemicals, natural medicines, and pharmaceuticals	●	○	○	○	●	●
Regulating						
Air quality regulation	●	○	○	○	○	○
Global climate regulation	●	○	●	○	●	●
Regional/local climate regulation	●	○	○	●		○
Water regulation	○	●	○	○		●
Erosion regulation	●	○	○	○		●
Water purification	●	●	●	○	●	●
Waste assimilation	●	●	○	○	●	●
Disease regulation	○	○	○	○		○
Soil quality regulation	●	○	○	○		○
Pest/invasive species regulation	●	○	○	○	○	○
Pollination	●	○	○	○		○
Natural hazard regulation	●	●	○	○		●
Cultural						
Recreation and ecotourism	●	●	●	●	○	●
Spiritual and religious values	●	●	●	●	●	●
Ethical/non-use values	●	●	●	●	●	●

Source: IPIECA and OGP 2011.

Table A-3 | Ecosystem services by land cover class

KEY: 0 = no relevant capacity of the land cover type to provide this particular ecosystem service; 1 = low relevant capacity; 2 = relevant capacity; 3 = medium relevant capacity; 4 = high relevant capacity; 5 = very high relevant capacity

	Crops	Livestock	Fodder	Capture fisheries	Aquaculture	Wild foods	Timber	Wood fuel	Energy (biomass)	Biochemicals/ medicine	Freshwater	Local climate regulation	Global climate regulation	Flood protection	Groundwater recharge	Air quality regulation	Erosion regulation	Nutrient regulation	Water purification	Pollination	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
Discontinuous urban fabric	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Industrial or commercial units	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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Port areas	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0
Airports	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mineral extraction sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dump sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction sites	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	0	0	0	0	0	1	0	1	0	0	0	2	1	0	2	1	2	1	1	1	3	0
Sport and leisure facilities	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	1	1	1	1	1	5	0
Non-irrigated arable land	5	5	5	0	0	0	0	0	5	1	0	2	1	1	1	0	0	0	0	0	1	0
Permanently irrigated land	5	5	2	0	0	0	0	0	5	1	0	3	1	1	0	0	0	0	0	0	1	0
Ricefields	5	0	2	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	1	0
Vineyards	4	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	5	0
Fruit trees and berries	5	0	0	0	0	0	4	4	0	0	0	2	2	2	2	2	2	1	1	5	5	0
Olive groves	4	0	0	0	0	0	4	4	0	0	0	1	1	0	1	1	1	1	1	0	5	0
Pastures	0	5	5	0	0	0	0	0	0	0	0	1	1	1	1	0	4	0	0	0	3	0
Annual and permanent crops	5	5	5	0	0	0	0	0	5	1	0	2	1	1	1	1	1	0	0	0	1	0
Complex cultivation patterns	4	0	3	0	0	0	0	0	0	2	0	2	1	1	1	0	0	0	0	0	2	0
Agriculture and natural vegetation	3	3	2	0	0	3	3	3	3	1	0	3	2	1	2	1	3	0	1	0	2	3
Agro-forestry areas	3	3	2	0	0	0	3	3	0	0	0	2	1	1	1	1	2	1	1	3	3	0
Broad-leaved forest	0	0	1	0	0	5	5	5	0	5	0	5	4	3	2	5	5	5	5	5	5	5
Coniferous forest	0	0	1	0	0	5	5	5	0	5	0	5	4	3	2	5	5	5	5	5	5	5
Mixed forest	0	0	1	0	0	5	5	5	0	5	0	5	4	3	2	5	5	5	5	5	5	5
Natural grassland	0	3	0	0	0	2	0	0	0	0	0	2	3	1	1	0	5	5	5	0	3	3
Moors and heathland	0	2	0	0	0	1	0	2	5	0	0	4	3	2	2	0	0	3	4	2	5	5
Sclerophyllous vegetation	0	2	0	0	0	1	0	2	0	3	0	2	1	1	1	0	0	0	0	2	2	4
Transitional woodland shrub	0	2	0	0	0	1	0	2	0	0	0	1	0	0	0	0	0	0	0	2	2	2
Beaches, dunes, and sand plains	0	0	0	0	0	0	0	0	2	0	0	0	0	5	1	0	0	0	0	0	5	2
Bare rock	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	4	0
Sparsely vegetated areas	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0
Burnt areas	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Glaciers and perpetual snow	0	0	0	0	0	0	0	0	0	0	5	3	3	0	4	0	0	0	0	0	5	0
Inland marshes	0	2	5	0	0	0	0	0	0	0	0	2	2	4	2	0	0	4	0	0	0	0
Peatbogs	0	0	0	0	0	0	0	0	5	0	0	4	5	3	3	0	0	3	4	2	4	4
Salt marshes	0	2	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	2	0	0	3	0
Salines	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0
Intertidal flats	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	1	0	0	4	0
Water courses	0	0	0	3	0	4	0	0	0	0	5	1	0	2	1	0	0	3	3	0	5	5
Water bodies	0	0	0	3	0	4	0	0	0	0	5	2	1	1	2	0	0	1	0	0	5	4
Coastal lagoons	0	0	0	4	5	4	0	0	3	0	0	1	0	4	0	0	0	0	0	0	5	4
Estuaries	0	0	0	5	5	4	0	0	3	0	0	0	0	3	0	0	0	3	3	0	4	3
Sea and ocean	0	0	1	5	5	0	0	0	0	0	0	3	5	0	0	0	0	5	0	0	4	2

Source: Adapted from Burkhard et al. 2009.

GLOSSARY

Affected ecosystem service stakeholders, or affected stakeholders, are those ecosystem service beneficiaries who may be affected as a result of project impacts on priority ecosystem services. This group does not include the project for which the environmental and social impact assessment is conducted. Affected ecosystem service stakeholders are only identified at local and regional scales. Future generations who might be prevented from benefiting from ecosystem services as a result of project impacts should be considered as affected stakeholders.

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

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

Ecosystem service beneficiaries, or beneficiaries, are those individuals, communities, institutions, or companies who depend on ecosystem services to maintain their well-being or project performance; this group does not include the people who benefit from ecosystem services down the value chain (e.g., the people who transport fish to the market). Depending on the ecosystem service, beneficiaries can be identified at global, regional, and/or local scales.

An **ecosystem service benefit**, or benefit, is the gain in human well-being or in project performance derived from the use of an ecosystem service, often in combination with other inputs (e.g., labor and capital) (adapted from van Oudenhoven et al. 2012). A project's **planned benefit** is the gain in operational performance the project expects to derive from ecosystem service use over the project's life and that it relied on in setting its operational performance targets.

The **ecosystem service dependence assessment area** is the area relevant to the assessment of project dependence on priority ecosystem services. It includes the ecosystems relevant to the supply of priority ecosystem services and the locations where the project accesses these services.

The **ecosystem service impact assessment area** is the area relevant to the assessment of project impacts on priority ecosystem services. It includes the ecosystems relevant to the supply of priority ecosystem services and the locations where affected stakeholders access these services.

Ecosystem service supply is the maximum level of ecosystem service that the ecosystem can provide without undermining its future provisioning capacity (adapted from UNEP-WCMC 2011, Kareiva et al. 2011). Ecosystem service supply is determined by the ecosystem type and condition regardless of whether people actually use or value the service, and it is modeled based on ecological production functions (Kareiva et al. 2011, NRC 2005).

Ecosystem service use is the level of ecosystem service actually consumed or enjoyed by the beneficiaries (adapted from Boyd and Banzhaf 2007). It can be consumptive (e.g., agriculture crops for food, water for drinking) or non-consumptive (e.g., recreational and spiritual appreciation of a landscape or wildlife, pollination of crops by bees). A project's **planned use** is the level of ecosystem service the project counts on consuming or enjoying over its life.

Ecosystem services are the direct and indirect contributions of ecosystems to human well-being (de Groot et al. 2010). Ecosystem services that directly contribute to human well-being are called **"final services"**; services that contribute indirectly to human well-being, through supporting other services, are **"intermediate services"**.

Human well-being has 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 for a person to achieve what he or she values doing and being (MA 2005).

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

A **priority ecosystem service** is an ecosystem service on which project impacts affect the well-being of the ecosystem service beneficiaries, or a service that could prevent the project from achieving planned operational performance.

Project developers are the proponents of the project under consideration in the ESIA.

Project performance has multiple constituents, including the fulfillment of operational, financial, regulatory, and environmental and social goals.

Third-party actors are individuals, communities, institutions, or companies who are not affected beneficiaries but nevertheless drive change in priority ecosystem services. This group does not include the project for which the environmental and social impact assessment is conducted. This group might include land managers upstream of the project whose actions could impact project performance. Or, it might include a government agency implementing a watershed management plan that could help mitigate project impacts on benefits to affected stakeholders outside of the project area of influence. Third-party actors might be identified at local and regional scales, depending on the ecosystem service they impact.

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ABOUT WRI

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Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

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