Business dependence on ecosystem services: How to identify risks and opportunities?

An Ecosystem Services Review on Salmon Aquaculture in Chile

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List of Abbreviations

ASC	Aquaculture Stewardship Council
ESR	Corporate Ecosystem Services Review
FAO	Food and Agriculture Organization
GIS	Global Salmon Initiative
HG	Head-Gone
HON	Head-On
HVCA	High Value Conservation Area
ISA	Infectious Salmon Anemia
MEA	Millennium Ecosystem Assessment
MoU	Memorandum of Understanding
MPA	Marine Protected Area
NGO	Non-Governmental Organization
ROI	Return of Investment
RTRS	Round Table on Responsible Soy
TEEB	The Economics of Ecosystems and Biodiversity
WRI	World Resources Institute
WWF	World Wildlife Fund for Nature

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Executive Summary

The Challenge

Healthy ecosystems form the basis for numerous business operations. Some industries depend to such a great extent on the services ecosystems provide, that the degradation of their quality can pose severe risks to the entire business. At the same time, many companies contribute to the degradation of ecosystem services via the same business operations which depend on the ecosystem's health. In the last decades, businesses have contributed to the deterioration of ecosystems directly or indirectly causing deforestation, droughts, salinization, virus outbreak, biodiversity loss and others. Yet, many companies are not aware of the environmental consequences of their business operations due to the intangible nature of many ecosystem services. The study presented in this report aims to evaluate the relationship between healthy ecosystems and business performances. The challenge is to deliver insights in the dependencies and impacts businesses have on ecosystems and the services they provide. In addition, to provide information about and insights in the consequent risks and opportunities arising from this relationship that will support industries in their transition towards more sustainable business practices.

The Approach

The study focuses on the salmon aquaculture industry in Southern Chile; an industry that heavily depends on the health of the ecosystems in which it operates in. As a frontrunner in adapting sustainable business practices and one of the largest aquaculture businesses in Chile, the company Los Fiordos agreed on participating as a case study. Not only the company but also the whole industry and the Chilean economy had to record significant losses due to a virus outbreak in the salmon aquaculture industry in 2007, creating urgency for further research. To evaluate the relationship between healthy ecosystems and business performances, a Corporate Ecosystem Services Review is conducted on Los Fiordos' production operations. This five-step-framework was developed by the World Resources Institute and identifies risks and opportunities faced by businesses based on their dependence and impact on ecosystems and the services they provide.

Thereafter, conditions & trends in the company's priority ecosystem services are investigated in order to identify risks and opportunities resulting from these changes. Furthermore, this enabled the development of business strategies to minimize the potential risks and maximize the potential opportunities.

The Process

The necessary data was compiled through interviews with local stakeholders using structured and semi-structured surveys, and an extensive review on the scientific literature. In addition, semi-structured interviews were held with managers and other staff of Los Fiordos, a consultation session was conducted in relation to the identification of priority ecosystem services and a final full-day workshop was held to arrive at the priority risks and opportunities as well as to develop six business strategies accordingly.

The study involved the participation of the salmon aquaculture company, an environmental economics research consultancy, the VU University of Amsterdam, WWF-Chile, WWF-The Netherlands and Rabobank. The contribution of this multitude of actors provided valuable perspectives and support to the development of the study, which in turn contributed to achieving directly actionable results with relevance to all parties involved.

The Results

The study revealed that our case study, a salmon aquaculture company in Southern Chile, is primarily highly dependent on regulating ecosystem services and, furthermore, has a real negative impact on their maintenance. The identified regulating services are oxygen supply, water purification, waste treatment, maintenance of soil quality, and pest mitigation. In addition, the companies' operations, amongst other impacts, are perceived to decrease the availability of a number of ecosystem services for other local stakeholders, although the company does not depend on them for the production of salmon. These services are artisanal fisheries, ethical and cultural values, and recreation and ecotourism.

Changes in the ecosystem services the company depends on or impacts result in potential risks for the company. These risks are: negative perceptions by local stakeholders, sudden fluctuations in production due to changes in the natural system, a reduced productivity due to low water quality and ecosystem health, and a mismatch between the Aquaculture Stewardship Council (ASC) requirements for feed components and the company's real possibilities to purchase certified fish products for feed. On the other hand, there are business opportunities for the company by implementing practices that contribute to environmental protection, such as increasing productivity and decreasing unpredictability of natural change through innovation, increased access to funds for innovative research due to front-runner position, an increase in market share in existing and new markets through ASC certification, and securing a healthy ecosystem through the promotion and support of the implementation of Marine Protected Areas (MPAs).

Six strategies were articulated to minimize risks and maximize opportunities faced by the company. The goals of these strategies are: 1) to improve the companies' image; 2) to increase the number of innovation projects and the funds (both internal and external) to finance this innovation; 3) to develop a market strategy for ASC certified products; 4) to develop ecological indicators to measure, monitor and manage the company's impacts on the environment and to reduce changes in the priority ecosystem services; 5) to open a dialogue with the ASC regarding the certification of products for fish feed; and 6) to promote Marine Protected Areas.

Besides the specific results achieved for each of the five steps of the ESR, other overall conclusions of this study are:

- This research was extremely successful in revealing the relationship between salmon aquaculture practices and ecosystem health in the study areas, although from a qualitative perspective. This provided an important insight to the company on how crucial it is for its long-term survival to get an understanding of the natural environment in which they operate. To further build the case, future research should focus more on quantitative scientific data in order to ensure unbiased and measureable results.
- This ESR, and the particular approach applied in this study, provided a structured tool for the management of the company to understand how important ecosystem services are for its business operations, and how these same business operations can endanger the ecosystem services it needs to function. At the same time, the study showed that practices aiming to promote environmental protection and sustainability can minimize the risks for the company arising from environmental degradation, and thereby secure future operations. The strategies defined during this study most probably contribute to a sustainable long-term productivity as well as the maintenance of the local ecosystem's health. The collaboration between different organizations during this study also contributed to the success of the project and the relevance of the results for the company, the other stakeholders involved and the wider scientific community and salmon sector in the region.
- The insights obtained from the interaction with local stakeholders created also awareness by the management of the company about the negative perceptions that some of these stakeholders have of the practices of the salmon aquaculture sector and about how these practices affect important ecosystem services for these stakeholders. The study also showed that one of the main challenges that the company, and the

salmon sector in Chile as a whole, face is the lack of dialogue and cooperation between policy-makers, local stakeholders, the scientific community, and salmon businesses.

1 Introduction

1.1 Background

Ecosystem services, or the benefits ecosystems provide to humans, contribute to the human well-being. For example, ecosystems provide humans with goods for consumption, safety through the regulation of ecosystem processes and non-material goods such as aesthetic values or recreation. Tradeoffs between ecosystem services arise when the excessive use of one service limits the availability of another (Hanson et al., 2012). However, these negative externalities are seldom taken into consideration in day-to-day business operations. The impacts business practices may have on the availability of some ecosystem services, has become a major source of controversy. In return, this resulted in the development of frameworks, which aim to generate a better understanding on how an efficient and equitable use of natural capital can be achieved.

One popular framework is the Corporate Ecosystem Services Review (ESR) developed by the World Resources Institute (WRI). The ESR promotes guidelines for companies to identify business risks and opportunities, which arise from changes within ecosystems. The framework consists of a structured five-step methodology that supports decision-makers to proactively develop strategies to manage business risks and opportunities, which are caused by the company's dependence and impact on services of these ecosystems.

One ecosystem service humans substantially depend on is the provisioning of food. In a world with an increasingly growing population, fish products play an essential role in satisfying the growing demand for nutrition. Accordingly, the world food fish[1] production has increased by an average 3.2 percent per year (FAO, 2014). After the sudden collapse of conventional fish catches in the 1980s, aquaculture industry experienced a rapid expansion in order to meet the demand for fish products (see Figure 1). Aquaculture is currently the fastest growing animal-food producing sector and it is likely that it will surpass conventional fisheries as the main source of food fish eventually. However, its growing share in the world market has exposed the industry to a substantial amount of controversy. While some institutions acknowledge the

[1] Food fish, as defined by the Food and Agriculture Organisation, includes "finfishes, crustaceans, molluscs, amphibians, fresh water turtles and other aquatic animals (such as sea cucumbers, sea urchins, sea squirts and edible jellyfish) produced for the intended use as food for human consumption" (FAO, 2014; p. 18).

significant role it plays in feeding the growing world population, others protest about the potential negative socio-economic and environmental impacts the industry may have.

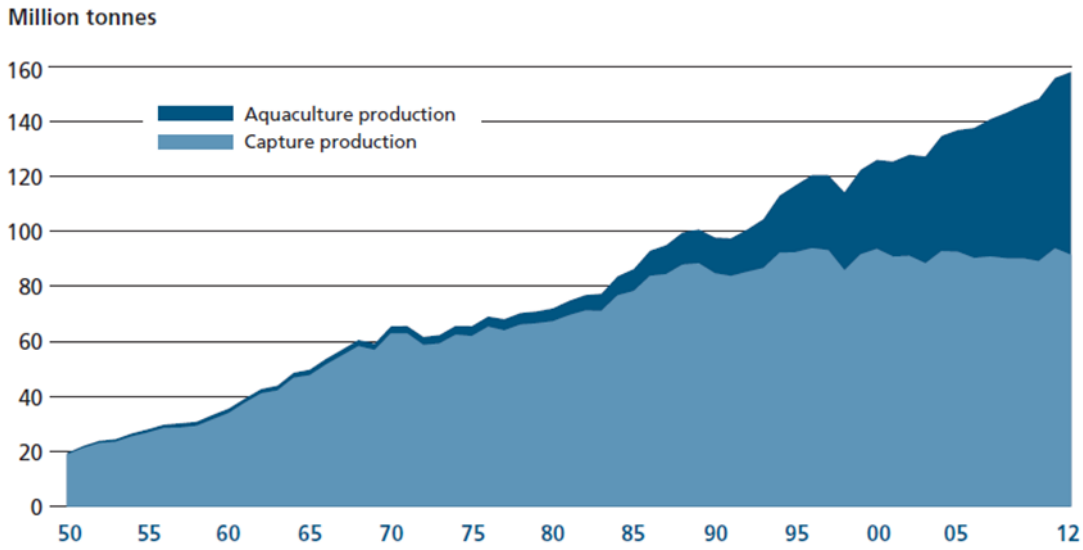

Figure 1: Global fish production - world capture fisheries and aquaculture production. (Source: FAO, 2015a, p. 3).

One of the most popular food fishes in the world is salmon. Although, commercial salmon production only emerged in the 1950s, the industry expanded rapidly and by 2013 the share of salmon in world fishery trade already reached 14% (FAO, 2015a). Today, around 60% of global salmon production originates from aquaculture (GSI, 2015). Triggered by this increasing demand of salmon products, Chile started to produce salmon at an industrial scale in the 1990s. Today, Chile is the second largest producer and exporter of salmon in the world after Norway (FAO, 2015b).

However, state regulations but also business strategies regarding the sanitary conditions in aquacultures were not able to keep pace with the rapid growth of the industry. In 2007, this discrepancy eventually led to a sanitary crisis causing a decline in the industrial salmon production in Chile by more than 60% (Little et al., 2015; Buschmann et al., 2009a). The unexpected dimension of the impact by the crisis on the aquaculture industry, and the Chilean economy as a whole, created a significant amount of national and international criticism, regarding weak regulations and unsustainable business practices. Therefore, efforts were made to mitigate the environmental impacts salmon aquaculture may have in order to avoid, amongst others, similar supply shortfalls from happening in the future.

1.2 Objectives

The purposes of the study presented in this report are:

- To illustrate the interrelationship of aquaculture industries and ecosystem services. Therefore, **the impacts and dependencies** of the Southern Chile aquaculture industry **on ecosystems are analyzed** with the help of an ESR in order **to identify** the resulting **business risks and opportunities**.
- **To identify business strategies** to support aquaculture companies to minimize risks and maximize opportunities arising from ecosystems change, in the short and long run.

In order to conduct the analysis, the Chilean company Los Fiordos, a major player in the nation's salmon industry, participated as case study. The remainder of this paper is divided into four sections. Section 2 presents a brief overview on the ESR and the steps involved. In Section 3, the ESR is applied to Los Fiordos and the results of each step are presented. Section 4 discusses the findings and presents the conclusions.

2 Methodology: Corporate Ecosystem Services Review

2.1 Ecosystem Services and ESR

An ecosystem is defined as a system involving the interactions between a community of living organisms in a specific area and its non-living environment. These biotic and abiotic components are in most cases linked together through energy flows (e.g. photosynthesis) or nutrient cycling (e.g. composting). Furthermore, the benefits humans obtain from ecosystems are referred to as ecosystem services. According to the Millennium Ecosystem Assessment these services can be grouped into four categories (MEA, 2005):

Table 1: The four categories of ecosystem services

Provisioning Services	Products obtained from ecosystems; e.g. food, fresh water, wood and fiber, fuel, etc.
Regulating Services	Benefits obtained from the regulation of ecosystem processes; e.g. climate regulation, flood regulation and protection, disease regulation and protection, water purification, etc.
Cultural Services	Nonmaterial benefits people obtain from ecosystems; e.g. aesthetic, spiritual, educational, recreational, etc.
Supporting Services	Although humans do not benefit from supporting services directly, they are essential for the production and maintenance of the remaining services; e.g. nutrient cycling, soil formation, primary production, etc.

The degradation of ecosystems leads to a decline in the services the ecosystem provides. Additionally, this causes trade-offs between ecosystem services, by which the increase in the consumption of one service leads to the decrease in the availability of others. A poorly managed ecosystem will therefore not only cease to deliver ecosystem services to its full potential, but may even intensify vulnerability and risks in areas which already struggle from related issues. Economic growth and the often accompanied overexploitation of natural resources have led to changes in ecosystems, affecting not only the well-being of humans and other living species, but

also business performances (Hassan & Scholes, 2005). Figure 2 illustrates the linkages between ecosystems, its services, and elements of human well-being.

Figure 2: The natural resources in ecosystems provide services that humans benefit from. Business operations, policy decisions and the actions of individuals often impact the availability of natural resources and the provision of services. (Source: EPA, 2015).

Besides humans, businesses and ecosystems live in an interdependent relationship as well, since most businesses both depend on and have an impact on ecosystem services. Often businesses are unaware of this relationship and in turn fail to utilize the opportunities or minimize the risks associated with it (Hanson et al., 2012). According to the MEA (2005, p.1), *"over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any other comparable period of time in human history"*. As ecosystems are changing at an increasing rate, businesses are most likely to benefit from developing strategies, which address these changes.

One way of illustrating this interdependent relationship is by the use of the ESR. This method is already implemented into the management strategies of over 300 companies, integrating risks and opportunities associated with changes in ecosystem services (Hanson et al., 2012). The five steps of the ESR methodology consist of: (I) selecting the scope of the ESR, (II) identifying priority ecosystem services, (III) analyzing trends in priority ecosystem services, (IV) identifying risks and opportunities, and (V) developing strategies which internalize these risks and opportunities. The model provides businesses with the flexibility to determine the boundaries of their assessment, by generating insightful illustrations of the linkages between ecosystem services and business performance (Hanson et al., 2012). Figure 3 describes the ESR steps, the incentive behind the steps as well as the respective approaches. For a more elaborate description of the five steps see Annex 1.

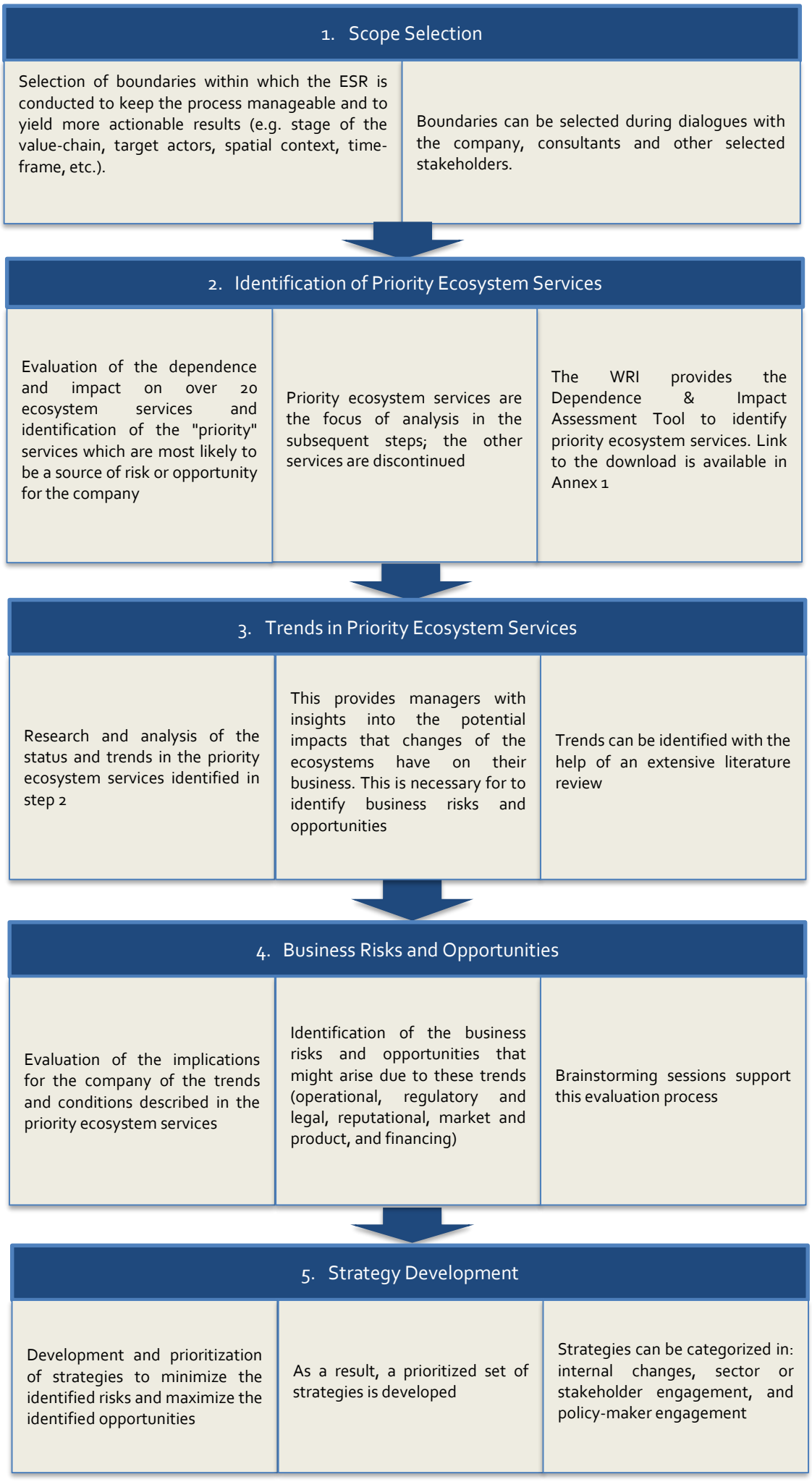

Figure 3: Steps in an ESR. (Source: Adapted from Hanson et al. (2012)).

2.2 Constraints of the used framework

It must be noted that there are some constraints to the use of the ESR as an analysis framework. Despite the fact that the WRI provides different tools and guidelines on how to develop each step of the ESR, specific elements offer a wide range of interpretation to the model-user. Therefore, neither the collection of data, nor the tool for interpreting the data (ESR) are value-free. Hence, they can be manipulated to support the interests of one specific stakeholder and cannot automatically ensure an unbiased outcome. This especially applies for step four and five; the identification of risks and opportunities and the development of strategies. Here, the ESR provides less detailed guidelines on the process which allows for the implementation of more creative approaches by those conducting the review. In order to minimize the risk of biased outcomes, it would add value to document future ESR cases in more detail, so that the model can further be refined through trial and error. In addition, addressing the ESR-approach in academic literature can potentially contribute to a more transparent and unbiased application of future ESRs.

3 Application of the ESR to the Salmon Aquaculture in Chile

The previous Section explained the ESR framework. In this Section, the framework is applied to Los Fiordos, the Chilean salmon farming that serves as case study. In this chapter, first the Chilean salmon industry and the company Los Fiordos are briefly described, then the process of data collection for this particular case study is presented. Thereafter, the five consecutive steps of the ESR are applied to the company according to Figure 3: (i) the scope of the review is presented; (ii) the priority ecosystem services are defined; (iii) the trends in these priority ecosystem services are illustrated; (iv) the risks and opportunities for Los Fiordos are shown; and finally (v) potential business strategies that can be undertaken are presented.

3.1 The Chilean salmon industry and Los Fiordos

Salmon production in marine ecosystems requires clean, oxygen rich waters with steady temperatures. The Chilean fiords system fulfills these requirements to a great extent, which enabled Chile to become the second largest salmon producer in the world after Norway. After experiencing a steady rapid growth in the late 1990s, the Chilean salmon aquaculture industry experienced the outbreak of the ISA-Virus and a consequent loss of more than 60% of its production. This negative supply shock drew attention to the country's fish production industry and the established business practices. As a result, the importance of sustainable business practices was emphasized and a series of structural reforms targeting the Chilean salmon industry's business model were implemented. For example, in a Memorandum of Understanding (MoU) with WWF-Chile, one of the largest salmon producing companies in Chile, Los Fiordos, agreed to implement the ASC certification in all of its centres by 2020. The company's public motivation in adapting more sustainable business practices made it an ideal case study for the evaluation of the relationship between ecosystem health and business performance.

Los Fiordos, which specialized primarily on the production of salmonids, is a subsidiary of Agrosuper, one of the largest animal food production companies in Chile. The subsidiary initially focused on the production of coho salmon and trout, introducing Atlantic salmon only in 1999. Today, it specializes in the production of coho and Atlantic salmon, producing a variety of goods, such as head-on (HON) and head-gone (HG) salmon as well as portions and filets. Los Fiordos supplies its own fodder, eggs, and smolt[2], and owns the largest salmon processing plant in Chile (SalmonChile, 2015a). Additionally, it manages the fright transport of the produced goods (Agrosuper, 2014). This vertical integration enables the company to directly control all stages prior, amid, and following the production process.

[2] The term "smolt" refers to juvenile fishes.

On the demand side, worldwide the highest level of salmon consumption takes place in the EU (966,000 tons), North America (471,000 tons), and Japan (274,000 tons).[3] Hence, the majority of salmon produced by Los Fiordos is exported to foreign markets, such as the US (23.3%), Japan (18.5%), Brazil (16.4%), China (5.3%), Russia (4.8%), Canada (2.6%). The company's main national clients are supermarkets (42.4%), traditional markets (44.6%), food service (12.8%), and industrial clients (0.2%) (Agrosuper, 2014). Earnings by Los Fiordos are to a great extent determined by the price volatility of the goods it produces as well as the price of crops that account for a large proportion of its operational costs. Further variable operational costs include energy, transport, and combustion (Agrosuper, 2013). For a more elaborate description of the history of aquaculture, the administrative structure of aquaculture in Chile, as well as Los Fiordos, see Annex 2.

3.2 Data collection

Two sources of data were used to analyze the linkages between business performance and ecosystem health. Primary sources include interviews, surveys, meetings, and a workshop. Interviews with scientists and experts were held with members from research centers, academics, consultancies, and environmental organizations. Interviews with the employees of the company were held with managers, sub-managers, and staff members of Los Fiordos. Furthermore, managers of Los Fiordos were asked to complete surveys in order to get an in-depth perspective of the company's practices and the knowledge of decision-makers on the environmental impacts of the company[4]. A one-day workshop was attendant by decision-makers from Los Fiordos, members of WWF-Chile, and an environmental consultancy member. Representatives of Wolfs Company, an environmental economics research company, facilitated the workshop. Secondary sources include published literature, as well as governmental and business databases. An illustration of how the different data sources contribute to each step of the ESR can be found in Table 2.

3.3 Data constraints

In order to strengthen the relevance of the results of this study, it is mainly based on primary data collection, which consists of qualitative data, gathered through interviews and surveys. However, due to formal and time constraints, no stakeholders were surveyed in the two selected areas, but semi-structured interviews were used instead. In addition, a relatively low number of surveys were conducted among managers and sub-managers of Los Fiordos. The outcome of these semi-structured surveys is used to create an overview of the company's decision-makers' awareness on the relationship of the salmon production and the ecosystems in which the business operates.

[3] Numbers for 2014 (Agrosuper, 2014).
[4] An overview of the environmental impacts of salmon farming can be found in Annex 3.

For future similar studies, it is recommended that surveys are conducted with both, stakeholder representatives and members of the assessed company. In doing so, a better insight in the views and perceptions of stakeholders regarding their knowledge on business operations, ecosystems, and the services created by ecosystems will be provided. This finds further support by Hanson et al. (2012), who emphasize the importance of taking into account not only facts and empirical evidence but perceptions as well, since they may equally result in risks and opportunities for businesses. Nevertheless, perceptions should always be stated as such and must be accompanied by supporting evidence to either prove or disprove arguments. Moreover, as qualitative research is not value-free and often subject to the interpretation of the data compiler, it is desirable to add a more quantitative approach since it increases the credibility of the implemented data.

Regarding the secondary data, very limited scientific publications and no scientific benchmarks on the state of Patagonian marine ecosystems were available. Therefore, information on Patagonian marine ecosystems and how salmon aquaculture businesses affect them is scarce.

Table 2: Sources of input and information used during different stages of the ESR

	Involvement in step:				
Sources	**1**	**2**	**3**	**4**	**5**
Primary data sources					
Interviews with NGOs	*	*	*	*	*
Interviews with scientists and experts		*	*		
Interviews with stakeholders		*	*		
Interviews with the company		*	*		
Surveys with the company		*			
Workshops with the company		*		*	*
Secondary data sources					
Published literature		*	*	*	*
Databases and other internet sources	*	*	*	*	*
Information sources provided by the company	*			*	

As Table 2 shows, interviews and surveys were mainly used to select the scope of the ESR, to prioritize ecosystem services for Los Fiordos, and to analyze trends within the priority ecosystem services. In a meeting prior to the workshop, representatives of Los Fiordos discussed some of the dependencies and impacts the company has on ecosystem services. Then, during the workshop the results from the first three steps of the ESR were reviewed with all participants. The main risks and opportunities faced by the company were discussed. Based on these, the participants developed a number of strategies to address these risks and opportunities and then prioritized them accordingly. For more details on the sites visited during primary data collection, the actors interviewed, and the survey see Paulin (2015) and Annex 4. The complete workshop report can be made available on request.

3.4 Selected scope

3.4.1 Company profile

Los Fiordos owns six pisciculture centers and 101 feedlot concessions, out of which 33 are currently active. Two of the pisciculture centers focus on the production of eggs, while the remaining four focus on smolt production. The feedlot centers are located in two main areas, Melinka and Puerto Cisnes (See Figure 4 and Figure 5)). ASC is being implemented at 11 of the feedlot centers and certification is pending, while at the time of this study one had already been approved. All of these feedlot centers are located in the Puerto Cisnes area. Therefore, the company's production operations in Melinka and Puerto Cisnes have been selected as primary scope.

3.4.2 Ecosystems in Puerto Cisnes and Melinka

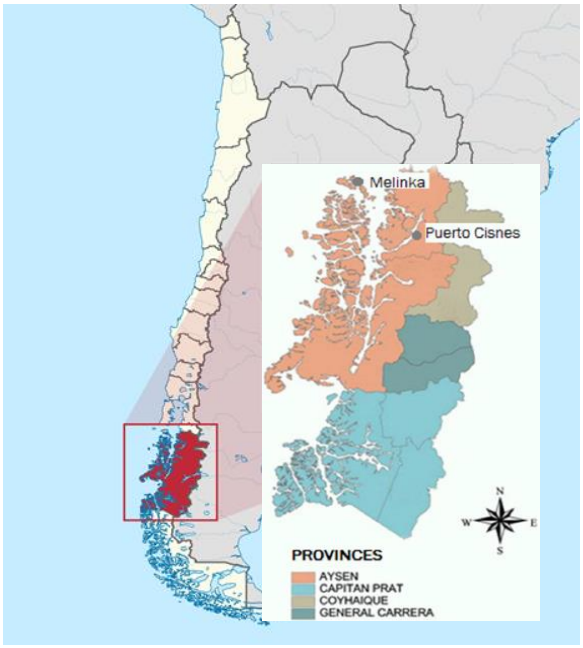

Figure 4: Chile and the provinces in the Aysén region. (Source: Adapted from Gobierno y Consejo Regional de Aysén (2015)).

Puerto Cisnes and Melinka are both located in the region of Aysén, in Southern Chile. Along with the region of Los Lagos, Aysén forms the Chiloense ecoregion, a remarkably biodiverse area characterized by unique species and exceptional environmental conditions, both of which are essential for the ecoregion's long-term subsistence (Miethke & Galvez, 2009; Hucke-Gaete, 2010). Furthermore, a vast network of channels and fjords characterize the ecoregion. Because of their biological richness, uniqueness, functionality, cultural value, and provisioning of services the ecosystems within this ecoregion have been identified as important conservation objectives (Miethke & Galvez, 2009). Table 3 lists some of the important ecosystems in this ecoregion.

Table 3: Important ecosystems of the Chiloense ecoregion. (Source: Miethke & Galvez, 2009).

Underwater canyons	Reproduction areas for commercially important species
Basins	Highly productive areas which determine salinity, oxygen, nutrient contents, sediment, and circulation balance in the fjords
Fjords	Even though not enough research has been done on this ecosystem, it is thought to resemble an estuarine zone
Kelp beds	Are habitat to relevant vertebrate and invertebrate species
Soft substrate beaches	Recruiting grounds for invertebrates, and feeding and reproduction sites for migratory bird species
Hydrothermal vents	Assumed to have a significant relationship with the level of bio-diversity

Besides the above mentioned, there are an additional number of ecologically important areas in which Los Fiordos operates. For example, the Puyuhuapi channel in Puerto Cisnes, characterized by a high level of primary production due to glacier sedimentations. Further, the Corcovado Gulf near Melinka has been identified as an important conservation area. It plays an essential role in maintaining system functionality by providing habitat to a number of keystone species and concentrating high-levels of biodiversity and biomass (Miethke & Galvez, 2009).

3.4.3 Local stakeholders

Even though Aysén is one of the largest regions, it has one of the lowest populations in Chile (Gobierno y Consejo Regional de Aysén, 2015). Located in the municipality of Cisnes, Puerto Cisnes has a population of around 2,500 inhabitants (Ilustre Municipalidad de Cisnes, 2015). The village's main source of income used to be artisanal fishing. However, according to stakeholder representatives from the area, artisanal fishing has become unfeasible as commercial fish stocks have been depleted (Anonymous, personal communications, April 14-16). Nowadays, the main economic activities in Puerto Cisnes are salmon production and services associated with the salmon industry (Anonymous, personal communication, April 16, 2015). Located in the municipality of Guaitecas, Melinka has a population of around 1,800 people with the main economic activity being artisanal fishing. Most of the workers of the salmon companies live on

floating pontoons. If they would be included in the census, the population of Melinka increases to around 3,000 people (Ilustre Municipalidad de Guaitecas, 2015).

3.4.4 Scope for the ESR

The aim of the ESR is to identify the risks and opportunities Los Fiordos may face as a result of its interaction with ecosystems. Therefore, from a value chain perspective the company's production operations have been selected as primary scope. On a spatial scale, the study focuses on the feedlot and pisciculture-centers situated in the areas *Melinka* and *Puerto Cisnes*; two high value conservation areas (HVCAs) where most of the company's feedlot centers are located and where other stakeholders benefit from the same ecosystems. Figure 5 is an illustration of the results of the scoping step of the ESR.

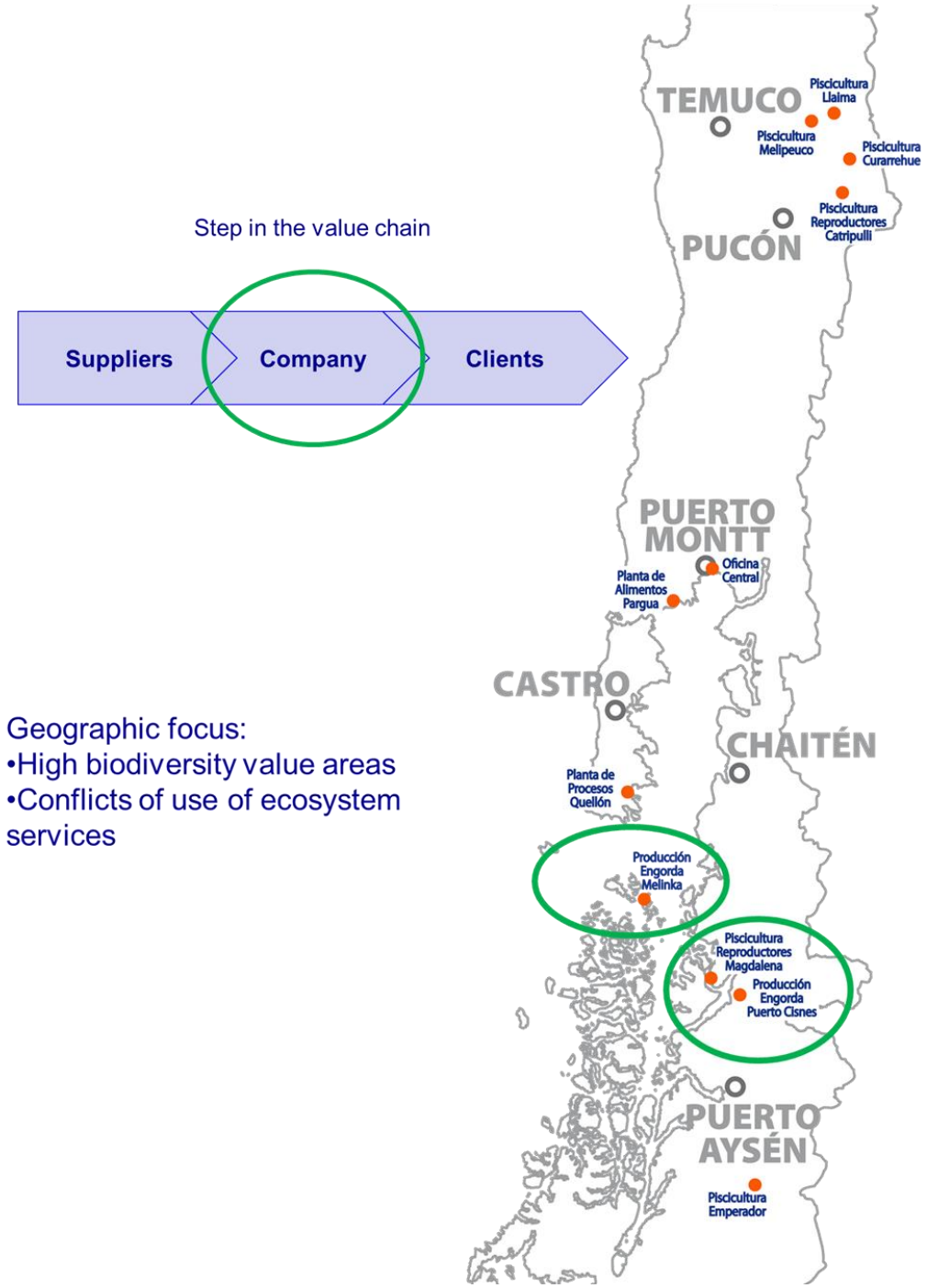

Figure 5: Illustration of scope selection

3.5 Priority Ecosystem Services

After selecting the primary scope and the spatial scale of the review, the priority ecosystem services for Los Fiordos will be identified. Therefore, the ecosystem services Los Fiordos depends on or impacts most, need to be prioritized from a list of 20 ecosystem services. The Dependence

and Impact Assessment Tool[5] developed by the World Resources Institute was used to illustrate the degree of interdependence the company has with the ecosystem services. The tool consists of a questionnaire and a summary matrix. The questionnaire helps managers analyze a company's dependence and impact on ecosystem services in a structured and systematic manner. In particular, it helps managers determine whether or not the company depends on and/or impacts an ecosystem service and, if so, the significance of this dependence/impact.

A company depends on an ecosystem service if that service serves as an input or it enables, enhances, or influences environmental conditions required for successful corporate performance. A company impacts an ecosystem service if it affects the quantity or quality of the service. Once the dependence and impact of a business on ecosystem services has been evaluated, it is possible to identify the respective priority ecosystem services. According to Hanson et al. (2012), priority ecosystem services should be selected based on their relative importance. Ecosystem services where a high level of impact and dependence are identified should have the highest priority, followed by those deemed high in one of the two aspects and medium in the other. Of minor priority are services which ranked high in one of the aspects and low in the other. Ecosystem services on which the company has a low impact as well as low dependence should not be prioritized. Table 4 illustrates how to determine the level of priority for an ecosystem service, with the 1st and 5th tiers representing the highest and lowest priority levels respectively.

Table 4: Level of importance of ecosystem service

Dependence	Impact	Priority Level
High	High	1st tier
High	Medium	2nd tier
Medium	High	2nd tier
High	Low	3rd tier
Low	High	3rd tier
Medium	Medium	4th tier
Medium	Low	5th tier
Low	Medium	5th tier
Low	Low	-

Accordingly, the review identified the most important ecosystem services. For example, Los Fiordos' salmon production is heavily dependent on the natural oxygen supply of the marine ecosystem it operates in. At the same time, the amount of oxygen in the ecosystem decreases with the amount of salmon produced by the company. Consequently, Los Fiordos' production of salmon has a significant impact on the natural oxygen supply to other businesses and, not least, other living beings in the ecosystem. Table 5 presents an overview of the results, followed by a

[5] Downloadable at http://www.wri.org/sites/default/files/esr_dependence_impact_assessment_tool.xls

detailed description of the interrelationship between Los Fiordos and the respective priority ecosystem service.

Table 5: Overview of priority ecosystem services for Los Fiordos

	Ecosystem services	Dependence			Impact			Priority level (tier)
		Does it enhance/enable performance?	Does it have cost-effective substitutes?	Level of dependency	Impact on quantity or quality	Does it affect the ability of others to benefit from ES?	Level of impact	
	Provisioning							
1	Crops	Yes	Yes	Medium	Yes	No	Medium	4
2	Industrial fisheries	Yes	Yes	Medium	Yes	No	Medium	4
3	Artisanal fisheries	No	No	Low	Yes	Yes	High	3
	Regulating							
4	Oxygen supply	Yes	No	High	Yes	Yes	High	1
5	Water purification and waste treatment	Yes	Yes	Medium	Yes	Yes	High	2
6	Maintenance of soil quality	Yes	No	High	Yes	Yes	High	1
7	Pest mitigation	Yes	No	High	Yes	Yes	High	1
	Cultural							
8	Recreation and ecotourism	No	No	Low	Yes	Yes	High	3
9	Ethical and cultural values	No	No	Low	Yes	Yes	High	3

The ecosystem services given the highest priority are oxygen supply, maintenance of soil quality, and pest mitigation. Water purification and waste treatment rank on the second highest tier. Artisanal fisheries, ethical and cultural values, as well as recreation and ecotourism rank on the third tier. The ecosystem services with the relatively lowest priority are crops and industrial fisheries. For a more detailed insight on the determinants of level of interdependence of Los Fiordos with ecosystem services, see Annex 1.

3.5.1 High priority services

As demonstrated in the previous step, priority ecosystem services are essential for the company's performance or the company has a rather significant, real or perceived, negative impact on the availability of ecosystem services used by others. Therefore, the company Los Fiordos and other stakeholders of these ecosystem services have assigned a high priority to these ecosystem services.

1. Oxygen Supply

Los Fiordos highly depends on the supply of oxygen in the waters surrounding the net pens. The oxygen level in the water is essential for the production of salmon. Artificial oxygen supply would require high investments and does not represent a cost-effective solution compared to the cost-free natural oxygen supply. Furthermore, the overall impact caused by insufficient oxygen in the marine ecosystem would most probably cause damage to the production of salmon. Natural inputs which increase the availability of oxygen in a body of water are, among others, freshwater inflows from melting glaciers, freshwater basins, or rains (Hucke-Gaete, 2010). In the semi-closed water embayment of the Puerto Cisnes area the amount of oxygen available is rather limited. Freshwater in this fjord mostly originates from melted glaciers and the small sea opening in the southwest of Puerto Cisnes (See Figure 5).

The large quantity of salmon being grown in the area requires large amounts of oxygen and may limit the oxygen availability to other salmon farms in the same body of water. Furthermore, it may limit the amount of oxygen available for other organisms being harvested and/or living near the concessions of aquaculture industries. This theory finds support in an interview held with a representative of the scientific community (Anonymous, personal communication, April 24, 2015). However, the majority of research on the impacts of salmon farming focuses on the contribution of the industry to the lack of oxygen in the sediments below the net pens (Bourgault et al., 2012). Therefore, further research is needed before more thorough statements on the impact of salmon aquacultures on the oxygen supply in the surrounding body of water can be made.

Figure 6: Map of the Puerto Cisnes area. As it can be seen, the supply of oxygen rich freshwater is limited by the narrow strait in the south west of Puerto Cisnes

2. Water purification, waste treatment, and maintenance of soil quality

A number of organisms can be found in marine ecosystems that support the decomposition of organic matter. These organisms play a key role in breaking down the organic discharge

generated by aquacultures. The ability of the benthic sediment to treat waste degrades when the level of hypoxia[6] reaches a certain threshold. The resulting soil quality degradation affects primary production and the overall structure of the trophic cascade. Since this could lead to a loss in productivity for Los Fiordos, and other stakeholders who benefit from healthy marine ecosystems, the level of dependence and impact on these ecosystem services, is in both cases high.[7]

3. Pest mitigation

Aquaculture operators often have to face the risk of virus outbreaks through pests. In a healthy and biodiverse ecosystem, pests are controlled through other species in the trophic chain. However, since aquacultures mainly produce one specific species, pests can spread more easily. Hence, fish producers like Los Fiordos depend on natural pest mitigation to a great extend in order to avoid an intensive use of vaccines and antimicrobials. In the case of the SRS virus, no effective vaccine has been found yet. Consequently, there is no cost-effective substitute to this ecosystem service. Furthermore, the use of antibiotics and vaccines used to treat diseases and parasites, may lead to a resistance of fish outside net pens against diseases. This could negatively affect biodiversity and alter the trophic structure of the ecosystems where Los Fiordos operates. Additionally, this impacts the availability of this ecosystem service to other stakeholders in the area.

3.5.2 Medium priority services

Although Los Fiordos does not depend on the following ecosystem services in its production cycle, the research demonstrates that the stakeholders that were contacted are of the opinion that the company, as part of the salmon aquaculture sector, has an impact on the supply of the services and hence decreases the ability of others to benefit from them. Therefore, they have been assigned a medium priority.

1. Artisanal fisheries

Los Fiordos has a low dependency on this priority ecosystem service, since artisanal fisheries do not enhance Los Fiordos' performance. However, it is possible that some of Los Fiordos' practices contribute to the degradation of ecosystems on which other stakeholders depend. Even though artisanal fishing is no longer a predominant economic activity in Puerto Cisnes, it remains the main economic activity in Melinka, where fishermen specialize in the capture of benthic species such as mussels and sea urchins. Through potentially enhancing eutrophication and increasing hypoxia, Los Fiordos may have an impact on the quantity of the benthic species and thereby the quality of the ecosystem service.

[6] Hypoxia defines a reduced oxygen content of air or a body of water detrimental to aerobic organisms.

[7] It is worth noting, that conversations with stakeholders revealed that Melinka has no sewage system. This may act as an additional source of nutrient in the water.

The common perception within the Melinka community is that the salmon industry's practices are the main cause for the decreasing quantity of benthic species, prohibiting a legal harvest. This perception is shared by community members in Puerto Cisnes, believing the loss of fish stock for artisanal fisheries results from the intensive aquaculture practices in the region. However, members of the scientific community and a fishery's representative in Melinka countered this argument; they argued that it is likely that the main reason for the decline in quantity is overfishing. Representatives from Los Fiordos did not share this view either, and suggested that overfishing by both artisanal and industrial fisheries is the main cause for the decrease of fish stocks near shore. Nevertheless, it was decided to keep this as a priority ecosystem service to provide insight to Los Fiordos of the other stakeholder's views and to allow the contemplation of risks and opportunities derived from these perceptions.

2. Ethical and cultural values

Los Fiordos' business operations are not directly affected by ethical or cultural values; hence, its dependence on this ecosystem service has been categorized as low. Nevertheless, one important ethical issue identified by both, stakeholders in the local areas as well as representatives of the company, is the importance of the conservation of cetaceans. Whales and dolphins in particular, are national and pride symbols for the two locations. However, according to stakeholder representatives the number of cetaceans-sightings close to the shore has decreased since aquaculture operators started their business in the area. Even though this argument lacks empirical background, it could negatively affect the image of Los Fiordos as well as the willingness of communities to collaborate with the company. Hence, its relevance to include it as a priority ecosystem service.

One example of how this can negatively impact the industry's operations can be found during the ISA outbreak in 2007. During that time, indigenous communities in Melinka revealed information to the national and international media about the unsustainable practices adopted by several companies. This behavior was triggered by the perceived lack of interest of the salmon industry in answering to the pleas of these communities. This is one of many examples how the lack of cooperation between the industry and stakeholders can have a negative impact on the industry's future image.

3. Recreation and ecotourism

Recreation and ecotourism is not a part of Los Fiordos' value-chain. Consequently, its dependence of this ecosystem service is low. Nevertheless, stakeholder representatives criticize the visual contamination net pens generate, arguing that they obstruct tourism activities in the area. Hence, the activities of Los Fiordos and other aquaculture companies have a high negative impact on this cultural ecosystem service. However, the recreation- and ecotourism sector in the areas is economically rather insignificant; therefore, it has been assigned an overall medium low priority level. Nonetheless, if the Ministry of Economy, Development, and Tourism of Chile

further increases investments in ecotourism projects in the discussed areas, this ecosystem service might be assigned a higher priority. [8]

3.5.3 Low priority services

The last two priority ecosystem services are important for the company's productivity. However, cost-effective substitutes are available as well. Furthermore, the availability of these services to others is affected by the company's actions, but not to a degree that would deprive other actors from benefitting from the services at all. Therefore, these ecosystem services have been assigned a relatively low priority for the company Los Fiordos.

1. Crops and Industrial Fisheries

The company has a medium dependence on crops and industrial fisheries, as they constitute the main source of protein in the fodder. The composition of fodder consists mainly of fishmeal, crops, and input from other animal species. The marine species used most commonly are anchovies and sardines. However, throughout the years Los Fiordos has reduced its use of fish drastically, decreasing the proportion of fishmeal in the feed by more than half. Consequently, crops have gained an increasing role in feed production. One of the cost-effective substitutes that can be used instead of feed-fish is soybean. The use of soybean as a protein substitute for feed-fish has led Los Fiordos to increase the percentage of soybean in the feed from around 20% in 2008 to around 40% in 2014. Even though the worldwide increase in the demand for soy-bean as fish feed increases the pressure on soybean producers, it is unlikely that Los Fiordos limits the availability of soy-products to others. Hence, it can be concluded that Los Fiordos has a medium impact on the ecosystem service and a medium dependence resulting in a low priority.

3.6 Trends in priority Ecosystem Services

In the previous step, the priority ecosystem services of Los Fiordos were identified and prioritized. In this step, changes in the supply of the priority ecosystem services are examined. This step is essential for the remaining review, since it should provide managers with a sufficient amount of relevant information and insights to identify the consequences that changes in the supply of important ecosystem services have on their business. This will be translated into identified risks and opportunities in the next step. Therefore, this section analyzes the drivers behind the trends in Los Fiordos' priority ecosystem services.[9] The ESR does so by analyzing the indirect drivers of change together with the impacts the company and other relevant actors have on the ecosystem. These result in direct factors influencing the ecosystem which in return

[8] Investments in the tourism sector have increased by 30 % in 2015 (Ministerio de Economía, Fomento y Turismo, 2015).

[9] Pest mitigation has not been included in the analysis since efforts are already being made by Los Fiordos, SalmonChile, and pharmaceutical companies to find solutions to minimize the use of chemicals and antibiotics in the aquaculture.

influence the amount of services the ecosystem can supply. See Figure 7 for an example illustration.

3.6.1 Trends in high priority ecosystem services (tiers 1 and 2)

The capacity of ecosystems to purify water, process organic waste, maintain soil quality, and ensure oxygen supply, may be negatively impacted by the business practices of salmon aquacultures. For example, large quantities of fish biomass often lead to high levels of inorganic and organic waste discharge, a higher incidence of diseases and pests, and a significant demand for oxygen. These factors provoke eutrophication, resistance to chemicals and antibiotics by organisms outside net pens, and anoxia[10]. Moreover, these factors deteriorate the overall quality of the water and affect the trophic structure of ecosystems in close proximity to the net pens. As a result, the performance of the growing number of aquaculture concessions in Chile suffers. Not only does salmon depend on a static supply of oxygen, moreover, the production faces a much higher risk of a virus outbreak in an interrupted trophic structure. Therefore, a diminishing supply of these priority ecosystem services has a direct effect on any aquaculture industry's profits operating within the same body of water. Figure 7 illustrates the direct and indirect drivers behind the current trends in the supply and demand of these priority ecosystem services.

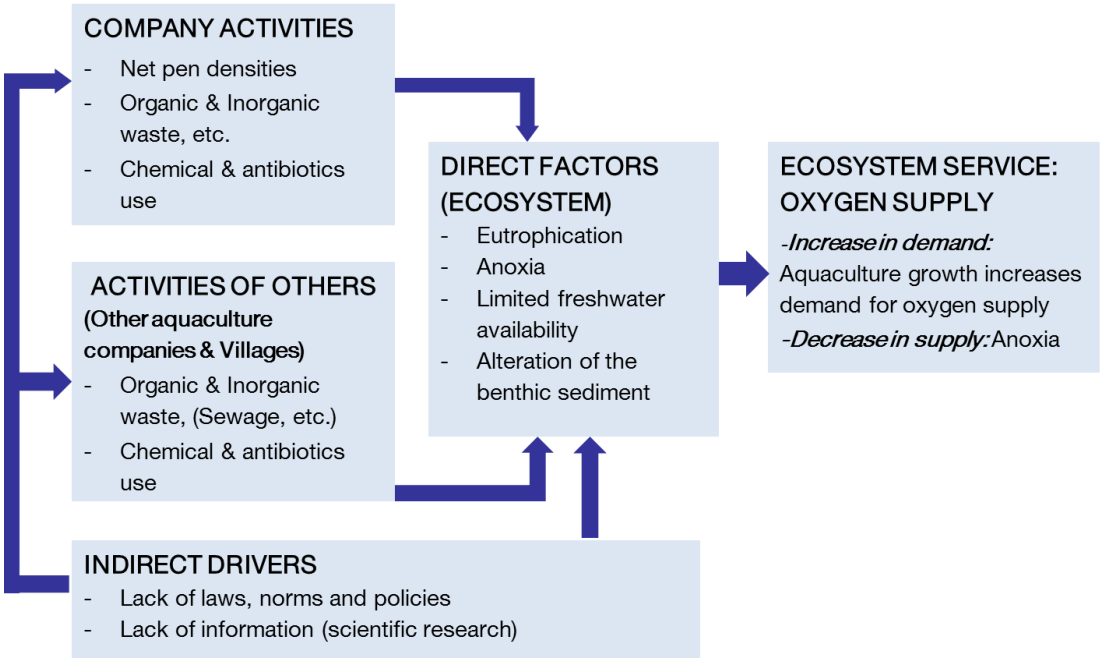

Figure 7: Direct and indirect drivers of supply and demand for oxygen, water purification, waste treatment, and soil quality maintenance services

3.6.2 Trends in medium priority ecosystem services (tier 3)

In this paragraph the conditions and trends of the medium priority ecosystem services are described.

[10] The term anoxia means a total depletion in the level of oxygen, an extreme form of hypoxia or "low oxygen".

1. Artisanal fisheries

The stocks of commercial marine species like sea urchins and mussels have worsened in both, the Melinka and Puerto Cisnes areas. The drivers of change behind the decrease in wild species are most likely due to the use of unsustainable practices by artisanal fisheries, industrial fisheries as well as the salmon aquaculture. This trend further intensifies due to illegal fishing practices in the areas. Even though there is no scientific proof for the cause, it is very likely that the reputation of the aquaculture industry will suffer from the decrease in wild marine species. Figure 8 illustrates the direct and indirect drivers that affect the supply and demand of wild aquatic species on which artisanal fishermen depend.

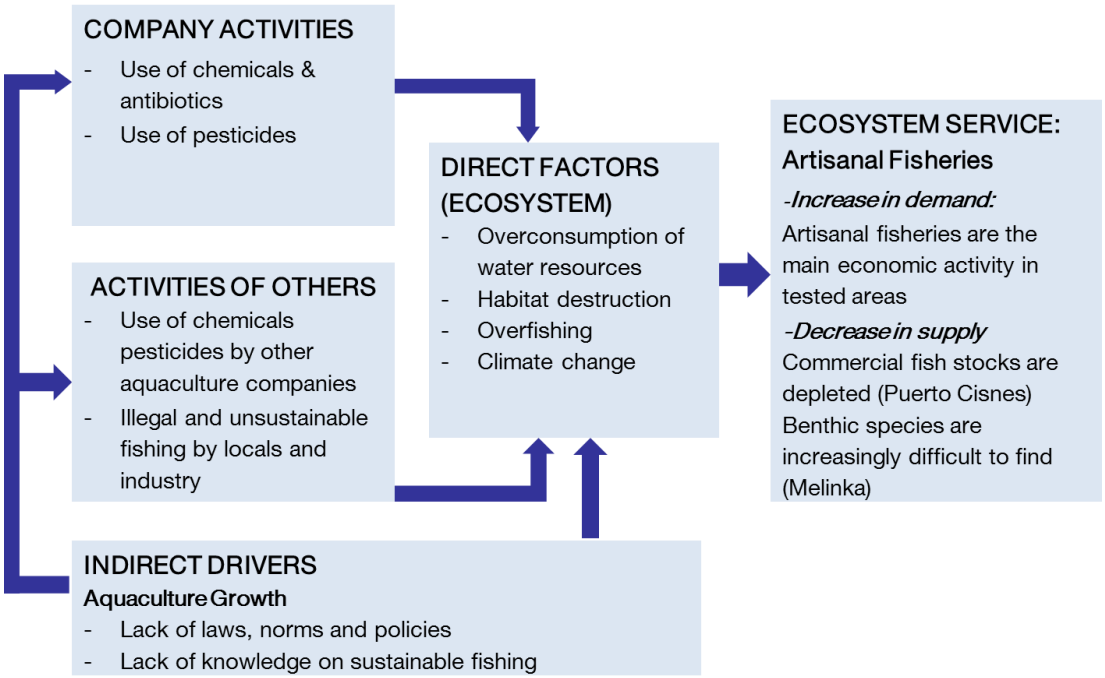

Figure 8: Direct and indirect drivers of supply and demand for artisanal fisheries.

2. Recreational and Ecotourism & Cultural and Ethical values

Figure 9: Industrial waste found on the shores of Melinka.

According to stakeholders in Melinka and Puerto Cisnes, both regions are interested in further developing a sustainable tourism sector as an additional source of income. However, access to both villages is very limited, due to the lack of an appropriate infrastructure. In addition, industrial waste materials from the aquaculture facilities pollute vast stretches of land. Commonly found waste includes sunken pontoons and cages, ropes, hoses and nets (see Figure 9).

The strongest cultural and ethical value in Melinka and Puerto Cisnes is attributed to cetaceans. Therefore, people see them as representative of the two areas and are willing to invest in their protection. Nevertheless, cetacean sightings have reportedly steadily decreased in the last decades. Even though, the drivers behind it can be disputed between local inhabitants, aquaculture operators, and scientists, is the aquaculture industry is largely blamed and it is very likely that it may suffer from the dispute, regardless of possible sanctions. Figure 10 illustrates the direct and indirect drivers affecting the supply and demand of cultural ecosystem services.

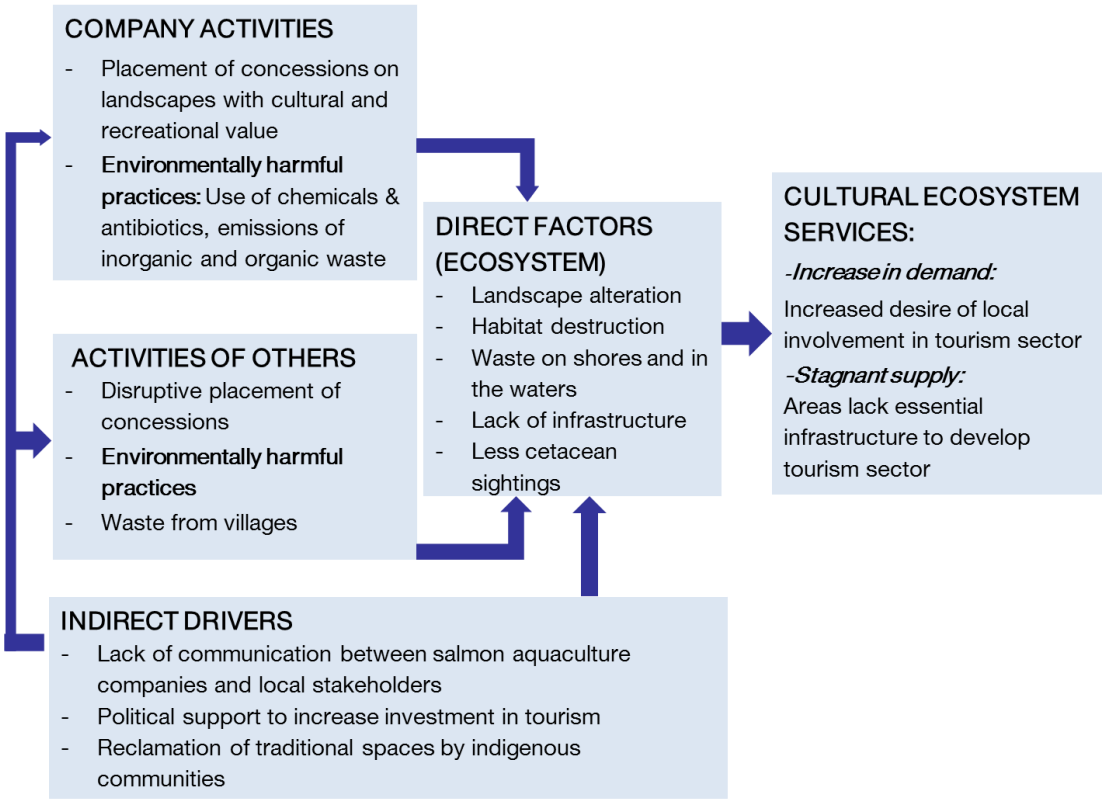

Figure 10: Direct and indirect drivers of supply and demand for cultural services.

3.6.3 Trends in low priority ecosystem services (tier 4)

In this paragraph the conditions and trends of the low priority ecosystem services are described.

1. Industrial Fisheries

Two of the main ingredients for fishmeal are fish captured by industrial fisheries, and crops. In order to meet the increasing demand from aquacultures, global fishmeal production has increased by more than threefold between 1992 and 2006. Approximately one fifth of the global fishmeal and fish-oil production is used for the production of salmon and trout in aquacultures. Chile is the second largest producer of fishmeal after Peru and the third largest consumer after Japan and China. This position gives the country a comparative advantage in terms of its accessibility to the good. However, the increased demand of fish for the use as animal feed has

led to increased prices of the resource since 2004[11], increasing the cost of production for aquaculture businesses. Figure 11 illustrates the direct and indirect drivers that determine the supply and demand of fishmeal.

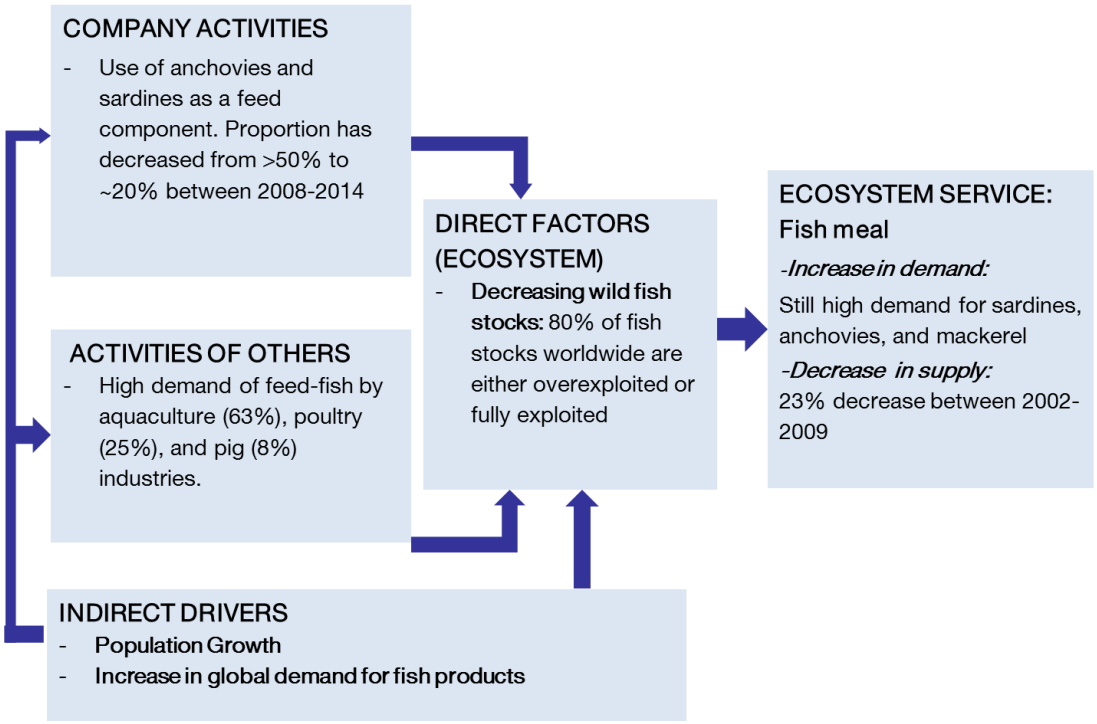

Figure 11: Direct and indirect drivers of fishmeal supply and demand. (Source: FAO, 2011).

2. Crops

The recent price development of industrial fish has led to a change in the main source of fish fodder. Today, soybean is a commonly used replacement for fishmeal due to its high protein content. As a result, approximately 70% of global soybean production is used as animal feed (IISD, 2014). The increased role of soybean production for animal feed as well as human consumption has led to various impacts on the environment. By 2014, around 2.2% of agricultural land on the planet was used for soybean production. However, this also increased deforestation, which in return affects biodiversity, pest management, soil erosion, and creates land ownership disputes (IISD, 2014).

One solution for this problem is the use of certified soybeans as input for fish fodder. Currently, the ASC standard requires participating farms being soybean certified by the Round Table on Responsible Soy (RTRS) by the year 2017. As the price for certified soybeans is higher than for regular soybeans, the production-cost of salmon and trout will rise as well. However, as the demand of certified soybeans increases due to the use as animal fodder and consumption by humans, its production will increase. Between 2008 and 2012, the production of RTRS certified soybeans grew by 3% annually, confirming the above-proposed trend (IISD, 2014). For the case of

[11] FAO, 2011.

Chile, it might in addition be a comparative advantage in terms of spatial market accessibility, that two of largest producers of certified soybeans are Argentina and Brazil (IISD, 2014). Figure 12 illustrates the direct and indirect drivers.

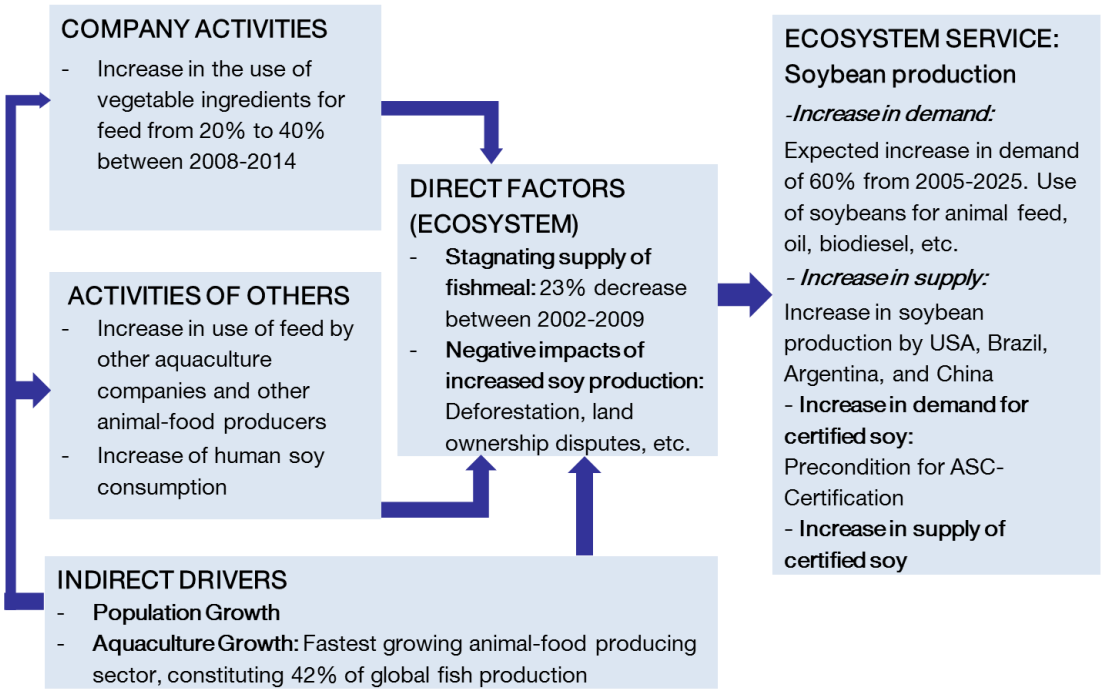

Figure 12: Direct and indirect drivers of supply and demand for soybean production. (Sources: FAO, 2011; IISD, 2014; Statista, 2015; Worldwatch Institute, 2015).

3.7 Business Risks and Opportunities

After the current trends in the priority ecosystem services have been analyzed, the next step of the ESR serves to identify risks and opportunities for Los Fiordos derived from the conditions and trends described. The risks and opportunities influence one or more operational, regulatory and legal, reputational, market and product, or financing aspects of the company. After potential risks and opportunities are determined, the company is able to develop coherent management strategies addressing the identified issues caused by the dependence or impact on ecosystem services in the consecutive step.

3.7.1 Identification of the main risks and opportunities

Based on an analysis of changes in priority ecosystem services, a number of risks and opportunities were identified and presented to Los Fiordos. The ESR methodology suggests two ways to identify risks and opportunities: based on the identified priority ecosystem services or according to the risk categories (as described above). In this study the approach of the risk categories was chosen to enable the company to better consider the risks and opportunities in the context of its business operations. Table 14 and Table 15, respectively, in Annex 5 present the long-list of risks and opportunities, organized according to the risk categories, that formed the basis for the discussion during the workshop held with Los Fiordos. During the workshop, the participants chose the six risks and six opportunities with the highest priority for the company.

The lists of selected risks and opportunities are presented in Table 6 and Table 7 respectively. These risks and opportunities were subsequently prioritized by the representatives of Los Fiordos, as explained in the next paragraph.

Table 6: Risks selected

	RISKS	Times selected
	Operational	
1	Spatial conflict for concessions due to scarcity of (productive) locations and use of locations by other stakeholders	7
2	Not being able to obtain ASC because of mismatch between ASC requirements for fishmeal components and current certified fishmeal production	7
3	Reduced productivity due to low water quality and low ecosystem health (i.e. aquaculture activities, tourism, and population growth)	6
4	Uncertainty about abrupt changes in natural systems resulting in anoxia or disease outbreak (disruption to business operations)	6
	Legal and regulatory	
5	Complying with current legal and regulatory measures do not steer towards sustainable operations (lack of technical and scientific basis in policy making)	8
	Reputational	
6	Negative perception by local stakeholders of salmon aquaculture (impact on the environment, artisanal fisheries, and cetaceans) causes bad reputation and makes cooperation difficult	8

Table 7: Opportunities selected

	OPPORTUNITIES	Times selected
	Operational	
1	Increase productivity or increase efficiency by engaging with scientific community (i.e. best practices, technological innovations, etc.)	6
2	Increase in productivity caused by innovations (i.e. multi-trophic aquaculture) resulting in more healthy ecosystems	7
	Legal and regulatory	
3	Promote the creation of Marine Protected Areas to protect healthy ecosystems	5
	Reputational	
4	Engage with scientific community by facilitating/participating in research to improve scientific reputation	5
	Market and product	
5	Increase market share and sales with ASC certification, in existing markets and by accessing new markets (geographic, type of products, new purchasers)	6
	Financial	
6	Access to external financing for innovative research and projects by being a frontrunner of sustainable practices	5

3.7.2 Prioritization of the main risks and opportunities

In order to assist the company with the prioritization of the main risks and opportunities, parameters were used to enable the assessment of the relative level of risk or opportunity faced by the company. In addressing the risks sufficiently, the company is able to prevent direct economic losses as well as additional risks which emerge through indirect impacts[12]. Finally, the company can assess the urgency to address the risk and whether there are quick solutions available that could be implemented. In short, the four parameters to prioritize the risks are:

- Possible losses
- Other impacts
- Urgency of the risk
- Availability of quick solutions

For opportunities, the parameters focus on the potential return of investment (ROI) as well as the potential of creating additional (non-monetary) benefits. Finally, the ease of implementation of a measure to seize the opportunity and the possibility to achieve a good result with relatively low or without additional effort (quick win) are evaluated. In short, the four parameters for the prioritization of the opportunities are:

- Potential return on investment (ROI)
- Availability of further benefits
- Relative ease of implementation
- Possibility of achieving a 'quick win'

Accordingly, the parameters for the risks and opportunities were evaluated from high to low. Based on the scores for each of the four parameters, it was discussed in which timeframe (priority) the company should address each risk or realize an opportunity. Table 8 and Table 9, respectively, illustrate the results of the prioritization exercise and the timeframe assigned by the company to work towards minimizing the priority risks and maximizing the priority opportunities Issues assigned the value "0" in the last column ('Years') are considered already being addressed by Los Fiordos. Issues assigned the value "1" were deemed urgent or important, thereby making it necessary for the company to start working on them within the upcoming year. Higher numbers indicate that the issues should be dealt with in the medium to long term.

[12] Regarding this specific case study, indirect impacts refer to e.g. the insufficient communication with local stakeholders has on the company's reputation, which in return could lead to image problems and monetary losses for the company.

Table 8: Prioritization of Risks (OP= Operational, LR= Legal and regulatory, RE= Reputational. H= High, M= Medium, L= Low. ASC= Aquaculture Stewardship Council certification)

	Type	RISKS	Possible losses	Other impacts	Urgency	Availability of quick solutions	Time frame
1	OP	Spatial conflict over concessions	H	L	H	M	1
2	OP	Reduced productivity due to water quality and ecosystem health	H	L	H	H	1
3	OP	Uncertainty due to change in the natural system	H	L	M	M	1
4	OP	Mismatch between ASC requirements for feed components	L	M	H	H	1
5	LR	Legal requirements not supporting sustainability	L	L	M	L	3
6	RE	Negative perception by local stakeholders	L	H	H	M	5

Table 9: Prioritization of Opportunities (OP= Operational, LR= Legal and regulatory, RE= Reputational. H= High, M= Medium, L= Low. ASC= Aquaculture Stewardship Council certification)

	Type	OPPORTUNITIES	Potential ROI	Other benefits	Relative ease of implementation	Quick win	Years
1	OP	Increase productivity-scientific community	H	M	L	L	3
2	OP	Increase productivity-innovation	H	M	L	L	1
3	OP RE	Promote MPAs	H L	H	H	H L	0-1
4	RE	Facilitate and participate in scientific research	L	H	L	H	5
5	MP	Increase market share in existing/new markets through ASC	H	H	L	L	1
6	FI	Finance for innovative research	H	H	M	H	0-1

3.8 Strategy development

After the selected risks and opportunities were prioritized and a timeframe was assigned to work on them, the company has a basis to develop strategies aiming to minimize the risks and maximize the opportunities Los Fiordos faces from changes in ecosystem services. Following Hanson et al. (2012), first potential strategies first need to be categorized according to their field of implementation. This section concludes by presenting a short description of the strategies sketched by Los Fiordos, which can be developed further.

3.8.1 Categorization of strategies to address risks and opportunities

Different strategies can be pursued to address identified risks or realize potential opportunities. By using the strategy categorization presented by the ESR methodology, to classify the risks and opportunities according to the most suitable strategy category to deal with each of them, the connection between the risks and opportunities and the field of strategy implementation is made. Furthermore, the company is able to develop integrated strategies that address multiple risks and/or opportunities that may be tackled through one of the three categories of strategies, being:

- Internal changes
- Sector or stakeholder engagement
- Engagement with policy makers

For examples of each of the strategy categories, see the explanation of step 5 of the ESR in Annex 1. Table 10 illustrates the classification of risks and opportunities according to the strategy category identified by the company as the most suitable to address the relevant risk or opportunity. Two things need to be noted here:

- this classification exercise was only conducted for the risks and opportunities that were assigned an immediate action priority during the prioritization exercise (those with values 0-1 on Table 8 and Table 9);
- for some risks or opportunities, more than one strategy was identified as suitable; in which case, the order in which each strategy should be pursued is indicated in Table 10.

Table 10: Classification of prioritized risks (red) and opportunities (green) according to the most suitable strategy category to address them

Internal changes	Sector or stakeholder engagement	Policy maker engagement
Increase productivity-innovation (1st step – internal innovation strategy)	Reduced productivity due to water quality and ecosystem health	Increase productivity-innovation (2nd step – engage policy makers for regulation to allow innovation)
Increase market share in existing/new markets through ASC	Promote MPAs (1st step – involve the sector and other stakeholders)	Promote MPAs (2nd step – engage with policy makers after support of sector and stakeholders is obtained)
Negative perception by local stakeholders (of Los Fiordos)	Negative perception by local stakeholders (of the salmon aquaculture sector)	
Finance for innovative research	Uncertainty due to change in the natural system	
	Mismatch between ASC requirements for fish oil and fishmeal	

As part of this last fifth step, a strategy was sketched for each prioritized risk and opportunity for Los Fiordos. Some risks and opportunities were grouped into one strategy where it was considered that this would be more appropriate, based on the classification discussed above. Each strategy consists of the following elements:

- **Goal**: the objective that the company would like to achieve in relation to the relevant priority risk or opportunity.
- **How**: the main activity or activities the company will undertake, alone or in collaboration with other stakeholders, to achieve the identified goal.
- **With whom**: the main stakeholders, both internal and external, the company needs to involve in the activities to be undertaken for each strategy.

These strategies form the action plan shown in Table 11. The resulting six strategies are briefly described in the following sections.

Table 11: Action plan for the minimization of risks and maximization of opportunities

	RISK/OPPORTUNITY	Goal	How?	With whom?
1	Negative perception by local stakeholders	Improve image of Supersalmon (over the coming 3 years)	Work with: Indigenous communities, science/academia, local governments, other companies Program for diffusion and communication	Academia specialized in Southern Chile region Education/research Fishermen/ indigenous communities
2	Increase productivity-innovation Finance for innovative research	One project every 2 years focusing on sustainability	Foster innovation in different areas of the company Direct internal funds to sustainability and compete for government grants	Managers for different areas General manager Committee (to be formed) lead by the sustainability area
3	Increase market share in existing/new markets through ASC	Pending (The goals still need to be discussed internally)	Define market strategy for ASC products	Commercial manager General manager
4	Uncertainty due to change in the natural system Reduced productivity due to water quality and ecosystem health	Create indicators to be able to measure/ change impact and be able to manage/ monitor	Create a working plan and validate it with experts	Environment and sustainability areas
5	Mismatch between ASC requirements for feed components	Create dialogue with ASC	Training and capacity building Information inventory	Technical department
6	Promote MPAs	Promotion in places where Supersalmon operates	Create alliances with key actors, NGOs, and local stakeholders	Manager of sustainability and relationship with the communities

3.8.2 Short description of the different strategies

1. **The first strategy** is meant to deal with the risks associated with the negative perception by local stakeholders of the salmon industry as a whole and to a lesser extent of the company. The goal of this strategy is therefore to improve the image and the reputation of the company among the local stakeholders in the focus areas of this study: Melinka and Puerto Cisnes. In the past, the involvement in community programs in the Puerto Cisnes area has improved the image of Los Fiordos amongst local stakeholders. However, sustainable initiatives such as joining the Global Salmon Initiative, promoting land-based pisciculture, and committing itself to achieve the ASC certification in all centers by 2020, do not contribute to their reputation locally. Furthermore, the research has shown that stakeholders in these areas do not differentiate between the single

companies in the industry. Therefore, one of the activities to be carried out to achieve this goal is to develop a communication program that disseminates information about the company's efforts and existing initiatives to improve its business practices. Fostering conversations between stakeholders, members of the scientific community, and local governments can further support achieving this goal. A transdisciplinary approach will not only provide new input for Los Fiordos, the scientific community, and policy makers, but will further increase legitimacy and science-based policy, diminishing the gap between science, policy, industry, and the local communities. This will ultimately improve Los Fiordos reputation among the stakeholders and its interaction with the local communities and ecosystems.

2. **The second strategy** is geared towards the opportunities that innovation can generate for the company, both by increasing productivity through innovations in sustainable practices thereby diminishing their environmental impact, as well as obtaining financing for these innovations thanks to their front-runner position in the market. For example, by co-developing the ESR, Los Fiordos is taking a front-runner position in the field of sustainable aquaculture in Chile. The results of this review can help the company to avoid risks and generate additional profits. Furthermore, by fostering research on sustainable practices, Los Fiordos can enhance its reputation as a sustainable salmon producer in Chile and avoid the costly and controversial implementation of artificial substitutes. The goal in respect of these opportunities is to have at least every two years one innovation project that focuses on sustainability and to increase their investments in innovative research. A promising field of research could be the implementation of integrated multi-trophic aquaculture [13]. Moreover, the investment in sustainable research and development could give Los Fiordos access to funds for sustainable projects provided by the Chilean government, while adding to the existing body of knowledge on sustainable practices.

3. **The third strategy** relates to the opportunity to increase the company's market share based on the ASC certification by either increasing the share of Los Fiordos' products in existing markets or through entering new markets where sustainable products are preferred, such as Europe. Los Fiordos has only recently started the implementation of ASC certifications in its centers, so it hasn't developed yet a strategy around the market

[13] Integrated multi-trophic aquaculture (IMTA) makes use of the by-products (e.g. waste or faeces) from one aquatic species as inputs (fertilizers, food) for another. Farmers combine fed aquaculture (e.g., fish, shrimp) with inorganic extractive (e.g., seaweed) and organic extractive (e.g., shellfish) aquaculture to create balanced systems for environment remediation, economic stability (improved output, lower cost, product diversification and risk reduction) and social acceptability (better management practices).

opportunities that the ASC may bring. Furthermore, the importance of certification schemes for the company's overall market strategy remains to be discussed internally.

4. **The fourth strategy** is a response to two risks directly related to changes in the ecosystem services: the risk of reduced productivity due to ecosystem deterioration and the uncertainty that arises from sudden changes in the natural system. The ESR demonstrated that Los Fiordos faces various risks regarding its operations due to changes in the priority ecosystem services. The strategy that was discussed to minimize these risks focuses on developing ecological indicators that will enable the company to measure and monitor the company's impacts on the environment and the priority ecosystem services. Based on these indicators, the company could manage these impacts and any changes to the ecosystem services derived therefrom. These indicators are to be validated by experts. Furthermore, the gained information can help Los Fiordos to adapt to future changes in the provision of ecosystem services, which may result from the actions of other industry actors and other circumstances that are beyond its control.

5. **The fifth strategy** deals with the risk generated by the mismatch between the requirements of ASC to use certified fish for fish food production and the company's real possibilities of buying certified fish for fish meal and fish oil. The main issue is that the low supply of MSC certified fish in South America, forces Los Fiordos to import these fish meal inputs from distant markets, which in turn increases its carbon footprint. However, this is inconsistent with the aim of ASC to promote sustainable production standards. Soybeans are a potential substitute of feed-fish but certified soy is expensive as its market share is comparatively low. Thus, using certified soy as a substitute for fish meal and fish oil is not cost-efficient. As a result, the strategy consists of creating a dialogue with the ASC in order to discuss alternatives that are both cost-efficient for Los Fiordos and in line with the ASC objectives.

6. **The sixth strategy** aims at maximizing the opportunity that promoting marine protected areas (MPAs) presents to the company. The strategy entails giving support to implement MPAs in areas where Los Fiordos operates. By promoting the implementation of MPAs close to its operations, the company can help to protect and maintain the marine ecosystems in these areas and the services they deliver, on which it depends. By doing so Los Fiordos can, on the one hand, secure efficient operations while, on the other hand, strengthening its relationships with NGOs and local communities. In order to reach this goal, Los Fiordos has to create a dialogue with the Chilean

Government as well as other stakeholders in order to discuss the possibilities of implementing MPAs in the areas of interest.

4 Conclusions and next steps

4.1 Conclusions

The challenge of this project was to examine the relationship between healthy ecosystems and business performance. The case used aimed to support a salmon aquaculture company in its transition towards more sustainable business practices. The following conclusions are made based on the results obtained during the project:

1. **Risk**: It was found that the impact of salmon aquaculture on the environment has negative effects on Los Fiordos' productivity. Their environmental impacts weaken the provision of regulating ecosystem services in the areas they operate, such as oxygen supply and water purification, of which the company depends for its operations. Therefore, current activities of the company, other salmon companies and other stakeholders that endanger the provision of these services, also represent a risk for the health of the company's operations. The company acknowledges the need for their business performance to focus more on sustainable operations.
2. **Perception by the company**: Even though the company perceives the environment as a central part of the production chain, the services provided by ecosystems were rarely considered as factors of production. Highlighting environmental degradation as a risk to the company's operations created awareness among company managers and made them think of finding ways to prevent this impact. The risk is formed by diminishing capacity of ecosystems to provide regulating services like disease control or oxygen supply to salmon aquaculture. This issue cannot structurally be addressed by changing antibiotics and chemical doses alone. The information gained about the services of the ecosystem made Los Fiordos realize that the natural environment is crucial for the company's long-term survival. The managers started to realize the relationship between healthy ecosystems and business performance.
3. **Perception by other stakeholders**: Insights from interviews with local stakeholders made the management of the company aware of the negative perceptions that some stakeholders have of the salmon industry as a whole. For example, the industry's role in diminished viewings of cetaceans or depletion of artisanal fish stocks. The process emphasized the importance of creating dialogues with stakeholders. Local communities are users of the same ecosystem services on which the company depends and which it impacts. In dialogue common environmental threats and opportunities can be addressed. This awareness enables the company to evaluate their social responsibility strategies. To understand whether they are actually addressing environmental issues that are causing social problems and vice-versa can improve these strategies. For

example, the lack of knowledge of local fishermen about sustainable fishing practices or the absence of a sewage system in Melinka does impact business performance.

4. **Strategies to minimize risks:** Several strategies have been identified to enhance business performance addressing ecosystem health. Fort example practices aiming to promote environmental protection and sustainability (e.g. ASC adoption and the promotion of MPAs) serve as feasible means to minimize the risks for the company that arise from environmental degradation. These and other defined strategies allow for sustainable long-term business productivity based on maintenance of local ecosystem's health. See Figure 13 for an idea of potential strategies that could be implemented, following the results of this project.

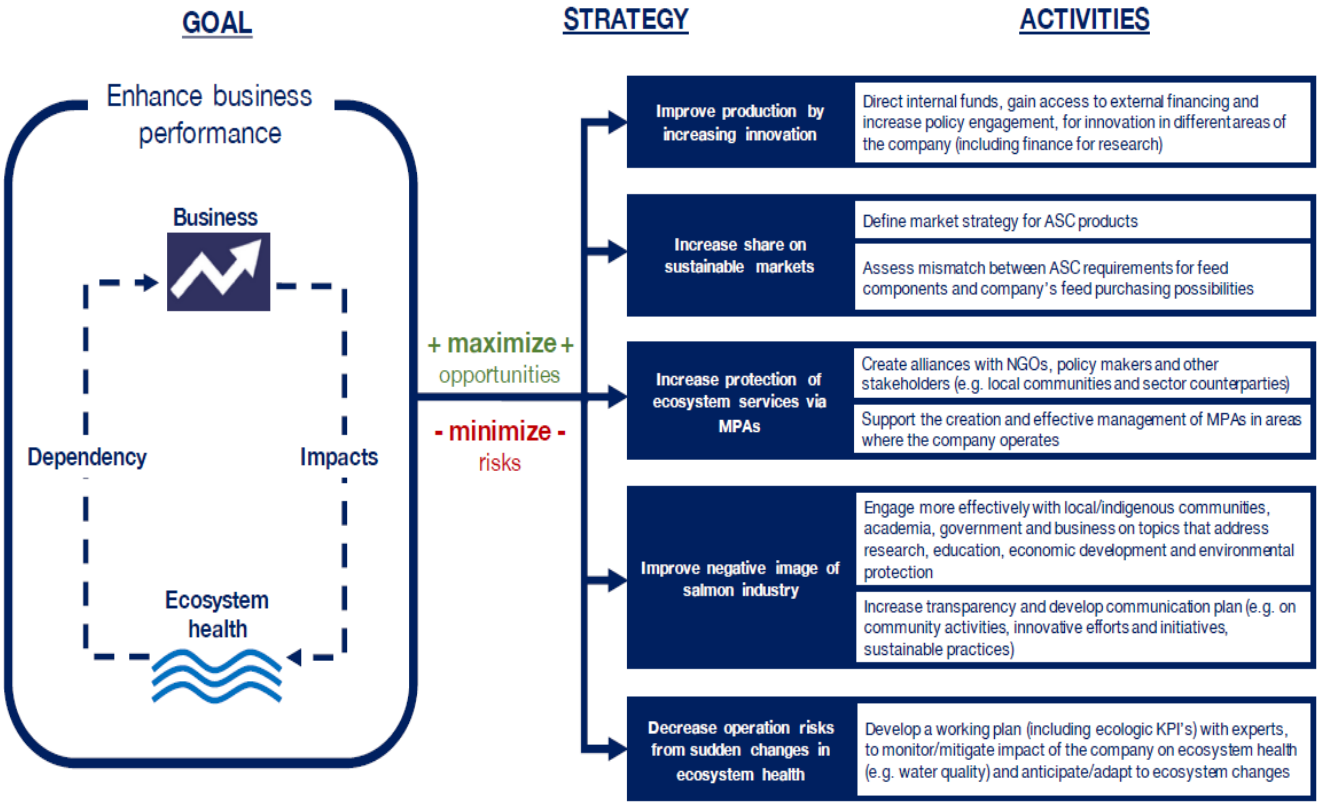

Figure 13: Summary of potential strategies

5. **Practice-science-policy gap and need for independent research:** One of the main challenges that the company, and the salmon sector in Chile as a whole, face is the lack of dialogue and cooperation between policy-makers, local stakeholders, the scientific community, and salmon businesses. The results of the project identified misperceptions about the company's approach towards more sustainable business practices and a general lack of understanding amongst the different stakeholders. This lack of dialogue and cooperation also causes an obstacle for the development of independent scientific research on salmon aquaculture. Lack of independent scientific research can pose a barrier for business innovation, environmental protection and consequently risk management. Promoting scientific research within, and in areas surrounding, salmon

farms could contribute to bridge the gap between policy-makers, salmon aquaculture companies, local stakeholder and the scientific community. Which in turn supports business performance.

6. **Engagement with stakeholders is essential**: The participation of WWF-Chile in the project enabled a more open engagement with other stakeholders in the communities of Melinka and Los Cisnes. This provided valuable insights on the perceptions of the company's impacts on the social and natural environment. It clearly identified perceptions of stakeholder of which the business managers were not aware.

   Furthermore, the direct involvement of high-level management of the company, allowed for a better understanding by the company of the process, more applicable results of the study and, most importantly, a crucial high level understanding of the linkage between ecosystem services and the company's operations.
7. **Interdisciplinary collaboration**: The project benefitted from the active collaboration between the company, an environmental economics research consultancy, the VU University of Amsterdam, WWF-Chile, WWF-The Netherlands and Rabobank. Having an NGO involved in the study facilitated, amongst others, the contact with the local stakeholders and their willingness to participate in interviews. Furthermore, the results of the ESR will also serve as input for the further implementation of the MoU between the company and WWF-Chile, making the results directly actionable.

4.2 Next steps

This ESR was the first step to create awareness of, and demonstrating the interdependence between healthy aquaculture business and healthy ecosystems. The following steps are recommended to further apply and increase the impact of the results of this process:

1. The study was based mainly on quantitative data, and as such did not provide scientific quantitative evidence of the findings. To measure the exact environmental economic implications of the interdependencies and impacts described, it is recommended to:
   a. analyse the economic benefits that can be obtained from implementing certain strategies, like the ones that resulted from this study; and
   b. conduct long term ecological studies in the Patagonian marine ecosystem and the dependency and impact of local economic activities on ecosystem services.
2. Gaining a better understanding of the underlying business dependencies on ecosystem services is not only important for Los Fiordos. Awareness by and actions from other companies are also necessary to effectively manage the health of the ecosystems on which aquaculture businesses depend. In order to scale up the learnings from this project and achieve concrete measures to ensure the health of these ecosystems, the identified risks and opportunities could/should be broadly shared with other aquaculture

businesses and other businesses. This could support them in the development of their own strategies to achieve more sustainable business practices.

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Annex 1 – Steps in an ESR[14]

Step 1: Scope selection

In the first step of an ESR, boundaries are set in order to define the scope of the assessment. Boundaries vary, depending on the purpose of the analysis, time, budget, actors involved, etc. The scope selection is conducted in order to keep the process manageable and yield more actionable results. Some of the main points to address during the scope selection phase of an ESR are the following:

1. **Stage of the value chain**: Actors conducting an ESR should decide whether they would like to address the operational sector of the company, the 'upstream' sector, or the 'downstream' sector of the value chain.
2. **Target actors, aspect of the business and the spatial context**: Depending on the stage of the value chain being analysed, the main actors within (e.g. main suppliers or customers) have to be identified, as well as the main aspect of the business (e.g. a business unit, a product line, a facility, a project, or land-holdings) has to be assessed.
3. **The strategic, timely and supported aspects of the scope**: The feasibility of the scope, regarding its timeframe or resource availability, has to be identified as well. It can further be helpful to define the strategic intention of the scope.

Step 2: Identification of priority ecosystem services

In the second step of an ESR, the priority ecosystem services are being identified. The priority ecosystem services are the services which are most likely to be a source of risk or opportunity for the company. One way to identify priority ecosystem services is by making use of the Dependence and Impact Assessment Tool[15], a tool provided by the WRI to identify priority ecosystem services. The tool further provides users with a short questionnaire which helps determining the degree of impact and dependence a company has on an ecosystem service. This step is of crucial importance, since the priority ecosystem services are the focus of analysis in the subsequent steps. All other remaining services are not further taken into account in the remaining review. Following, a brief explanation of how to determine the dependencies and impacts as well as how to allocate priorities regarding the ecosystem services is provided.

- **Dependencies**

To identify a company's dependence on an ecosystem service, the question of whether the ecosystem service at stake serves as an input or as an enhancement to the company's performance has to be answered. If the response is negative, the company has a low dependence on the ecosystem service. If the response is positive, it is necessary to further ask if the ecosystem service has any cost-effective substitutes (e.g. artificial dykes for flood protection). If

[14] Adapted from Hanson et al. 2012.
[15] Downloadable at http://www.wri.org/sites/default/files/esr_dependence_impact_assessment_tool.xls

it does, it implies the company has a medium dependence on the ecosystem service; but if the answer is negative the company is highly dependent on the ecosystem service. Figure 14 illustrates the steps suggested for the determination of the dependence of a business on an ecosystem service.

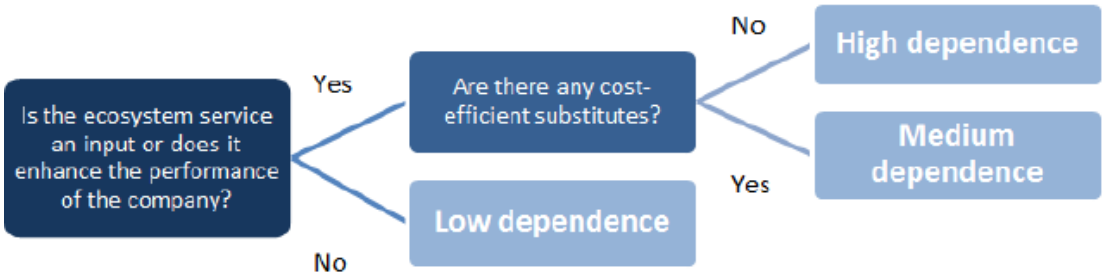

Figure 14: First two questions for evaluating the dependence of business on an ecosystem service. (Source: Adapted from Hanson et al. (2012, p. 15)).

- **Impacts**

In order to identify the degree to which a company impacts an ecosystem service, it is essential to ask whether the company affects the quantity or quality of the service being evaluated. It is important to note that quantity and quality can be affected both positively and negatively by the business. If it is found that the business does not affect the quantity or quality of the ecosystem service, the company has a low impact on the service. If the business does affect the quantity or quality, it had to be determined whether this affects the ability of other actors to benefit from the service. If it does, the business has a high impact on the ecosystem service; if it does not, the business has a medium impact on the ecosystem service (see Figure 15; Hanson et al., 2012).

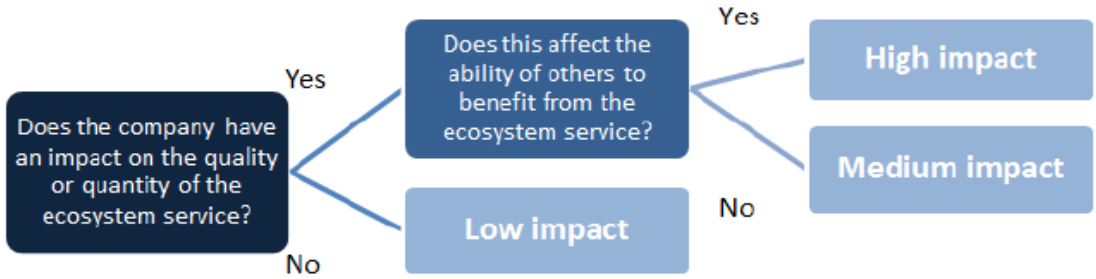

Figure 15: Next two questions for evaluating the impacts of business on an ecosystem service. (Source: Adapted from Hanson et al. (2012, p. 16)).

- **Prioritization**

Once the dependence and impact of a business on ecosystem services has been evaluated, it is possible to identify the respective priority ecosystem services. According to Hanson et al. (2012), priority ecosystem services should be selected based on their relative importance. Ecosystem services with a high level of impact and dependence should have the highest priority, followed by those deemed high in one of the two aspects and medium in the other. Of minor priority are services which ranked high in one of the aspects and low in the other. Ecosystem services on which the company has a low impact as well as dependence should not be prioritized. Table 12 illustrates how to determine the level of priority for an ecosystem service, with the 1st and 5th tiers representing the highest and lowest priority levels, respectively.

Table 12: Level of importance of ecosystem service

Dependence	Impact	Priority Level
High	High	1st tier
High	Medium	2nd tier
Medium	High	2nd tier
High	Low	3rd tier
Low	High	3rd tier
Medium	Medium	4th tier
Medium	Low	5th tier
Low	Medium	5th tier
Low	Low	-

Step 3: Analysing trends in priority ecosystem services

Once the priority ecosystem services have been identified, it is possible to analyse the main trends for each service. Trends in an ecosystem service are reflected through changes in the demand or supply of the quantity or quality of a service throughout time. This can be done by comparing the current and future (quality or quantity of) supply and demand of an ecosystem service. By examining the direct and indirect drivers and actors of change for an ecosystem service, it is possible to identify the company's influence on priority ecosystem service trends. Furthermore, this provides managers with a sufficient amount of relevant information and insights so that they can later identify business risks and opportunities. (Hanson et al., 2012)

Step 4: Identification of business risks and opportunities

Changes in the company's priority ecosystem services result in business risks and opportunities, which influence the operational, regulatory and legal, reputational, market and product, and

financing aspects of the company (see Table 13). By predicting potential risks and opportunities, a company can develop coherent management strategies (Hanson et al., 2012).

Table 13: Types of risks and opportunities (Source: Adapted from MEA (2005)).

Type	Relates to
Operational	Day-to-day activities, expenditures and company processes
Regulatory/legal	Laws, government policies, court actions
Reputational	Brand, image, relationship with general public/stakeholders/customers
Market and product	Product and service offerings, customer preferences, other factors affecting corporate performance
Financing	Cost and availability of capital from investors

Step 5: Strategy development

The final step of an ESR is conducted once the risks and opportunities have been identified for the selected priority ecosystem services. It includes creating and implementing management strategies which aim to maximize the opportunities and minimize the risks associated with trends in priority ecosystem services in the short and long run (Hanson et al., 2012). Figure 16 presents the three categories of strategies proposed by Hanson et al. (2012), which can help businesses when considering potential management strategies, as well as some examples of strategies that fall under each category.

Figure 16: Strategy categories and examples (Source: Adapted from Hanson et al. (2012)).

Annex 2 – An Overview of Salmon Aquaculture in Chile

1. Background

Farmed salmon production has historically taken place in four countries: Norway, Chile, the UK, and Canada, which altogether accounted for 75% of global salmon production in 2012 (Bjørndal & Aarland, 1999; FAO, 2014). Chile is currently the second largest salmon producer and exporter in the world after Norway (FAO, 2014). Salmon production accounts for approximately 90% of the country's total aquaculture output, being Chile's second largest export (Subpesca, 2015; SalmonChile, 2015b). The country specializes primarily in the production of rainbow trout (Oncorhynchus mykiss), coho salmon (Oncorhynchus kisutch), and Atlantic salmon (Salmo salar). Its main export markets are Japan (37%), the United States (20%), Brazil (14%), Russia (6%), the EU (5%), and Latin America (4%) (SalmonChile, 2015b).

Salmon farming locations require the use of marine ecosystems characterized by specific temperatures, non-disturbance, and excellent quality (Barton, 1997; Ibieta et al., 2011). The conditions offered by the fjords landscape of Southern Chile provide the country with almost perfect salmon production locations (Barton, 1997; Barton & Fløysand, 2010). Moreover, the industry is fully privatized, which has fostered the implementation of high level technology and a well-organized business structure (FAO, 2015a). The assimilation of foreign technologies, and development of technological capabilities, as well as the favorable environmental conditions, have been the cornerstones of the industry's success (Ibieta et al., 2011).

Unlike Norway, which began producing industrially in the 1980s, Chile did not shift to industrial production until the 1990s (GSI, 2015). The non-implementation and non-enforcement of adequate biosecurity and environmental measures, for proper sanitation, production, breeding, and other sustainable operational matters, triggered the spread of the ISA-virus. This led to the industry's collapse in 2007 (Little et al., 2015; Buschmann et al., 2009a; FAO, 2015b). Only in 2011 production levels were able to surpass pre-crisis levels. Figure 17 illustrates Chile's global share in production of Atlantic salmon, coho salmon, and rainbow trout from 1980 to 2012. As shown, despite its late development the country has managed to reach production levels almost on a par with those of its counterpart Norway.

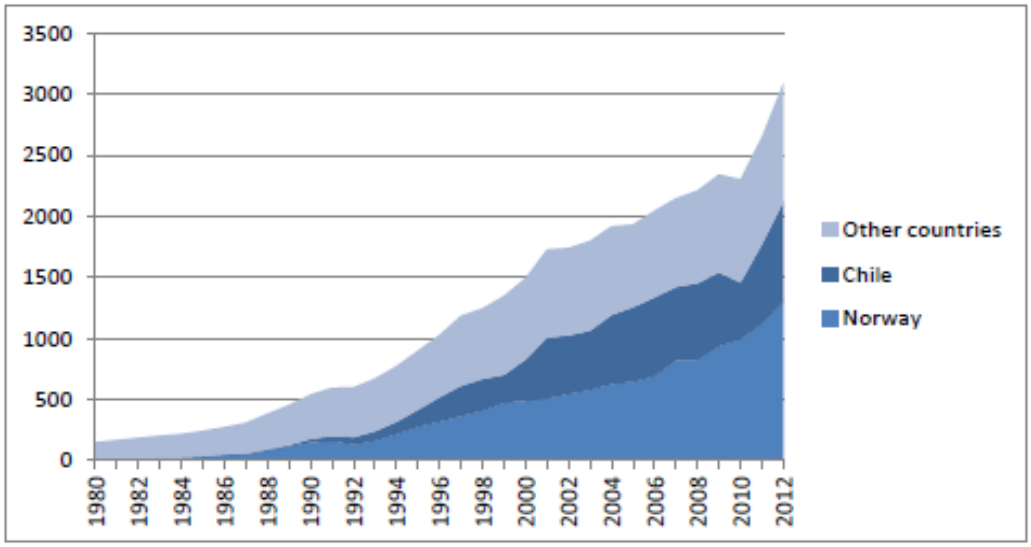

Figure 17: Global production of rainbow trout, coho salmon, and Atlantic salmon (1980-2012, in tons). (Source: FAO database).

NOTE: Main producers selected according to their production level in 2012

2. Administrative Structure in Southern Chile

The geographical scope of the study is Southern Chile; this is where Los Fiordos has its production facilities. In this region two main governmental institutions are in charge for overseeing fisheries and aquacultures, namely Subpesca (the Under-secretariat of Fisheries) and Sernapesca (the National Fisheries Service). Subpesca is responsible for promoting ecosystem sustainability and conservation through the implementation of policies, norms, and administration measures which target aquacultures and fisheries (Subpesca, 2015). Sernapesca is responsible for the enforcement of these norms, policies, and measures (Sernapesca, 2015).

Throughout time, the Chilean salmon farming industry has merged, from 35 companies representing 80% of production in 1997 to only 16 in 2012 (Little et al., 2012). The *Association of Salmon and Trout Producers in Chile A.G.*, known today as SalmonChile, was created by 17 companies in 1986, in an effort to foster collaboration in socio-economic, environmental, and sanitary matters (SalmonChile, 2015b). Today unifying 16 salmon farming companies, SalmonChile constitutes roughly 85% of domestic production (SalmonChile, 2015c.). SalmonChile promotes the certification of farms through the implementation of a number of standards. The latest standard decided upon is GLOBAL G.A.P., which supports the implementation of best practices that address health, safety, environmental, and further multi-criteria issues (Ibieta et al., 2011).

The *Global Salmon Initiative* (GSI) was formed in 2012 as a result of a discussion around on the topic of sustainability by salmon companies from Chile, Norway, and Scotland. Ever since then, the GSI promotes integration, cooperation, and transparency in achieving sustainability. The

main guideline to achieve these objectives is the adoption of the Aquaculture Stewardship Council (ASC) standard. Today 17 companies, representing 70% of the global production volume of salmon, belong to the GSI (GSI, 2015).

Annex 3- Environmental Impacts of Salmon Farming

This section serves to list some of the impacts salmon aquaculture can have on ecosystems. Naylor et al. (2000) refer to aquaculture as a 'mixed blessing', since in some aspects it can compensate for the deterioration of wild fish in the ocean, while at the same time it can potentially damage the oceans and coastal resources. Since the ISA crisis took place, greater emphasis has been put on the environmental impacts which may result from salmon aquaculture practices. These include the spread of diseases, habitat destruction, invasion of exotic species, and acceleration of eutrophication (Buschmann et al., 2009a; Naylor et al., 2000). This section addresses the issues of chemical and antibiotics, waste disposal by salmon farmers and fish meal demand and the impact of trophic structure.

Overview of the Ecosystem around Aquacultures

The interaction of salmon farming practices with the environment is illustrated by Figure 18. As shown, fodder contains nutrients and antifouling paint on the cages contains copper, both of which deposit on the sediment. This reduces the level of oxygen in the sediment and enhances algal growth which in return reduces biodiversity and increases turbidity. Escaped fish may compete with wild species and may further spread pathogens and diseases. This, as well as the attraction of predatory birds and mammals to net pens, affects the overall trophic structure of the ecosystem.

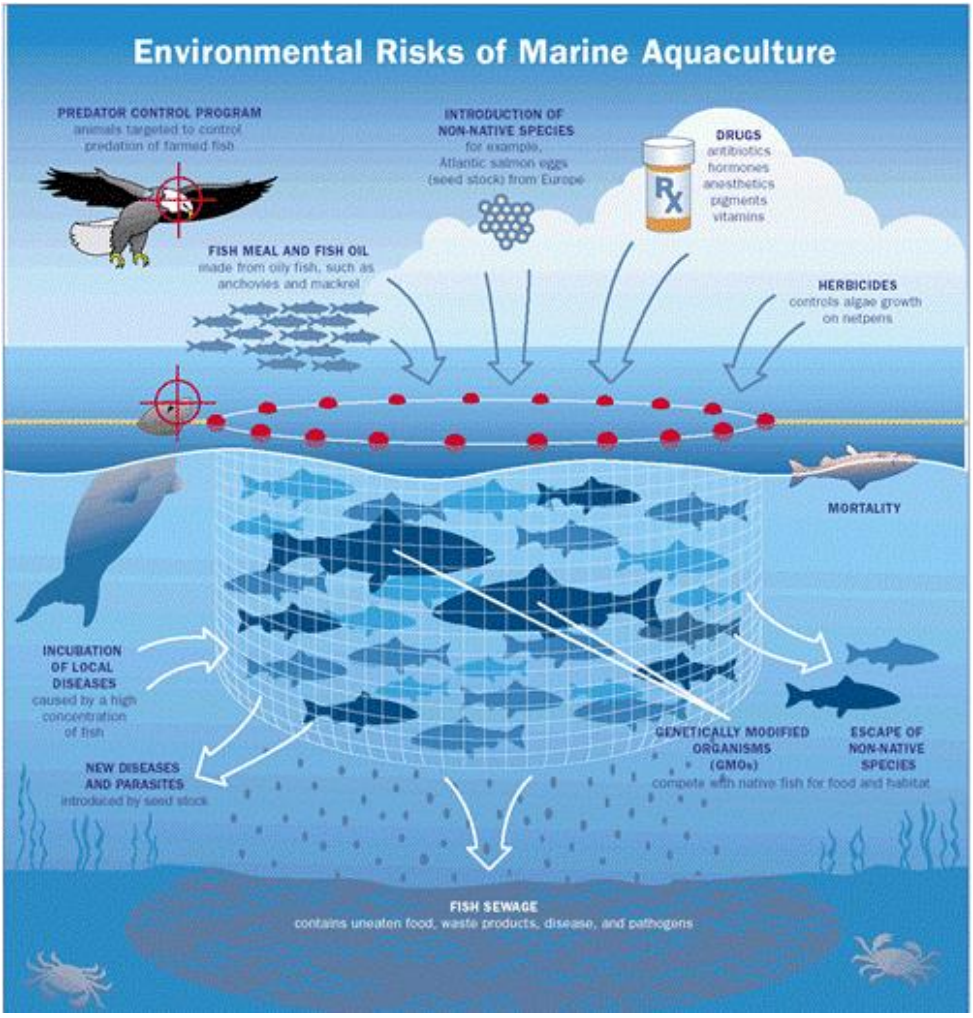

Figure 18: Summary of environmental impacts on the benthic and pelagic systems of aquaculture. (Source: FoAC, 2015).

Chemicals and antibiotics

Intensive production in aquaculture systems increases the occurrence of pathogens within net pens (Buschmann et al., 2009a). A study by Ibieta et al. (2011) illustrates that the number of diseases increased substantially as the production volume of salmon increased prior to the ISA virus outbreak (see Figure 19). Further, a lot of criticism towards the industry resulted from the high use of antimicrobials to treat major diseases. In order to fight the ever growing number of diseases, baths and vaccines are commonly used methods. Hence, the number of authorized vaccines reached 44 different serums by 2011 and is expected to grow further as the number of pathogens grows (Ibieta et al., 2011).

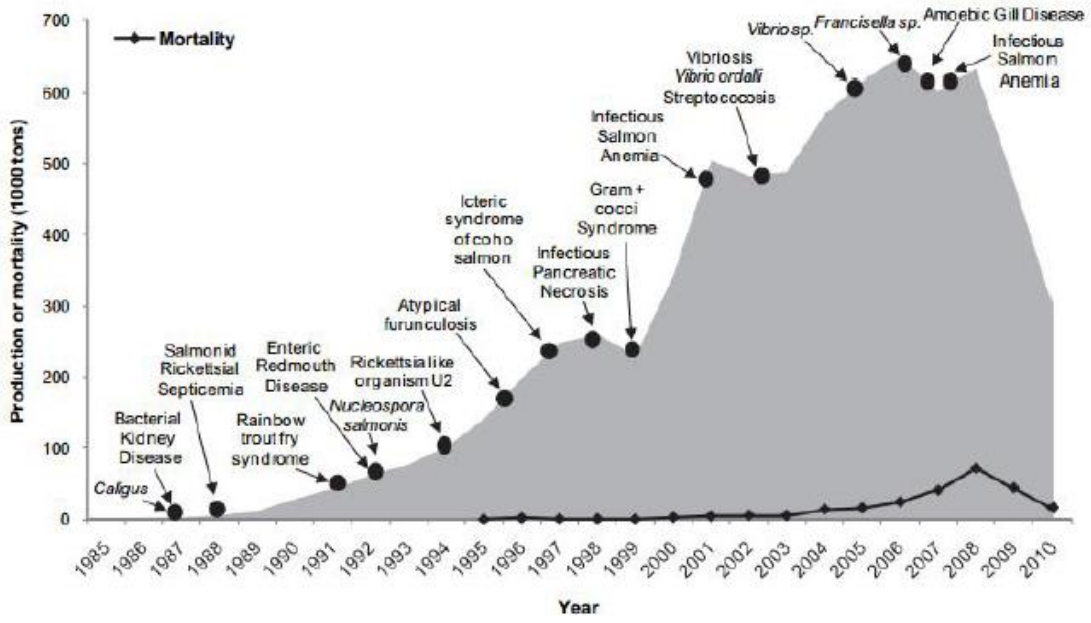

Figure 19 - Timeline of production, disease emergence, and mortality in salmon farming in Chile (period 1985-2010). (Source: Ibieta et al., 2011, p. 227).

However, most antimicrobials are fed to fish orally through the fodder. Since not all of the antimicrobial-fodder gets consumed by the salmon, part of it sinks through the net pans to the sediments in the areas underneath. Once the antimicrobials deposit they can remain there for months. Empirical evidence has shown that antimicrobial-resistant bacteria are found in the proximity of net pens as well (Cabello et al., 2013). Hence, the use of antimicrobials in aquaculture increases the frequency of resistant bacteria. Additionally, even though a direct linkage between antimicrobials and human health has not been found, antimicrobial-resistant bacteria in waters near aquaculture concessions can potentially be consumed by humans (Cabello et al., 2013).

When a pathogen found in a native species attacks a non-native species, the lack of resistance of the latter could cause it to be severely prone to a disease outbreak. This was the case for the sea lice (*Caligus rogercresseyi*) spread on salmonids in Chile. The pathogen's habitat lies in the Chilean marine ecosystems and salmon, a non-native species in Chile, has a low resistance to it. Additionally, sea lice are known to carry the ISA virus passively on their skin, infecting the salmon by nesting inside their protective skin (WOfAH, 2015). In 2004, the sea lice count per salmon ranged between 3 and 10, whereas in 2007, the year where the ISA virus outbreak took place, the count had increased to between 29 and 34 sea lice per salmon (Ibieta et al., 2011). It is likely that the use of chemicals to treat the salmon has generated drug-resistance by sea lice to certain chemicals, accelerating the spread of the ISA virus during the outbreak (Outeiro & Villasantes, 2013). Moreover, the chemicals used to fight the disease are known to affect other species like crustaceans (Outeiro & Villasantes, 2013).

Waste disposal

Salmon farming aquacultures lead to the accumulation of organic and inorganic materials, such as waste fodder, faeces, and metabolic by-products. This can cause eutrophication of pelagic systems and benthic environments (Bannister et al., 2014). Enrichment of the benthic environment by effluents such as nitrogen, phosphorous, and carbon, changes the physio-chemical and microflora biodiversity of benthic sediments. The nutrient load, the increased level of turbidity from feed and waste particles, and the release of metals such as copper from antifouling paints, further exhilarates algal growth and leads to a higher oxygen demand by sediments. The resulting eutrophication and hypoxia can in return result in biodiversity loss and water quality degradation (Buschmann et al., 2009a; Bannister et al., 2014).

The effects of organic and inorganic waste on farms located on shallow embayments are well-known, whereas literature on the effects on deep water locations is rather scarce (Bannister et al., 2014). Even though most of the literature on organic waste emissions focuses on the deposition on sediments below and near net pens, recent studies have shown that organic waste can travel longer distances depending on floc[16] size, settling velocity, and density (Law et al., 2014). Flocs which reach inlets or bays can degrade ecosystems through the transportation of contaminants from distant salmon farms.

Fish meal

As salmon farming demands a high amount of fish meal and fish oil for feeds, it exerts pressure on capture fisheries as well. According to FAO (2014), fish feed constitutes a significant but diminishing proportion of production by world fisheries. For most aquaculture species, the level of output is lower than the level of input. This is certainly the case for farmed salmon, which uses on average 3.16 kilos of input per kilo of output produced, and trout, which uses on average 2.46 kilos of input per kilo of output (Naylor et al., 2000). The rest of the fodder is usually being obtained through agricultural production. Naylor et al. (2000) examine, whether marine and freshwater aquacultures enhance or diminish the availability of wild fish. They find that aquacultures can compensate for the deterioration of wild populations in the ocean for some practices, while the same argument is unfounded for others. This implies that, although aquaculture can act as a substitute for the depleting wild fish stocks, it can also enhance depletion if unsustainable practices are part of daily operations.

Trophic structure

There are three major impacts aquacultures may have on the trophic structure of an ecosystem. Firstly, high fish densities in net pens often attract carnivorous birds and mammals which otherwise wouldn't hunt in these ecosystems. Secondly, the enhanced eutrophication disrupts the trophic structure of the surrounding environment. Finally, the structure can additionally be

[16] According to Law et al. (2014), "flocculation is the aggregation of smaller particles into larger, faster settling agglomerations known as 'flocs'" (p. 30)

altered by fish escaping from fish farms and competing with the wild species for territory and food (Buschmann et al., 2009a).

Annex 4 – Survey

This annex includes an example of the survey that was conducted with five managers of Los Fiordos.

BUSINESS SURVEY

INTRODUCTION

Thank you for your time. This survey is part of a project in which I am participating as part of my postgraduate study at the VU University Amsterdam. The project is commissioned by WWF-Chile in collaboration with Los Fiordos.

In the project we are using the **ecosystem services review (ESR)** framework**,** a model developed in the US by the World Resources Institute, to identify the dependencies and impacts that salmon aquaculture has on ecosystem services, and also the risks and opportunities that these may result in. This will allow for the development of new sustainable business strategies.

The aquaculture sites of Los Fiordos that have been chosen for this project are Melinka, one of the priority high value conservation areas (HVCA) in the Chiloense eco-region, and Puerto Cisnes, where twelve centers are currently postulating for the ASC standard certification.

Within Part 1 of this survey, we will ask you questions regarding your personal background and your position within the company. In Part 2 we will ask you a number of questions regarding your views on the subjects of ecosystem services and sustainability. In Part 3 we have a few questions regarding other stakeholders.

All answers in this survey will be confidential and anonymous.

If you have any questions during the interview, please do not hesitate to ask. At the end of the interview you will be given the opportunity to make comments.

PART I: GENERAL INFORMATION

A. PERSONAL DETAILS

1. **Name:**
2. **Age:**
3. **Nationality:**
4. **Gender:**
5. **Do you come from one of the regions where the company operates?**

Yes ○

No ○

Please, specify where you come from: _____

6. **What is your educational background?**

High school ○

Technician ○

University education ○

Postgraduate studies ○

Other ○ Specify: _____

_____

Relevant field(s):

_____

_____

7. **Was environmental science part of your education (for example biology, ecology, environmental management, etc.)?**

Yes ○

No ○

If your answer is yes, please specify: _____

B. EMPLOYMENT DETAILS

8. **What company do you work for?** Los Fiordos Ltda.
9. **What is your position within the company?**

_____

10. **What department do you work for within the company?**

_____

_____

11. **Approximately how many people work within your department?**

_____

12. **What are your main responsibilities within the company?**

_____

_____

_____

_____

_____

13. **How many years have you been working for the company?**

_____

14. **State the four departments within Los Fiordos with which your department has the highest level of interaction. State the departments in order of level of interaction (1 for highest, 4 for lowest).**

    Department

    1. _____
    2. _____
    3. _____
    4. _____

PART II: ECOSYSTEM SERVICES AND SUSTAINABILITY

A. ECOSYSTEM SERVICES

An **ecosystem** is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment, which interact with each other.

15. Which of the following ecosystems surround or are part of Melinka and Puerto Cisnes:

	Yes	I do not know
Cold water coral	○	○
Kelp beds	○	○
Beaches	○	○
Fresh water basins	○	○
Underwater canyons	○	○
Fjords	○	○
Soft substrate beaches	○	○
Hydrothermal vents	○	○

Other:

Other:

16. How important do you consider the following threats to ecosystems in the region?

	1. Not important	2. Less important	3. Neutral	4. Important	5. Very important	I do not know
Agricultural practices	○	○	○	○	○	○
Aquaculture practices	○	○	○	○	○	○
Tourism industry practices	○	○	○	○	○	○
Urban waste	○	○	○	○	○	○
Climate change	○	○	○	○	○	○
Invasive species	○	○	○	○	○	○
Overfishing	○	○	○	○	○	○
Eutrophication	○	○	○	○	○	○
Deforestation	○	○	○	○	○	○
Trophic cascade alteration	○	○	○	○	○	○
Biodiversity reduction	○	○	○	○	○	○
Benthic sediment alteration	○	○	○	○	○	○

Other:

Other:

Ecosystem services are the services that ecosystems provide humans with. They can be *material*, such as the food we eat, the water we drink, or wood for fire. They can be *non-material*, such as the spiritual, religious, or educational value that humans derive from nature. Ecosystems can also provide us with *regulatory* services, such as flood protection and carbon sequestration by forests, or water filtering by corals and mangroves.

17. To what extent do you consider that the following ecosystem services are important for Los Fiordos' operations?

	1. Not important	2. Less important	3. Neutral	4. Important	5. Very important	I do not know
Provisioning services						
Crops	○	○	○	○	○	○
Wild fish products	○	○	○	○	○	○
Freshwater	○	○	○	○	○	○
Regulating services						
Climate regulation	○	○	○	○	○	○
Water purification and waste treatment	○	○	○	○	○	○
Animal pest mitigation	○	○	○	○	○	○
Cultural services						
Recreation and ecotourism	○	○	○	○	○	○
Natural medicine, biochemicals and pharmaceuticals	○	○	○	○	○	○
Education and inspirational values	○	○	○	○	○	○
Supporting services						
Habitat (spaces where species live and which protect an ecosystem's capacity to recover)	○	○	○	○	○	○

Other:

Other:

18. To what extent do you agree with the following statements?

	1. Highly disagree	2. Disagree	3. Neutral	4. Agree	5. Highly agree	I do not know
Healthy ecosystems in the region are important for the profitability of the company	○	○	○	○	○	○
The sustainable use of ecosystems create new business opportunities for the company	○	○	○	○	○	○

The end costumer demands that we are sustainable	○	○	○	○	○	○
The image of the company is determined by its impact on the ecosystems	○	○	○	○	○	○
The international community demands that we operate sustainably	○	○	○	○	○	○
Shareholders demand that we operate sustainably	○	○	○	○	○	○

19. Which of the following problems poses a risk to Los Fiordos' operations?

	1. No riskt at all	2,. Low risk	3. Some risk	4. Moderate risk	5. High risk	I do not know
Predators that feed in our produce	○	○	○	○	○	○
Negative changes to biodiversity	○	○	○	○	○	○
Climate change	○	○	○	○	○	○
Sea water pollution	○	○	○	○	○	○
Algal growth	○	○	○	○	○	○
Anoxia	○	○	○	○	○	○
Overfishing	○	○	○	○	○	○
Pests	○	○	○	○	○	○
Drastic weather events	○	○	○	○	○	○
Coral reef degradation	○	○	○	○	○	○
Other:						
Other:						

20. To what extent do you agree with the following statements?

Salmon aquaculture has a negative impact on ecosystems through…	1. Highly disagree	2. Disagree	3. Neutral	4. Agree	5. Highly agree	I do not know
Alteration of the cultural/spiritual landscape	○	○	○	○	○	○
Changes in benthic sediment condition	○	○	○	○	○	○
Organic waste release	○	○	○	○	○	○
Use of antibiotics and chemicals to fight pests	○	○	○	○	○	○
Inorganic waste emissions	○	○	○	○	○	○
Spreading of diseases to native species	○	○	○	○	○	○
Anoxic conditions under net pens	○	○	○	○	○	○
Release of antifouling paint contaminants on the water	○	○	○	○	○	○
Use of copper cages	○	○	○	○	○	○
Components used in fishmeal	○	○	○	○	○	○
Biodiversity reduction	○	○	○	○	○	○
Other:						
Other:						

21. Does Los Fiordos raise awareness among their employees on the potential impacts of salmon aquaculture on the environment?

Yes ○

No ○

If your answer is yes, please give examples:

22. Do the following groups negatively affect the ability of Los Fiordos to make use of ecosystem services?

	1. Highly disagree	2. Disagree	3. Neutral	4. Agree	5. Highly agree	I do not know
Other salmon aquaculture companies	○	○	○	○	○	○
Miticulture industry	○	○	○	○	○	○
Tourism industry	○	○	○	○	○	○
Fisheries	○	○	○	○	○	○
Indigenous communities	○	○	○	○	○	○
Local residents	○	○	○	○	○	○
Other:						

B. SUSTAINABILITY

In the business world, **sustainability** is defined as the capacity of a business to maintain long-term social, cultural, ecological and economic well-being.

23. Does your company participate in any project to enhance the sustainability of the company (for example its operations, image, community relations, etc.)?

Yes ○

No ○

I do not know ○

If yes, what are these projects where your company participates?

24. Do you think your company is relatively more sustainable than other Chilean salmon aquaculture?

Yes ○

No ○

I do not know ○

a. If your answer is yes, what practices make the company relatively more sustainable?

Lower antibiotic use ○

Lower net pen densities ○

More stringent monitoring of inorganic and organic waste deposition ○

Less organic waste generation ○

Less inorganic waste generation ○

Lower number of escapes ○

Lower use of antifouling chemicals ○

Proper disposal of net pens ○

Cleaning of nets outside of the water ○

Land-based pisciculture ○

Use of certified animal products for fishmeal ○

Use of certified crop products for fishmeal ○

No use of transgenic products for fishmeal ○

Substantial use of renewable energy (i.e. solar energy) ○

Use of multi-trophic aquaculture ○

More concessions with distance dictated by law separating them ○

Net pens located at places with lower depth ○

Other:

Other:

25. Does Los Fiordos raise awareness among their employees on sustainable practices?

Yes ○

No ○

If your answer is yes, please give examples:

26. What is the level of importance of the following factors for the successful performance of your department?

	1. Very low	2. Low	3. Medium	4. High	5. Very high	Not applicable
Global salmon prices	○	○	○	○	○	○
Global prices of substitutes of salmon	○	○	○	○	○	○
Salmon prices in competing markets	○	○	○	○	○	○
Healthy ecosystems	○	○	○	○	○	○
Environmental certification	○	○	○	○	○	○
Local image	○	○	○	○	○	○
International image	○	○	○	○	○	○
The international image of the Chilean salmon industry	○	○	○	○	○	○
Price of fish for fishmeal	○	○	○	○	○	○
Price of other fishmeal components	○	○	○	○	○	○
Accessibility to licenses	○	○	○	○	○	○
Compliance with local regulations	○	○	○	○	○	○
Compliance with international regulations	○	○	○	○	○	○

Other:

Other:

Other:

27. Do you think sustainable practices can improve the company's performance?

Yes ○

No ○

a. If your answer is yes, select the 4 most important reasons?

Sustainable practices go hand in hand with the company's short-term productivity ○

Sustainable practices are important for the long-term productivity of the company ○

Sustainable practices reduce the company's vulnerability to extreme environmental events ○

Sustainable practices enhance the company's efficiency ○

Sustainable practices enhance the company's local image ○

Sustainable practices can allow us to increase our share in the regional markets we operate ○

Sustainable practices can offer us entry into new regional markets ○

Sustainable practices diminish the probability or legal disputes ○

Sustainable practices can provide us with better access to loans ○

Sustainable practices enhance our stakeholder involvement ○

Sustainable practices increase shareholder value ○

Other:

Other:

b. If your answer is no, select the three main reasons?

The company does not have a negative effect on ecosystems	○
We do not depend highly on ecosystems for our productivity	○
Sustainable practices are not cost-effective	○
Other salmon aquaculture companies also have a negative impact on ecosystems	○
Other local groups and industries also have a negative impact on ecosystems	○
Shareholders do not care for sustainable practices or the mother company does not care for sustainable practices	○
The use of sustainable practices will not make the company more competitive	○
The market for sustainable products is not appealing enough	○
Other:	
Other:	

28. How important are the following factors to make your business more sustainable?

	1. Not important	2. Slightly important	3. Important	4. Very important	I do not know
Financial ability to invest in sustainable practices	○	○	○	○	○
Cost-efficiency of implemented sustainable measures	○	○	○	○	○
Required by mother organization/ head quarters	○	○	○	○	○
Required by shareholders	○	○	○	○	○
Customers' demand and price premium for sustainable products	○	○	○	○	○
Availability of credible certification schemes	○	○	○	○	○
Governmental regulation and legislation	○	○	○	○	○
International pressure	○	○	○	○	○
Local pressure	○	○	○	○	○
Other:	○	○	○	○	○

PART III: OTHER STAKEHOLDERS

29. How would you define your department's relationship with the following groups?

	1. Very bad	2. Bad	3. Neutral	4. Good	5. Very good	Not applicable
Local fishermen	○	○	○	○	○	○
Local governments	○	○	○	○	○	○
Local mollusk aquaculture	○	○	○	○	○	○
Local residents	○	○	○	○	○	○
Local tourism industry	○	○	○	○	○	○
Local and international tourists	○	○	○	○	○	○
Local and foreign researchers and scientists	○	○	○	○	○	○
Local and international NGOs	○	○	○	○	○	○
Native communities	○	○	○	○	○	○
Other:						

30. How important is the participation of the following groups within the decision making process of your department?

	1. Very low	2. Low	3. Medium	4. High	5. Very high	Not applicable
Local fishermen	○	○	○	○	○	○
Local governments	○	○	○	○	○	○
Local miticulture	○	○	○	○	○	○
Local residents	○	○	○	○	○	○
Local tourism industry	○	○	○	○	○	○
Local and international tourists	○	○	○	○	○	○
Local and foreign researchers and scientists	○	○	○	○	○	○
Local and international NGOs	○	○	○	○	○	○
Native communities	○	○	○	○	○	○
Other:						

Thank you for your time!

Comments:

Annex 5 – Long-list of risk and opportunities

Table 14 and Table 15 present, respectively, the long list of risks and opportunities that was prepared as input for the workshop with Los Fiordos. These risks and opportunities were discussed with the company representatives that participated in the workshop, and formed the basis for the further selection and prioritization done by the company during the workshop.

Table 14: Step 4 - Preliminary list of potential risks

Type	Risks
Operational	Reduced productivity due to low water quality and low ecosystem health (aquaculture activities, tourism and population growth)
	Uncertainty about abrupt changes in natural systems resulting in anoxia or disease outbreak (disruption to business operations)
	Reduced productivity due to habitat destruction caused by illegal unsustainable fishing, over fishing and climate change
	High cleanup costs or low productivity due to waste by other actors (industrial and urban)
	High operational (fishmeal) costs due to depletion of fish stocks
	High opportunity costs for sustainable substitutes for fishmeal ((certified) soy bean)
	Spatial conflict for concessions due to scarcity of (productive) locations and use of locations by other stakeholders
	Loss of social license to operate due to lack of interaction with stakeholders
	Not being able to obtain ASC because of mismatch between ASC requirements for fishmeal components and current fishmeal production
Legal and Regulatory	Complying with current legal and regulatory measures do not steer towards sustainable operations (lack of technical and scientific basis in policy making)
	Higher costs or counterproductive measures caused by mismatch between legislation and ASC requirements
	Zoning that may prioritize tourism or artisanal fisheries as economic activities
	Legal moratorium to restore ecosystem balance
	Permit or license suspension to reduce pressure on ecosystems
	Higher license fees to invest in ecosystem health
Reputational	Reputation of environment degrading business (can cause loss of competitive advantage by negative perception by customers, such as retailers and consumers)
	Perception of unhealthy salmon products can cause decrease of sales

Type	Risks
	Negative perception by local stakeholders of salmon aquaculture (impact on the environment, artisanal fisheries and cetaceans) causes bad reputation and makes cooperation difficult
	Bad image of salmon aquaculture industry due to perceived impact on local landscape
Market and product	Loss of market share due to final consumers' demand for certified aquaculture products
	Loss of market share because of perceived health issues due to disease outbreak or antibiotics
	Increased competition, causing lower prices for non ASC certified products
Financial	Increased scrutiny by shareholders and clients of financial institutions of whether money is invested in sustainable companies
	Higher insurance fees, because institutions incorporate ecosystem degradation into risk profile

Table 15 Step 4 – Preliminary list of potential opportunities

Type	Opportunities
Operational	More efficient operations due to certification greening operational standards
	Increase productivity or increase efficiency by engaging with scientific community (best practices, technological innovations, etc.)
	Reduce uncertainty about abrupt environmental changes by engaging with scientific community (understanding ecosystem health in relation to operations)
	Higher productivity caused by innovations (such as multi-tropic aquaculture) resulting in healthier ecosystems,
	Engage with tourism sector to promote green growth of tourism to prevent degradation of the ecosystem
	Additional income by fee system for collecting the waste of others from the beaches
	Additional income through consulting services on ASC or other sustainable practices (e.g. land based pisciculture, efficient water and energy use) to other (salmon) companies
	Promote in the industry use of certified soy and fish for fishmeal to increase demand and reduce costs
	Reuse or sell collected waste
Legal and Regulatory	Promote creation of Marine Protected Areas for healthy ecosystems
	Shape zoning plans by participating proactively on zoning discussions
	Promote support for alignment of zoning with geographical location of ecosystem services
	Use frontrunner position to influence regulations to adapt to new sustainable products or operational methods
	Promote participatory approach for policy making, involving other stakeholders and scientific and technical community
	Become sparring partner to policy makers to shape policy

Type	Opportunities
	Coordinate with community and government to install sewage plant in Melinka
	Advocate for more stringent waste regulations
Reputational	Frontrunner position creates possibilities for brand differentiation by marketing and PR campaign of the sustainable practices
	Engage with scientific community by facilitating/participating in research to improve scientific reputation
	Improve reputation by organizing coast & beach cleaning days together with local stakeholders (fishermen, residents, tourist sector)
	Increasing community outreach and buy in for behavior changes (e.g. capacity building on sustainable fishing)
	Increase other salmon aquaculture companies' buy in for behavior changes to improve industry standards and reputation
	Learning from local stakeholders and creating support for the company by engaging with local community for exchange of knowledge and ideas (e.g. indigenous community and fisheries syndicate)
	Improve stakeholder relations through supporting the creation of marine protected areas that: protect/regenerate fish stocks, help keeping water quality, biodiversity and production functions of ecosystem, protect/enhance tourism and cultural value
Market and product	Increase market share with certified products in existing markets
	Increase sales with certification accessing new markets (geographic or type of products)
	Create new revenue streams, from e.g. ecotourism or sustainable aquaculture consultancy
	Increase market share by partnership with retailer or company (airline, cruise, hotel chain, etc.) that wants to green their purchases by selling ASC salmon products
	Either increase product price or ensuring stability in sales price through sustainable products

Type	Opportunities
Financial	Access to external financing for innovative research and projects by being a frontrunner of sustainable practices
	Ensure manageable insurance fee due to active risk management on degrading ecosystems
	Being seen as an example on CSR within the group of companies could influence investment decisions
	From shareholder value to stakeholder value