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Fit for purpose? Evaluating climate change adaptation laws and policies for marine aquaculture in Chile

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This research article describes Chile's climate change adaptation policies and plans for marine aquaculture in Chile, with a focus on the nationally important salmon farming industry, and assesses whether they have adequately addressed legal barriers to adaptation and the need for legal transformation. The article first outlines Chile's climate change law, policies, and institutional framework, as reflected in the 2022 Framework Act on Climate Change, the 2020 updated Nationally Determined Contribution, the 2022 Strengthening of the Nationally Determined Contribution, and the 2022 Long-Term Climate Strategy. The article highlights the special attention given to the ocean-climate nexus in both international and national policy agendas. It then summarizes and assesses the adaptation policies and plans for the aquaculture sector. Three main shortcomings are identified: the lack of implementation of committed activities, the lack of a strategic vision for the role of aquaculture in a changing climate and oceans, and the lack of attention to the limits of adaptation resulting from existing regulatory frameworks. The article then strengthens this assessment with a legal analysis of the adaptive capacity of aquaculture planning and leasing frameworks. This assessment concludes that mainstreaming climate change into existing planning instruments is an ineffective adaptation measure due to the fragmented, rigid, and inefficient legal framework for the planning of aquaculture and other uses of the coastal zone. In turn, the leasing system is too rigid to allow for effective adaptation. Various mechanisms to introduce flexibility are suggested. The article concludes by highlighting an unprecedented window of opportunity to advance strategic, coherent, long-term, and transformative adaptation, resulting from concurrent initiatives to reform or update aquaculture law, policy, and adaptation planning and the principled approach to climate action embedded in the Framework Act on Climate Change.

KEYWORDS

climate adaptation, law and policy, Chile, aquaculture, barriers to adaptation

1 Introduction

Climate change, on its own and in combination with pollution and biodiversity loss, is changing ecosystems, economies, and communities. The impacts of climate change are widespread and profound, affecting everything from the very existence of States to the way we produce goods and services, including how we produce food for a growing population. The need to adapt to climate change has been recognized as a necessary complement to mitigation efforts (IPCC, 2007: 14; Verschuuren, 2022) and is increasingly being incorporated into international and national law and policy frameworks (McDonald, 2011; Yazykova and Bruch, 2018; McDonald and McCormack, 2021; Verschuuren, 2022). Adaptation policies to date have prioritized immediate and near-term risk reduction and emphasized incremental adjustments to business-as-usual activities (McDonald and McCormack, 2021; Noble et al., 2014, p. 839; see also: IPCC, 2022: 20; UNEP, 2022). However, there is growing evidence that, in some cases, "there are limits to the effectiveness of incremental approaches" (Noble et al., 2014: 836). A shift from incremental to transformational adaptation, i.e. adaptation that changes the fundamental attributes of a socio-ecological system in anticipation of climate change and its impacts, seems increasingly necessary (IPCC, 2018, 2022: 26; UNFCCC, 2022a, b; Verschuuren, 2022).

Legal systems play an important role in adaptation responses to climate change, as laws and regulations can both facilitate and constrain adaptation (New et al., 2022: 2581; Soininen et al., 2021; McDonald and McCormack, 2021; Wenta et al., 2019). Thus, the need to analyze, and in some cases reform, legal and regulatory frameworks is central to the design and implementation of adaptation, including transformational adaptation (Garmestani et al., 2019; New et al., 2022: 2584). However, the role of legal systems is often overlooked or considered only in general terms (Soininen et al., 2021; Garmestani et al., 2019; McDonald and McCormack, 2021). Early assessments of adaptation legislation reveal a superficial focus on removing legal barriers to adaptation and mainstreaming climate change considerations into existing legal instruments (McDonald and McCormack, 2021; McDonald, 2011).

This article addresses the adaptation law and policy for marine aquaculture in Chile, with a focus on salmon mariculture. In particular, it assesses the adaptive and transformative capacity (Garmestani et al., 2019) of existing aquaculture legal frameworks and whether these capacities have been addressed in adaptation plans. Four reasons explain the focus of the article. First, aquaculture stands out as a key component of a "more productive, efficient, resilient, climate-smart and socially and environmentally responsible agri-food systems" (FAO, 2021a) contributing to food security and nutrition (HLPE, 2014) while also contributing to livelihood diversification (IPCC, 2022), marine environmental conservation and resilience (Le Gouvello et al., 2022), and climate change mitigation (Gephart et al., 2021; Jones et al., 2022). Second, the production of seafood, and particularly salmon, is a very important component of Chile's export-oriented economy. The aquaculture industry is heavily concentrated in the three southern regions of the country (Regions X to XII), which offer few alternative economic opportunities. As such, the industry contributes significantly to the Chilean economy in general (Banco Central de Chile, 2022) and to rural economic growth, employment, and poverty reduction in particular (Ceballos et al., 2018). Third, aquaculture's dependence on the marine environment makes it particularly vulnerable to climate change, making adaptation an imperative. Finally, Chile has been an international leader in advancing the climate-ocean nexus in climate negotiations and has similarly adopted progressive climate change mitigation and adaptation laws and policies that emphasize ocean protection. It is therefore important to assess whether domestic sectoral policies reflect the same leadership, vision, and ambition.

The rest of the article is structured as follows. Section 2 provides a brief description of the Chilean aquaculture industry and its vulnerability to climate change, with a focus on salmon farming. Section 3 provides a general but necessary background on Chile's climate change legislation, policies, and institutional framework, and in particular the consideration of oceans within this framework. Section 4 describes and critically assesses the sectoral adaptation plans and commitments with particular attention to measures related to the legal and regulatory framework. Section 5 expands on the critical assessment with an in-depth legal analysis of the adaptive capacity of the aquaculture planning and leasing framework, in response to one key adaptation response included in these plans (namely the integration of climate change considerations into spatial planning instruments). Section 6 concludes with a summary of key findings and recommendations.

2 The Chilean salmon mariculture industry and its vulnerability to climate change

Commercial salmon farming has been one of the drivers of the Chilean economic "miracle" (Barton and Fløysand, 2010: 742). The industry was established in Chile only in the late 1970s. By 1985, 36 farms were producing 1,200 tons of salmonids. Production increased significantly during the 1980s and 1990s, favored by ideal oceanographic conditions in the southern regions of the country, counter-seasonal advantages compared to other producers in the Northern Hemisphere, supportive macroeconomic policies, strong government support, and few environmental regulations (Barton and Fløysand, 2010; Fuentes and Engler, 2016). As early as 1992, Chile was the second largest producer of salmonids in the world and its production has continued to grow. Currently, there are approx. 1350 salmon farms in the internal waters of the southern fjords in Regions X, XI, and XII. Approximately 500 are in operation each year, producing close to 1 million tons of salmonids (SUBPESCA, 2021), most of which are exported (Banco Central de Chile, 2022).

The outstanding growth of the salmon farming industry has not come without challenges. Despite championing the industry as a success story, it was clear that the underregulated industry was having an impact on the environment and the communities in which it operated. Progressively stricter requirements have been

introduced since the early 2000s. However, it was the massive and costly outbreak of infectious salmon anemia (ISA) in 2007 that triggered a significant overhaul of the regulatory framework for the industry (Fuentes and Engler, 2016). Elements of this regulatory framework are addressed in section 5; suffice it to say here that, since 2010, the government has stopped accepting applications for aquaculture leases in the three salmon-producing regions of the country. Thus, the current regulatory framework focuses on reorganizing the industry for sustainability, including relocation and merging of farms, managing salmon farm clusters (groups of farms in a specified area – the barrio or neighborhood – subject to some coordinated management measures), and controlling production at the farm and cluster level through various regulatory mechanisms (Fuentes and Engler, 2016; Engler, 2023).

Aquaculture production is highly dependent on the quality of the surrounding open marine environment. This represents a significant operational challenge for the industry, not least because of the changing marine conditions due to climate change. The risk of climate change to the aquaculture industry was recently assessed as part of the broader government project "Atlas de Riesgo Climático" (ARClim) (Climate Risk Atlas), partially funded by the German Gesellshaft für Internationale Zussammenarbeit (GIZ). The project mapped climate change exposure, sensitivity and adaptive capacity (relative climate risk) based on technical reports prepared by independent experts. The main drivers of climate change, particularly in Regions X and XI, are consistent with an observed trend of marked drying and weak warming (Soto et al., 2019: 360). Draught and warmer weather are expected to impact aquaculture production through different pathways. In the case of salmon mariculture, draught and warming weather are projected to trigger more frequent, intense, and extensive harmful algal blooms (HABs) events and increased prevalence of parasites and other pathogens, both resulting in biomass and productivity loss (Soto et al., 2019). These climate trends may also overlap with natural variability, increasing the risk of episodic acute events. For example, in 2016 the El Niño event combined with climate change to produce an intense drought that resulted in the worst HAB event on record and extensive losses to the aquaculture industry (Buschmann et al., 2016; León-Muñoz et al, 2018).

3 The Chilean climate change response and oceans: policy foresight and leadership

Chile's geographical and oceanographic features make it particularly vulnerable to climate change (*United Nations Framework Convention on Climate Change*, art 4(2)(8); Gobierno de Chile, 2021: 20). Consequently, the country has prioritized the development of a comprehensive institutional and policy framework for climate change mitigation and adaptation. While this framework has developed and evolved over the last three decades, it has recently been formalized and strengthened in the Chilean *Framework Act on Climate Change* (Act No. 21,455, hereinafter the Framework Act) published in the official gazette on 13 June 2022. The Framework Act, together with the long-term climate strategy (Gobierno de Chile, 2021, hereinafter LTS) and the nationally determined contribution (Gobierno de Chile, 2020, hereinafter NDC; Gobierno de Chile, 2022) prepared in fulfillment of the obligations and commitments under the *Paris Agreement* (UNFCCC, art 4), establishes the architecture and objectives for climate change mitigation and adaptation. Importantly, this framework recognizes the intrinsic linkages between climate change mitigation and adaptation, sustainable development, and poverty eradication (e.g. Framework Act, art. 46(1); Gobierno de Chile, 2020, Section 3, Gobierno de Chile, 2021: 43-50). Chile recently endorsed the concept of just socio-ecological transition as a principle guiding its transformation towards a resilient and equitable society in the face of climate, ecological and social challenges (Gobierno de Chile, 2022).

The objective of the Framework Act is to guide the transition towards low greenhouse gas emissions to achieve carbon neutrality by 2050 and to adapt to climate change by reducing vulnerability and increasing resilience. To this end, the Act outlines the principles guiding climate change action: independent scientific knowledge, cost-effectiveness, ecosystem approach, equity and climate justice, progression, non-regression, participation, transparency, prevention, precaution, transversality, territoriality, coherence, flexibility (reflexivity) and climate urgency. It further defines the policy and institutional framework for responding to climate change and the legal instruments to plan and implement mitigation and adaptation measures. Recognizing that climate action must be cross-sectoral, multi-scale, and polycentric ["all hands on deck" (United Nations, 2021)] the Framework Act codifies an institutional and policy structure that promotes vertically and horizontally coordinated responses to climate change. At the policy level, in addition to the national policy instruments, the Act requires the adoption of sectoral mitigation and adaptation plans (for priority sectors) and regional (i.e. territorially decentralized) plans. At the institutional level, the Act designates the Ministry of the Environment and Climate Change as the lead agency for the design, implementation and coordination of climate change responses (Framework Act, art 16), but considers both a high-level policy coordination body (the Ministerial Council for Sustainability and Climate Change) and a technical inter-ministerial coordination group, as well as regional committees (Framework Act, Chapter IV). The Act also recognizes formal spaces for the participation of private actors (e.g. Scientific Advisory Council, national and regional consultative councils, and climate change round tables [Framework Act, arts. 19, 20, 26)] and promotes enhanced public participation (Moraga Sariego, 2022). Indeed, the process through which the government drafted the Framework Act and the national policy instruments (LTS and NDC) already reflected these principles by following what the government described as broad and unprecedented public participation (Gobierno de Chile, 2020: 11) (but see Madariaga Gómez de Cuenca, 2021 for a critical perspective).

Chile's vulnerability to climate change is driven, to a significant extent, by its maritime and coastal character. Chile has a long coastline, the marine areas under its jurisdiction exceed that of its territory, and its population lives predominantly on the coast and depends on coastal and marine economic activities and livelihoods

(Gobierno de Chile, 2021), particularly in the southern regions of the country. Changing oceans therefore have a significant impact on Chile's communities, livelihoods, and economy. This importance has in turn guided the development of climate change policies at the international and national level. Chile has led and supported international initiatives highlighting the ocean-climate nexus, the inclusion of oceans in NDCs, the need to promote ocean resilience to climate change, and, more generally, the promotion of a sustainable ocean economy (e.g. Because the Oceans Declarations, Friends of the Oceans and Climate, the "Blue" UNFCCC Conference under the Chilean Presidency, the Ocean-Climate Dialogue, and the High-Level Panel for a Sustainable Ocean Economy (the Ocean Panel); see: Dobush et al., 2022; UNFCCC, 2021; SBSTA, 2021; HLPSOE, 2024).

In line with Chile's efforts in international fora, the Framework Act and the national climate policies highlight the climate-ocean nexus throughout their texts (see in particular Gobierno de Chile, 2020, Chapter 7 on Oceans) and consider legal instruments to address ocean-based climate mitigation and adaptation (e.g. well-designed and well-managed marine protected areas (Gobierno de Chile, 2020, Chapter 7; Gobierno de Chile, 2021; Gobierno de Chile 2022; see also: HLPSOE, 2023); nature-based solutions (NbS), including ocean-based NbS (Framework Act, arts. 3(t), 5, 7, 13; see also Gobierno de Chile, 2020, section 3.2; 2021: 51; 2022); blue carbon (Framework Act, art. 3(d); LTC, section 5.14; see also Rehbein et al., 2020) and climate refugia [Framework Act, art. 3 (p)]. In addition, the Act mandates the development of three sectoral adaptation plans relevant to marine conservation and management: fisheries and aquaculture; biodiversity (including marine biodiversity); and the coastal zone (Framework Act, art. 9).

4 Aquaculture in the climate policies

Adaptation measures for the aquaculture sector have been laid out primarily in two instruments: the 2015 Climate Change Adaptation Plan for Fisheries and Aquaculture (Gobierno de Chile, 2015a, hereinafter the "2015 Plan"); and the LTS, which outlines specific long-term adaptation commitments for the sectors that, according to the Framework Act, require a sector-specific adaptation plan. Other policies, such as the Biodiversity Strategy 2017-2030 (Gobierno de Chile, 2018a), the Biodiversity Adaptation Plan (Gobierno de Chile, 2014, currently being updated), the National Oceanic Policy (Gobierno de Chile, 2018b) and the National Ocean Programme (Gobierno de Chile, 2023) are also relevant in shaping the priorities for the sector. Due to their more general nature, they will not be discussed in this article.

4.1 Climate change adaptation plan for fisheries and aquaculture

The 2015 sectoral adaptation plan was a commitment under Chile's intended nationally determined contribution submitted in 2015 (Gobierno de Chile, 2015b) and one of the first sectoral adaptation plans to be adopted in the country. The NDC committed to updating the plan in 2022 and 2027 (Gobierno de Chile, 2020). Although preparatory work has been carried out (ETTICC, 2022, 2023), the 2015 Plan has not been updated at the time of writing. More recently, the Framework Act set June 2024 as a legal deadline for the updating and development of all mandatory adaptation plans (Framework Act, transitional art 2).

The 2015 Plan's general objective is to strengthen the capacity of the fisheries and aquaculture sectors to adapt to the challenges and opportunities of climate change, considering the precautionary and ecosystem approaches. It comprises 29 actions organized around five objectives: 1) promote the implementation of the precautionary and ecosystem approaches to fisheries and aquaculture management as a means to improve the resilience of marine ecosystems and coastal communities; 2) undertake the necessary research to improve the knowledge of climate change impacts on the marine ecosystems and future scenarios; 3) implement education and capacity building activities directed to relevant stakeholders; 4) improve the regulatory, policy and institutional framework to effectively address the challenges and opportunities of climate change; and 5) implement direct adaptation measures to reduce vulnerability to climate change.

Even though one objective addressed the regulatory, policy and institutional framework, the Plan includes few actions directly addressing legal principles or planning and management instruments. Specific actions under that objective are: including marine areas in the national network of protected areas to reduce their vulnerability to climate change; adapting the regulations to respond promptly to events triggered by climate variability, and creating a technical advisory group on climate change within the ministerial agency responsible for the fisheries and aquaculture sector (the Undersecretariat for Fisheries and Aquaculture or SUBPESCA for its acronym in Spanish).

While the first objective (i.e. promoting the implementation of the precautionary and ecosystem approaches) could have considered the need to strengthen or amend the regulatory framework for the aquaculture sector, its associated actions address mostly fisheries. The only measure with potential relevance for aquaculture addresses a legal planning tool: promoting the development of marine spatial planning as an instrument for sustainable resource management. Eight of the thirteen actions included under the second objective (undertake research) are directly relevant to aquaculture, including four for salmon mariculture: considering the risks of climate change in the assessments supporting the designation of areas suitable for aquaculture; studying the vulnerability of key fisheries and aquaculture species to climate change; development of a predictive tool on climate conditions for fisheries and aquaculture; and studying the distributional changes of *Alexandrium catenella*. Finally, objective 5 (i.e. direct adaptation) considers two actions that could require, as one means of implementation, a regulatory measure: establishing an insurance system for small-scale fisheries and fish farmers; and implementing recirculating freshwater aquaculture systems (thus limited to the first growing phase of salmon).

The implementation of the actions included in the plan was primarily pursued through two key projects. First, and as already

mentioned, the government project "Atlas de Riesgo Climático" (ARClim) (Climate Risk Atlas) mapped climate change threats, exposure and sensitivity (relative climate risk) for different sectors, including aquaculture. The independent report supporting the analysis has been instrumental in establishing priority threats and areas, as well as highlighting gaps in scientific and local knowledge (Soto et al., 2019).

Second, a 5-year (2017-2021) FAO-administered and GEF-funded project undertook several actions to strengthen the adaptive capacity of the fisheries and aquaculture sector with a focus on small-scale fisheries and aquaculture (FAO et al., 2021). The project resulted in several outputs in line with objectives 2, 3, and 5 of the 2015 Plan, including an interoperable information system for climate change monitoring; an extensive training program for the public and private sectors; a participatory environmental monitoring program; climate change awareness initiatives and material; and direct adaptation measures in four pilot coastal communities with a focus on economic diversification (FAO et al., 2021; see generally FAO, 2024).

4.2 Aquaculture in the long-term climate change strategy

The elaboration of the LRT benefited not only from the experience gained in the implementation of the 2015 Plan, but also from the participatory process through which the LTS was developed. In particular, the work of the scientific committee of experts set up to support the Chilean COP25 Presidency (including its Roundtables on Adaptation, Oceans, and a technical group on adaptation in the fisheries and aquaculture sectors), was particularly influential in the final text (see Farías et al., 2019). The LTS is also influenced by recently adopted legal principles of climate change mitigation and adaptation (Framework Act, art. 2) and by the social and justice emphasis of recent adaptation policies (Gobierno de Chile, 2022; IPCC, 2022; Verschuuren, 2022). Compared to the 2015 Plan, the LTS has a much stronger emphasis on inclusive, participatory, gender-responsive, and evidence-based adaptation measures. Noteworthy, it also considers measures to address the carbon footprint of the sector.

The LRT organizes the sectoral adaptation commitments under six strategic objectives: 1) generating and sharing scientific, traditional, and local knowledge; 2) strengthening governance for resilience and adaptation; 3) developing nature-based solutions and implementing ecosystem and precautionary approaches; 4) designing and applying an integrated risk management approach; 5) diversifying livelihoods and promoting sustainable practices in the communities dependent on fisheries and aquaculture; and 6) contributing to the reduction of greenhouse gas emissions. Each objective, in turn, has between 2 and 5 associated targets.

Just as in the 2015 Plan, the adaptation objectives and targets emphasize information, monitoring, research, and capacity building, with limited attention to the need to assess or reform the current legal framework to prepare the sector for a future with increased climate variability and climate change. The tasks that have, directly or indirectly, implications for the legal framework include:

A) By 2030, the implementation of an ecosystem approach to fisheries and aquaculture which consider climate change risks and the relevance of the conservation and sustainable use of natural resources for social and economic benefits and increased resilience (Objective 3, Target 3.2).

B) By 2030, the spatial planning and suitable areas for aquaculture are revised, considering the risks of climate change, within the context of an ecosystem approach to aquaculture (Objective 4, Target 4.5).

A further measure of relevance for aquaculture, and potentially the regulatory framework, was included in Section 5.14 addressing oceans: by 2023, assess alternatives to implement extended business responsibility for the industrial and small-scale fisheries sector and salmon aquaculture (Target 3.10).

4.3 Critical assessment

Chile's climate change laws and policies seek to provide a comprehensive, cross-sectoral, polycentric and coordinated response to the challenges and opportunities of climate change. The ocean-climate nexus has been a particularly important aspect of the policy both internationally and domestically, and the fisheries and aquaculture adaptation plan was one of the first adopted.

The implementation of the 2015 Adaptation Plan, with international assistance and funding, has undoubtedly increased the adaptive capacity of the Chilean fisheries and aquaculture sector, mainly through increased resources (information) and capacity building (FAO et al., 2021). Furthermore, the participatory processes through which the LTS, the NDCs, and the Framework Act were developed have been important opportunities to strengthen dialogue and consensus-building, promote transparency, and foster coordination and integration.

Despite this encouraging outlook, there are several shortcomings in the adaptation policies and plans for the aquaculture sector. The first major shortcoming is the lagging implementation of the actions committed in the 2015 Plan. A recent report by the Office of the Auditor General (CGR, 2023) audited the implementation of the Plan's actions under the responsibility of SUBPESCA, revealing significant deficiencies in the institutional processes for monitoring and evaluating the implementation of the adaptation plan. This finding is consistent with a global assessment of adaptation monitoring and evaluation (Adaptation Committee, 2023). The Auditor General's Report also concluded that the SUBPESCA has made insufficient progress on several of the adaptation actions considered in the Plan, in particular adaptation measures for the aquaculture sector. For example, the SUBPESCA has not planned or adopted any measure to support the development of recirculating aquaculture systems to address the vulnerability of the aquaculture sector to reduced freshwater availability; it has not considered any measure to implement a co-financed insurance system for artisanal fisheries

and small-scale aquaculture operators; it has made no effort to consider climate change in the studies supporting the identification of areas for aquaculture development; and has not adapted the regulatory framework to respond to events triggered by climate variability nor has planned any amendments to that end. While some capacity-building initiatives and studies have been undertaken to support the promotion of marine spatial planning to implement ecosystem and precautionary approaches (target 4 under objective 1), the Auditor found that the SUBPESCA has neither achieved the target nor reported on the difficulties encountered in its implementation. Thus, despite numerous efforts to raise awareness and build capacity to integrate climate change into the work of the different sectoral departments, institutional practices have failed to internalize the imperative to consider, prepare, adapt, and transform to face climate change.

The second major shortcoming is that the policies largely take a reactive approach, focusing on how climate change may affect existing production systems and practices. However, they fail to articulate a robust (and perhaps even transformative) vision for the aquaculture sector in a changing climate and ocean, taking into account new opportunities, mitigation efforts, coastal community resilience, ocean resilience, food security, sustainable economies, and evolving technologies. There have been several missed opportunities to articulate this overarching and transformative vision for the sector. As noted above, the 2015 Plan has not been updated at the time of writing. Similarly, the 2003 National Aquaculture Policy (Gobierno de Chile, 2003) has not been updated even though preparatory studies have been completed (PUCV, 2019). In addition, the SUBPESCA has committed to the drafting of a new act for aquaculture in 2018 and 2022 (Undersecretary for Fisheries and Aquaculture, 2018, SUBPESCA, 2022), but work on this has not begun in earnest (Comités Científicos Técnicos de Acuicultura, 2023; SUBPESCA, 2023a).

Several factors may explain the lag in legal and policy reform for the aquaculture sector. These include the impacts of the social unrest in 2019, the COVID-19 pandemic. In addition, the new government installed in 2022 appears to have prioritized the legal reform for the fisheries sector, with a bill on a new fisheries act introduced to Congress in early 2024 (Congreso Nacional, 2024). The controversial nature of salmon aquaculture, with both strong supporters and vehement opponents, may be a contributing factor.

A further and related shortcoming of Chile's response to adaptation in aquaculture is the limited critical assessment of whether the regulatory framework requires transformative changes to enable successful adaptation of the aquaculture sector. Current policy documents take a distinctly incremental approach to adaptation: mainstreaming climate change considerations into existing frameworks (namely the ecosystem approach and spatial planning, in particular the sectoral planning tool), supported by increased knowledge and capacity. Is this incremental approach sufficient?

To date, the SUBPESCA has not developed the concept of the ecosystem approach as applied to aquaculture, what it entails, how it is implemented, and what regulatory instruments operationalize it. The situation is further complicated by the inadequate definition of the ecosystem approach in the *Fisheries and Aquaculture Act* (FAO, 2016), its questionable application to aquaculture management (compare Garrido Darricarrére, 2018 with Paredes and Martínez, 2020 and Engler, 2023), and its inconsistency with other definitions of the ecosystem approach in legislation (Framework Act) and policies (e.g. National Biodiversity Strategy, Gobierno de Chile, 2018a). While the experts participating in the Oceans Roundtable identified the need to clarify and strengthen (or 'reform', Scientific Committee 2020: 8, 19) the legal definition of the ecosystem and precautionary approaches and explicitly extend its application to aquaculture, the LTS did not include such measure in its final text.

In turn, the consideration of climate change in aquaculture zoning and spatial planning is generally recommended as an adaptation measure (FAO, 2016). However, neither the government nor the technical roundtables considered in any depth how implementing such an incremental measure within the existing aquaculture planning and leasing system could improve the resilience of the aquaculture industry, coastal communities, or the marine environment. The following section addresses the extent to which this incremental approach to zoning would be fit for purpose.

5 Adaptive capacity in aquaculture planning and leasing frameworks

In order to assess whether mainstreaming climate change into existing spatial planning instruments is a sufficient adaptation measure, it is first necessary to describe the aquaculture planning and leasing system in Chile. The legal framework for aquaculture in Chile is complex; this section synthesizes the information necessary for the assessment and it is not meant to be a comprehensive description (but see Fuentes and Engler, 2016; Engler, 2023).

5.1 Planning and leasing frameworks for marine aquaculture

Chilean aquaculture planning and management is primarily governed by the 1992 *General Fisheries and Aquaculture Act* (as amended) (hereinafter referred to by its Spanish acronym, LGPA). Several regulations implement the aquaculture provisions of the Act. The main regulations include the *Aquaculture Lease Regulations*, the *Aquaculture Environmental Regulations* (RAMA for its acronym in Spanish), and the *Fish Health Regulations for Aquaculture* (RESA for its acronym in Spanish). Each of them has been modified several times, in particular after the ISA crisis of 2007. There are several other pieces of legislation relevant to aquaculture. In particular, the institutional and legislative frameworks for nature protection and coastal zone use have evolved from their rather modest beginnings in the 1990s into complex legal regimes that have relevance for aquaculture licensing, management, and enforcement. These frameworks include the *Framework Act on the Environment* (Act No. 19,300 and subsequent amendments), the *Act creating Environmental Tribunals* (Act No. 20,600 as amended), the *National Policy on the Use of the Coastal Zone* (Decree No. 475 of 1994, Ministry of Defence), the *Act recognizing customary Indigenous use of marine and coastal space* (Act No. 20,249), and

the recent *Act on a National System of Protected Areas* (Act No. 21,600, published in the Official Gazette 6 September 2023) (all titles translated by the author; the text of all laws and regulations, in Spanish, can be found at www.bcn.cl). Several other pieces of legislation deal with specific aspects of the breeding process.

Any person undertaking aquaculture activities requires a license issued by the SUBPESCA authorizing the activity, and a lease issued by the Ministry of Defence granting the use of the public marine space (LGPA, art 67). All commercial salmon aquaculture and most shellfish aquaculture also require a favorable environmental impact assessment decision from the regional evaluation commission [*Framework Act on the Environment*, art. 10(n) and Regulation No. 40 of 2012, issued by the Ministry of the Environment and Climate Change, as amended, art. 3(n)]. In the original LGPA, aquaculture leases were granted for an indefinite period (subject to termination under specific grounds). An amendment to the Act in 2010 limited the duration of leases to 25 years, renewable for another 25 years if some minimum environmental performance indicators are met (LGPA, art 69). However, older leases were grandfathered (Act No. 20,434, transitional art. 15). As a result, the majority of leases currently operating are not limited in time. The lease does not grant the leaseholder a property right over the seabed or water column (LGPA art 67bis), but it grants property rights over the lease. Therefore, leases may be transferred, leased, mortgaged, and transmitted (LGPA, art 69).

Aquaculture leases are subject to prescriptive spatial restrictions resulting from a fragmented array of legal frameworks that have evolved at different times and rates. The main spatial restrictions result from a sectoral planning instrument (the Areas Appropriate for Aquaculture), a multisectoral planning instrument (the coastal plans), alternative uses (Indigenous marine and coastal areas, and the network of protected wildlife areas), and mandatory minimum distances between farms and between fish health zones (the "barrios", see Fuentes and Engler, 2016).

A key spatial planning tool is the Appropriate Area for Aquaculture or AAA, considered in the original LGPA. The AAA is a public coastal or marine area officially designated by the Ministry of Defence as suitable for the development of aquaculture activities (LGPA, art. 67), based on a technical report prepared by SUBPESCA, a public consultation and, since 2009, a consultation with Indigenous Peoples where appropriate. Aquaculture sites in the marine environment must be located within AAA, but being within an AAA does not guarantee a site approval.

The first AAAs were established in the mid-1990s on a regional basis, to allow for the development of the industry (SUBPESCA, n.d.a). They generally cover interior waters (bays and fjords) and coastal areas up to a distance of 1 nautical mile measured from the normal or straight baselines. In most cases, they were designated by excluding areas with other uses and were not supported by robust environmental studies. Few new AAAs have been designated since then.

Also in the mid-1990s, the government adopted the National Policy for the Use of the Coastal Zone (Decree No. 475 of 1994 issued by the Ministry of Defence). The National Policy calls for the adoption of integrated and multi-sectoral plans for the coastal zone (consisting of macro- and micro-planning) developed by public-private regional commissions (Gabinete Presidencial, 2005) and approved by a National Commission. The first region to undertake such a task was Region XI, largely in response to what was perceived as the reckless expansion of the salmon farming industry into the region (Fuentes and Engler, 2016). The regional plan was approved in 2004 by Decree No. 153 of 2004, issued by the Ministry of Defence. A second phase, the development of "micro- zoning" by the coastal municipalities within the region, has not yet been completed. Apart from Region XI, only Region IV has an approved coastal plan.

The coexistence of two zoning instruments (the sectoral AAAs under the LGPA, and the coastal plans under a national policy with no direct legal authority) led to several legal problems in the site application processes. This was eventually resolved by an amendment to the LGPA in 2010, which grants legal recognition to the ICZP, harmonizes the two planning instruments, and also requires the SUBPESCA to consult with the regional commission responsible for coastal zone planning before submitting a proposed AAA for the approval by the Ministry of Defence (LGPA, as amended by Act No. 20,434 of 2010). The ICZP received further legal recognition through an amendment to the *Framework Act on the Environment*, which introduced strategic environmental assessment (SEA) into the Chilean legal framework.

Even if a proposed site is located within an AAA and in areas compatible with aquaculture development under an ICZP (where applicable), there are further spatial restrictions on its siting, including minimum distances between salmon farms and between fish health zones. In 2016, the SUBPESCA determined that, given the leases granted, the applications submitted, and regulated spatial restrictions, there was no legal space available for new farms within established AAA in the southern regions of the country. As a result, the receipt of new aquaculture lease applications has been suspended (LGPA, s 76 and Orders No. 975 of 2012, No. 3264 of 2016, and N° 902 of 2020). SUBPESCA's decision effectively extended a moratorium on new fish farms established by law in 2010 (Act No. 20,434 as amended).

Although no new aquaculture lease applications are currently accepted in the southern regions, the 2010 Act introduced flexibility into the lease system by allowing a leaseholder to relocate a lease (including merging leases) within the same region, subject to certain restrictions (Act No. 20,434, art. 5). The intention was to allow existing farms to relocate to areas with better environmental and fish health conditions. Priority for relocation is given to leases that are located in "firewall zones" (i.e. the newly created farm-free zones between fish health zones), in contravention of the ICZP, or within national parks or marine parks. However, due to the lack of legal space available for new farms, relocations require the designation of new AAAs.

The establishment of new AAA and the subsequent relocation of leases have been further complicated by two laws addressing the use of marine space. The first is Act No. 20,249 published in the Official Gazette on 12 February 2008 ("Ley Lafkenche") which was enacted to recognize and protect the customary use of the marine and coastal spaces by Indigenous Peoples. Its main instrument is the designation of Indigenous marine and coastal areas, which are then managed by Indigenous communities based on a management plan

approved by the government (arts. 2(e), 3, 5, 11). The importance of this legal institution as a mechanism for recognizing Indigenous rights, including self-determination, as well as its pitfalls and shortcomings, has attracted considerable scholarly attention (e.g. Araos et al., 2020; Cid and Araos, 2020). In this article, the analysis is limited to its interaction with AAA and aquaculture leases.

The Act has addressed the potential conflict of use, i.e., the overlapping of Indigenous coastal and marine areas and other users, in particular aquaculture leases, by distinguishing between granted leases and lease applications. In the first case (i.e. granted aquaculture leases), the need to protect consolidated legal situations means that the Indigenous marine and coastal area cannot be granted as requested, but can be modified to avoid overlap (art. 7). In the second case (i.e. an application has been submitted but has not yet been granted), the Indigenous marine and coastal area has priority. The responsible authority must suspend the process of the submitted lease application, even if that submission precedes that for the Indigenous marine and coastal area (art. 10). If the Indigenous area is granted, the lease must be denied unless the Indigenous community consents to the activity, which must then be included in the management plan [art. 11(b)].

The implementation of the Act has been a significant hurdle for the relocation of aquaculture leases and the potential of new AAAs. By March 2023, there were 100 applications for Indigenous marine and coastal areas, 80 of which were located in the three southern regions of the country (75 in the X Region alone) (SUBPESCA, n.d.b). Only fifteen Indigenous coastal and marine areas have been granted, and the decision-making process is lengthy (usually 5 to 6 years, Araos et al., 2020), cumbersome and even contentious. Further, some stakeholders have expressed concern that the legal instrument is being abused to stop aquaculture projects (Araos et al., 2020).

Further spatial restrictions result from the fragmented legal framework for the designation of wildlife protection areas, which has also affected the establishment of AAAs and the relocation of leases. Aquaculture cannot take place in marine areas belonging to the national network of protected areas, except for national or forest reserves that include marine space within their boundaries (LGPA, art 158, as amended in 2002). While this provision did not pose a real obstacle to the designation of AAAs or the granting of aquaculture leases in the mid-1990s, the situation has since changed significantly. First, the *Framework Act on the Environment* declared that the marine areas included in the perimeter of a national park are part of the park and therefore incompatible with aquaculture activities (LGPA art 158 and Act No. 19300 art 34). In 2013, the Auditor General affirmed that this provision applies to national parks established before the *Framework Act on the Environment* from the date on which this Act entered into its entry into force (CGR, 2013). Second, the Chilean government has ambitious goals for marine protection, consistent with the Ocean Panel's Call to Action (HLPSOE, 2023). More than 40% of its exclusive economic zone is under some form of protection. This includes several large national parks that include marine waters and marine parks (e.g. Parque Nacional Kawésqar, Parque Marino Tic Toc – Golfo Corcovado, Parque Marino Islas Diego Ramírez y Paso Drake, Parque Marino Francisco Coloane).

In each of these cases, the recognition or the declaration of marine areas as a national or marine park triggered the need to revoke the AAA overlapping with the newly recognized or declared protected area and to reject the submitted lease applications. Leases already granted within a national park are required to relocate and are given priority to do so.

During the congressional debate of an Act creating the National Protected Areas Service (published in the Official Gazette as Act No. 21,600 in September 2023), there was a contentious debate on the compatibility of salmon mariculture and marine protected areas. Several organizations and members of Congress called for the exclusion of aquaculture activities from all protected areas and submitted numerous motions to this effect. However, these motions were defeated. The Act excludes commercial activities only from three categories of protected areas (parks, strict wilderness reserves, nature monuments, arts. 57-59) consistent with the *Washington Convention on Nature Protection and Wild Life Preservation in the Western Hemisphere*. However, the new Act requires that any commercial use in a protected area, if permitted, must be sustainable, not threaten its ecosystem services (Act No. 21,600, arts. 60-62), respect the objective of protection, and be compatible with its management plan (art. 63). Future regulations will specify the process for the development of the management plans and their content (art. 74). The compatibility of aquaculture with the protection objectives of national reserves will therefore be decided on a case-by-case basis. In any case, the government has already signaled that no lease (relocation) will be granted in a protected area until the relevant plan has been approved. This interpretation is consistent with the mandatory nature of management plans (art. 71) and the objectives of the Act. However, until the regulations are in place and the management plans are approved, the new legislation creates at least a procedural hurdle for the relocation of farms. It is also reasonable to expect that the new legal requirements will result in further spatial restrictions, particularly for salmon aquaculture.

The combined effect of aquaculture being excluded from granted or requested Indigenous coastal and marine areas and from marine areas within national parks, and the uncertain situation of aquaculture in national reserves, together with significant opposition from some Indigenous and local communities, has had a paralyzing effect on the approval of new AAAs and the relocation of leases. To date, the government has failed to relocate any lease (but see SUBPESCA, 2023b).

5.2 Critical assessment

The 2015 Plan and the LTS include the consideration of climate change in aquaculture spatial planning and the designation of new AAA as key adaptation measures for aquaculture management. However, there has been no in-depth assessment of whether this measure would indeed strengthen the climate resilience of the aquaculture industry and coastal communities. While at least some of the experts participating in the Ocean Roundtable of the Scientific Committee for COP 25 expressed doubts about the effectiveness of such an adaptation measure (Farías et al., 2019: 54), this concern did not lead to any revisions.

From the description of the existing aquaculture planning and leasing system, it can be concluded that incorporating climate change

considerations into future AAA designations would not only be scientifically challenging given the significant knowledge gaps (Soto et al., 2019), but would also have limited, if any, impact on the resilience of the existing and future industry given the rigid planning and leasing regulatory framework. In the case of existing leases, they are fixed to a specific marine area and granted for an indefinite period. Although the 2010 amendment to the LGPA introduced some flexibility into the regulatory framework (time limits on leases and relocation options), neither of these provides sufficient flexibility. Most leases are grandfathered and therefore not subject to time limits. In any case, the duration of a lease is effectively 50 years: 25 years with the right to extend for a further 25 years if most environmental monitoring results are acceptable, a threshold that is not particularly stringent. This period may be too long for rapidly changing oceans. Relocation, on the other hand, provides flexibility on paper but has not yet become a real option because of the fragmented and inefficient spatial planning frameworks. Further rigidity comes from the decision-making process for leasing, which has not been discussed in detail in this article.

In turn, the resilience of future leases granted in new AAAs (designated with climate change considerations) may also be limited for two reasons. First, the allocation of space for aquaculture within the coastal zone planning system is already challenged by other significant social and ecological constraints. Second, once granted, the lease will have limited flexibility to adapt to future, rapid, or unpredictable changes.

The incremental approach to adaptation considered in existing policies is not fit for purpose. There is a need for a more critical assessment and thorough review of the legal framework, most likely leading to a transformation of the planning and leasing system to introduce the flexibility needed to adapt to climate change. For example, it may be necessary to assess whether the AAAs still serve a useful purpose. The lack of uptake of coastal zone planning after 30 years of the National Policy for the Use of the Coastal Zone is a strong argument for retaining the sectoral planning tool, but flexibility can be introduced by other means. For example, the legal framework could consider the possibility of granting leases outside of an AAA, subject to a more comprehensive decision-making process and stricter environmental objectives and monitoring requirements. The Nova Scotia (Canada) regulatory framework adopted in 2015 (Nova Scotia Department of Fisheries and Aquaculture, n.d.) or the exemption from zoning restrictions considered in the Norwegian permitting system (Norwegian Ministry of Fisheries and Coastal Affairs, n.d.; Engler, 2023) could be models to draw on. However, in cases where there is opposition to new aquaculture activities, the legal flexibility may face practical challenges. This was reportedly the case in Nova Scotia, where the government decided not to issue aquaculture leases for finfish farms until aquaculture development areas were designated (Withers, 2023).

The legal framework could also create a new category of leases, subject to a separate regime, to promote and provide incentives for the development of new farming systems (e.g. semi-closed systems, multitrophic systems, non-fixed systems, land-based systems) or in new areas (e.g. offshore farming). Such a measure could facilitate the adaptation to new opportunities arising from climate change, as well as a transition to farming models that are better suited to meet ecological, social, or climate change challenges. The Norwegian development license provides a model for consideration (Hersoug et al., 2021; Hersoug, 2022).

The fragmented and uncoordinated legal instruments for the planning and use of the coastal zone also need to be reviewed. Indeed, marine spatial planning and the reform of the coastal zone planning system have been identified as a priority for climate change adaptation (e.g. Farías et al., 2019). The matter should primarily be addressed by the forthcoming sectoral plan for coastal adaptation to climate change (Ministerio de Defensa Nacional, 2024).

6 Conclusions

This article describes and assesses Chile's climate change adaptation policies and plans for aquaculture, with a focus on the nationally important salmon farming industry. Despite some promising initiatives and developments, progress was found to be insufficient on several fronts. First, the implementation of climate change adaptation measures has been poor, with many committed activities showing no progress. Second, the government has not adopted a strategic and national vision for the aquaculture sector in a changing climate and oceans, taking into account potential new opportunities and its role in climate-resilient ("climate-smart" (FAO, 2021a, b) food security and sustainable development. Third, the existing policies take a distinctly incremental approach by mainstreaming climate change into existing planning and leasing instruments, without a thorough assessment of the need for transformative changes to the regulatory framework. Chile's climate change adaptation plans for aquaculture are not fit for purpose.

The need for transformative change is illustrated by an in-depth analysis of the legal framework for planning and leasing. Indeed, the fragmented, rigid, cumbersome, and inefficient legal framework for the planning of aquaculture and other uses of the coastal zone is ill-suited to allocating space for the industry or to rationalize the current use of the space, taking into account environmental, social, operational and climate change criteria. Apart from the need for a holistic, integrated, and inclusive planning framework that takes into account local circumstances to decide whether and where to allocate space for aquaculture, the leasing system itself is also too rigid for the potential needs of climate change adaptation. Flexibility can be introduced through various mechanisms, including instruments that provide incentives for the transition to climate-smart aquaculture.

Chile is at a particularly promising juncture. Several simultaneous and ongoing initiatives to reform aquaculture law and policy, together with a comprehensive and principled approach to climate change adaptation in the context of socio-ecological transitions, provide a window of opportunity to advance strategic, coherent, long-term, and transformative adaptation. It is hoped that this opportunity will be seized.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2024.1386545/full#supplementary-material

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