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Social Enterprise Model Canvas and economic evaluation of an oyster farming project for poverty alleviation among women oyster farmers in the Saloum Delta, Senegal

Modelo Canvas de Empresa Social y evaluación económica de un proyecto de cultivo de ostras para aliviar la pobreza entre las mujeres ostricultoras del delta del río Salum, Senegal

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ABSTRACT | This study develops a social impact oyster farming model for the Saloum Delta (Senegal), focused on improving income and working conditions of women oyster farmers through suspended cultivation of *Magallana gigas* (Thunberg 1793) and *Crassostrea tulipa* (Lamarck 1819). Using the Social Canvas Model and an economic-financial evaluation based on a 5% discount rate, an integrated system is proposed that includes seed production, purification, and processing, with an estimated initial investment of € 572,000. The model generates 26 direct jobs, ensures positive accumulated cash flow during the evaluation period, and achieves financial sustainability under the zero NPV criterion. It is observed that profitability depends on combining both marketing formats (live oysters and dried meat), with exclusive production of dried meat being unfeasible. The approach adopted allows for designing a replicable, financially viable model that is consistent with the aquaculture development and poverty reduction objectives promoted by the Senegalese government.

Keywords
Cultivo de ostras
Mujeres
Pobreza
Modelo Canvas de Empresa Social
evaluación económica

RESUMEN | El presente estudio desarrolla un modelo de ostricultura de impacto social para el delta del río Salum (Senegal), enfocado en mejorar los ingresos y condiciones laborales de mujeres ostricultoras mediante el cultivo suspendido de *Magallana gigas* (Thunberg 1793) y *Crassostrea tulipa* (Lamarck 1819). Mediante el Modelo Canvas Social y una evaluación económico-financiera basada en una tasa de descuento del 5%, se propone un sistema integral que incluye producción de semillas, depuración y procesamiento, con una inversión inicial estimada de 572.000 €. El modelo genera 26 empleos directos, asegura una tesorería acumulada positiva durante el período de evaluación y alcanza la sostenibilidad financiera bajo el criterio de VAN igual a cero. Se observa que la rentabilidad depende de combinar ambos formatos de comercialización (ostras vivas y carne seca), siendo inviable la producción exclusiva de carne seca. El enfoque adoptado permite diseñar un modelo replicable, financieramente viable y coherente con los objetivos de desarrollo acuícola y reducción de la pobreza promovidos por el gobierno senegalés.

INTRODUCTION

Global production of aquatic products from fisheries and aquaculture, has maintained growth over the past 70 years. In 2022, this production reached a record high, totalling 223.2 million tons, with 164.6 million tons intended for human consumption, increasing the global apparent per capita consumption to 20.7 kg/person/year—significantly higher than the 9 kg recorded in the 1960s (FAO 2024a).

Technological advances, distribution, and the constant growth of aquaculture have significantly contributed to global food security and the sustained increase in apparent consumption. At the same time, the positive impact of aquaculture on the economic development of coastal communities has been demonstrated (Belton 2013, Béné *et al*. 2016, Bondad-Reantaso and Subasinghe 2013, Naldi 2015, Nguyen *et al*. 2016). In this context, aquaculture plays a crucial role in achieving the Sustainable Development Goals (SDGs) of the 2030 Agenda, with its most significant contribution in three fundamental areas: poverty alleviation, hunger eradication, and health improvement, SDGs 1, 2, and 3 (Bartley 2022, Troell *et al*. 2023).

Bivalves present great potential for economic and social growth in coastal communities, with a reduced environmental impact (Vélez-Henao *et al*. 2021). Various bivalve species have been used in inclusive business models to overcome

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poverty, ensure food security, and improve community incomes through small-scale projects using clams (Mohamed *et al*. 2016), mussels (Kripa and Surendranathan 2008), scallops (Cancino 2015), pearl oysters (Fong *et al*. 2005), and Japanese oysters (Chen *et al*. 2017).

The Saloum Delta is one of the six national parks in Senegal, located approximately 100 km south of Dakar. It is a coastal intertropical region recognized for the ecological importance of its mangroves and estuaries (Leal y Spalding 2022). It was declared a UNESCO World Heritage Site in 2011 and had previously been designated a Ramsar site in 1984. This estuarine complex, which covers approximately 29,720 km²—of which around 180,000 hectares (just over 6%) are protected as a Biosphere Reserve (Dia 2012) —constitutes an ecosystem of high environmental value. The exploitation of molluscs, mainly oysters, cockles, and sea snails, has been part of the coastal communities' tradition, with archaeological evidence showing this practice has existed for at least 10,000 years (Camara *et al*. 2017, Holl 2022). The exploitation of molluscs in this area has caused significant environmental damage, especially due to the harvesting of oysters that live attached to mangrove roots and are usually removed with the help of machetes (Chuku *et al*. 2021, Gallup *et al*. 2020). Today, the local population continues to rely heavily on marine resources, which represent their main source of protein and support for the household economy. It is estimated that approximately 5,270 people are engaged in fishing and shellfish processing as a livelihood, of whom between 80% and 92% are women. Considering a conservative estimate of 11 people per household, more than 59,000 people depend economically on this sector for their subsistence (Chuku *et al*. 2020, Wélé *et al*. 2021). Oyster harvesting in Senegal comes mainly from two geographic areas: Casamance and the Saloum Delta (Diadhiou y Ndour 2017). The volume of catches made by women oyster gatherers in the Saloum Delta is extremely difficult to determine due to the high informality, variability, and seasonality of the activity, which is concentrated in periods of 120 to 180 days per year. Estimates from the 1980s indicated annual productions of 10,000 t, and by the late 1990s around 1,500 t (≈ 48 kg/person/month) (Carney 2017). Wélé *et al*. (2021) estimated that monthly oyster catches per woman gatherer range between 25 and 50 kg, generating an informal monthly income of between 20,000 FCFA (€34.40) and 40,000 FCFA (€68.80).

Oysters of the genera *Crassostrea* and *Magallana* comprise a group of eight species that lead global production, currently close to 7.1 million tons (FAO 2024b). *C. tulipa* is the native species of Senegal, with a current production of around 1,000 t/year (FAO 2024b), previously known as *C. gasar* (Lazoski *et al*. 2011). It is distributed along the west coast of Africa, from Senegal to Angola, and along the Atlantic margin of South America between Venezuela and Brazil (Chuku *et al*. 2023, Poutiers 2016). It belongs to the group of tropical brackish-water oysters that live in mangroves and are capable of surviving across a wide range of salinities (4 to 50‰), temperatures (18 to 33 ºC), pH (6 to 8.5), and low oxygen concentrations (1 ppm) (Mahu *et al*. 2022). This species has high economic importance for several countries, such as Senegal, Gambia, Guinea, and Sierra Leone, among others. There is abundant scientific literature on multiple aspects related to this species in the region, including studies on reproductive biology and gametogenesis (Diadhiou *et al*. 2019, Thiao *et al*. 2024a, Thiao *et al*. 2024b), biometrics and morphology (Thiao *et al*. 2023), microplastic contamination (Addo *et al*. 2022), concentrations of heavy metals and organic substances (Catry *et al*. 2021, Diop *et al*. 2017, Diop and Amara 2016), spat collection methods and temporal dynamics (Chuku 2019, Chuku *et al*. 2020, 2023, Diadhiou and Ndour 2017), farming systems (Osei 2020, Osei *et al*. 2022, Osei *et al*. 2021a) and growth rate assessment (Osei *et al*. 2021b), as well as value chain analyses and product processing methodologies (Drago *et al*. 2023, FAO and PNUE 2023). In addition, given the relevance of this species for social development, poverty alleviation, and mangrove conservation in the region, various international cooperation projects—mainly promoted by organizations such as USAID (United States Agency for International Development) and WWF (World Wildlife Fund for Nature)—have been implemented in the area (Asare 2017, Chuku *et al*. 2020, Chuku *et al*. 2021, Dia 2012, USAID 2014, Wélé *et al*. 2021).

On the other hand, *M. gigas* was introduced in Senegal (Martínez-García *et al*. 2022, Bonham and Goulletquer 2017), likely as a triploid strain, in the early 2000s to initiate its commercial cultivation. So far, there are only a few references regarding its production, with figures close to 280 tons during the years 2015 and 2016, according to FAO statistics (FAO 2024b).

The development of oyster farming in Senegal has been identified as a strategic axis within the National Aquaculture Development Plan (SNDAq 2023–2032), promoted by the National Aquaculture Agency (ANA). Through the Support Project for the Modernization and Intensification of Oyster Farming (PAMIOS), the plan aims to reach a production of 2,500 tons of oysters in the coming years, to strengthen with the objective of strengthening food security and generate economic opportunities for coastal communities. The initiative seeks to create 3,000 direct jobs, mainly targeting women and youth, as well as to professionalize the sector through training programs in production and marketing techniques. In addition, the government of Senegal has emphasized the need to attract public and private investment to modernize production and improve processing and marketing infrastructure, promoting the sector's long-term sustainability. These efforts reflect a commitment to oyster farming not only as a productive sector but also as a tool for economic and social development, aligned with national strategies for poverty reduction and the promotion of rural employment (ANA 2023).

Business models are simplified representations of how organizations generate and deliver value to their customers, while achieving economic sustainability. The CANVAS methodology, developed by Osterwalder and Pigneur (2010), has become established as a practical visual tool that allows for the design, analysis, and communication of a company's operational logic through nine interrelated key elements.

The present study applies a specialized variant, the Social Enterprise Model Canvas (SEMC) proposed by Sparviero (2019), to design an oyster farming model in the Saloum Delta, Senegal. This adaptation is particularly appropriate due to its ability to integrate social objectives—such as job creation for local women—with the necessary economic viability. The proposed model is subjected to economic and financial analyses, establishing a minimum viability threshold of a Net Present Value (NPV) equal to zero, which ensures the recovery of the initial investment and the long-term sustainability of the project without compromising its social mission.

MATERIALS AND METHODS

The present study was based on the data collected within the framework of the project *"Strengthening the capacities of women from fishing villages, in the Saloum Delta, in sustainable mollusc farming as a complementary source of household income generation"*, managed by CETECIMA (Technological Centre for Marine Sciences) and funded by the International Cooperation Agency of the Government of the Canary Islands (Spain). Part of the information used came from the work carried out in this project, in which the lead author participated as a consultant, providing training, technical analyses, and development proposals for the implementation of a sustainable oyster farming production model.

This study was designed as a social project focused on poverty reduction through the suspended cultivation of two oyster species: the introduced triploid species (*M. gigas*) and the native species (*C. tulipa*). The project's approach was based on the CANVAS business model (Osterwalder and Pigneur 2010), specifically adapted for socially impactful initiatives according to the proposal by Sparviero (2019), which consists of 14 blocks, with an additional one added: "Cash Flow Surpluses" (Table I).

This model is a simple tool for strategic analysis where the various elements are interrelated. At its centre is the Social Value Proposition, connecting on the left side the resources, activities, and other actors necessary to create it; and, on the right side, the beneficiaries and customers, their relationship, and distribution channels. The upper part incorporates governance, while the middle section distinguishes between mission values (long-term) and operational objectives (short-term), with impact and results measurement on the right. Finally, at the base, the economic sustainability of the model is reflected.

Table I. Social CANVAS model, proposed by Sparviero 2019, used in this study. The "Cash flow Surpluses" block was incorporated into the model in this study.
Tabla I. Modelo CANVAS social, propuesta por Sparviero 2019, utilizado en este estudio. El bloque "Excedentes de tesorería" fue incorporado al modelo en este estudio.

Block	Meaning	Author
Social Value Proposition (SVP)	Value created for customers and women beneficiaries	Sparviero (2019)
Key Resources (KR)	Assets required for the project's operation	Sparviero (2019)
Key Activities (KA)	Essential activities to fulfill the project's mission	Sparviero (2019)
Non-Targeted Stakeholders (NTS)	Affected stakeholders who are neither customers nor beneficiaries	Sparviero (2019)
Customers and Beneficiaries (C&B)	Target groups to whom the project is addressed	Sparviero (2019)
Distribution Channels (DC)	How customers are reached	Sparviero (2019)
Customer & Beneficiaries Engagement (CBE)	Bidirectional relationships	Sparviero (2019)
Mission Values (MV)	Long-term goals that guide the strategy	Sparviero (2019)
Impact Measures (IM)	Assessment of the fulfillment of mission values	Sparviero (2019)
Objectives (OBJ)	Short-term, measurable goals	Sparviero (2019)
Outcome Measures (OM)	Evaluation of specific objectives	Sparviero (2019)
Revenues (R$)	Revenue sources, both financial and non-financial	Sparviero (2019)
Costs (C$)	Project costs	Sparviero (2019)
Cash Flow Surpluses (CFS$)	Proposed use of surplus cash generated	This study
Governance (GOV)	Organizational structure for project management	Sparviero (2019)

Based on this model, an economic and financial evaluation of the proposed production system was carried out, with particular emphasis on financial sustainability and its viability from a social perspective.

Small-scale oyster farming model

A hypothetical suspended farming model using longlines and lantern nets was proposed, including the acquisition of triploid *M. gigas* oyster spat in T6 size (> 6 mm) from specialized hatcheries in France, as well as the implementation of a local mini-hatchery with a nominal capacity to produce 1.5 million spat per year of the native species *C. tulipa*.

Both species were projected under a suspended farming scheme using longlines and lantern nets. The technical farming variables for the model design of *M. gigas* were estimated based on data collected by Burgos-Vega (2025), while for *C. tulipa*, seed production and farming studies were used (Brunetto *et al*. 2020, das Chagas *et al*. 2021, Ramos *et al*. 2014, Tureck *et al*. 2014).

The sizing of the production system was carried out following the methodology proposed by Burgos-Vega (2025), including the calculation of the total number of lantern nets required using three specific equations and the calculation parameters shown in Table II. Equation (1) determines the number of lantern nets required; equation (2) corresponds to the correction factor applied to the initial calculation; and equation (3) calculates the precise number of lantern nets needed at each moment (i) of the farming cycle.

$$\mathbf{L = F \times \max\{L_i\} \text{ for } i = 0, 1, 2, ..., n} \quad (1)$$

$$\mathbf{F(m, r) = (-0.00034 \times r + 0.0335) \times m + (-0.01 \times r + 2)} \quad (2)$$

$$\mathbf{L_i = [N_0 \times (1-m)^{\wedge}(i \times s)] / (P \times D_i)} \quad (3)$$

Where:

N_0 = Initial number of oysters calculated according to the following expression: ($Li \cdot P \cdot D_0$).

Li = Initial number of seeded lantern nets of any diameter and shape.

P = Number of tiers per lantern net.

D_0 = Initial oyster density per tiers (number of oysters).

D_i = Oyster density per tiers at time *i*.

m = Constant weekly mortality rate (in decimal form).

r = Density reduction percentage.

s = Number of weeks between tumbling operations.

i = Number of tumbling operations in a specific farming phase. The tumbling count (0, 1, 2, ..., n) applies when the same mesh size is maintained in the lantern net.

Tumbling = The process of tumbling, including lantern net replacement and adjustment of stocking densities.

Table II: Technical aspects considered in the installation calculations.
Tabla II: Aspectos técnicos considerados en los cálculos de las instalaciones.

	Calculation Variables and Values for Longlines and Lantern Nets	
Species	**Triploid *M. gigas***	***C. tulipa***
3 mm lantern-net	Duration: 6 weeks 1 tumbling in week 3 Initial density: 450 ind./tier Density reduction: 30% Weekly mortality: 1%	Duration: 9 weeks 1 tumbling in weeks 3 and 6 Initial density: 450 ind./tier Density reduction: 30% Weekly mortality: 1%
7 mm lantern-net	Duration: 8 weeks 1 tumbling in week 4 Initial density: 250 ind./tier Density reduction: 40% Weekly mortality: 1.1%	Duration: 8 weeks 1 tumbling in week 4 Initial density: 250 ind./tier Density reduction: 40% Weekly mortality: 1.1%
12 mm lantern-net	Duration: 12 weeks Tumbling in weeks 4 and 8 Initial density: 120 ind./tier Density reduction: 20% Weekly mortality: 1.3%	Duration: 12 weeks Tumbling in weeks 4 and 8 Initial density: 120 ind./tier Density reduction: 20% Weekly mortality: 1.3%
21 mm lantern-net	Duration: 14 weeks Tumbling in weeks 4, 8, and 12 Initial density: 70 ind./tier Density reduction: 10% Weekly mortality: 1.45%	Duration: 14 weeks Tumbling in weeks 4, 8, and 12 Initial density: 70 ind./tier Density reduction: 10% Weekly mortality: 1.28%
Lantern Nets:	10-tier lanterns with 50 cm diameter and mesh sizes of 3 mm, 7 mm, 12 mm, and 21 mm	
Longlines:	100 meters in length, each with a capacity for 100 lantern nets	
Buoys per Longline:	Two 200 L mother buoys, ten 50 L surface buoys, and one 50 L bottom buoy for each lantern	

Economic evaluation of the model

The economic-financial analysis was conducted by evaluating this oyster farming project from a social perspective. The profitability of the production system was assessed using traditional project evaluation indicators: Net Present Value (NPV) and Internal Rate of Return (IRR) (Engle 2007, 2010). The project was adjusted to the minimum profitability level at which the model reaches an NPV = 0 and the IRR equals the discount rate used, which was 5%.

The production model included the seeding of *M. gigas* triploid and *C. tulipa* spat (Table III) in four evenly distributed annual cycles, reaching approximately 240,000 and 1.12 million seeds stocked per year, respectively. For both species, a cumulative mortality rate of 50% was assumed during the production cycle in suspended farming systems (longlines), kept constant throughout the evaluation. The cost of *M. gigas* spat at T6 size was quoted from a commercial hatchery in France, including an estimate of transportation and importation expenses. In the case of *C. tulipa*, local production in the projected mini-hatchery was considered, incorporating a detailed estimate of variable and production costs.

The study considered a seven-year evaluation time horizon, plus an additional six-month period allocated to the execution of initial investments and setup, defined as year 0 (Table III). To estimate the commercial viability of the model, the applicable tax rates and the current fiscal and labour regulations in Senegal were applied (MEDD 2019, Ofecomes 2018). Two marketing formats were considered: live oysters (*M. gigas* triploid) and dried meat (*C. tulipa*), using the selling prices (€/kg) and the conversion ratio of the processed product as reported in the oyster value chain study in Senegal conducted by the FAO (Drago *et al*. 2023, FAO and UNEP 2023).

In addition, the break-even point was calculated, and an univariate sensitivity analysis was conducted for an optimistic scenario, applying a ±10% variation to five key variables of the model: initial investment, selling price, production volume, variable costs, and fixed costs—evaluating their impact on the financial indicators NPV and IRR.

The farming cycle in longlines was estimated at 40 weeks (9.3 months) for *M. gigas* and 49 weeks (11.4 months) for *C. tulipa*. It was estimated that the first commercial harvest of *M. gigas* would occur between months 9 and 10 of the first year, while that of *C. tulipa* would take place during the last quarter of the second year (the first year being used for spat production).

Table III. Variables considered in the calculations and economic evaluation.
Tabla III. Variables consideradas en los cálculos y evaluación económica

Farming Parameters	**Triploid *M. gigas***	***C. tulipa***
Estimated duration of production cycle	9.3 months (T6 to market size)	11.4 months (T6 to market size)
Project start date	January 1st, Year 1	
Origin	Commercial international hatchery	Project's mini-hatchery
Quantity stocked per cycle	60,000	280,000
Annual stocking (cycles/year)	4	4
Total mortality per cycle (materials calculation)	40%	40%
Total mortality per cycle (economic evaluation)	50%	50%
Market size	80–85 g per oyster	≈70 live oysters per 1 kg of dried meat (Drago *et al*., 2023)
Estimated annual production	10,000 kg/year	8,000 kg dried meat/year
Sales format	100% live	100% dried meat
Project timeline	6-month construction (Year 0) + 7 years	
First sale of live *M. gigas*	Months 9 and 10 of Year 1	
First sale of dried *C. tulipa*	Last quarter of Year 2 (no sales in Year 1)	
Delayed payments to suppliers and creditors	1 month	
Delay in payment collection	0 month	
Consumer Price Index (CPI)	3.3% (average 2017–2023, ANSD 2024), applied 100% to sale prices and costs	
Financing	100% equity, no debt or subsidies	
VAT	18% applied to sales, costs, and investments	
Corporate income tax	30%	
Depreciation rates	7%, 10%, and 15% (depending on asset type)	
Discount rate	5%	
Financial returns on cash surpluses	0%	
Selling price of *M. gigas* (live)	€7.25/kg (+VAT) (Drago *et al*., 2023)	
Selling price of *C. tulipa* (dried meat)	€8.86/kg (+VAT) (Drago *et al*., 2023)	

RESULTS

Development of the 15 blocks of the CANVAS-Social model (see model canvas in Table IV):

A. Social Value Proposition (SVP)

The social value proposition of the model is based on the generation of inclusive and sustainable employment, with active participation of women exceeding 80%, in coastal communities traditionally engaged in artisanal oyster harvesting in the Saloum Delta. This approach seeks to directly contribute to poverty alleviation by strengthening local capacities and facilitating access to stable sources of income. At the same time, the model promotes local economic development, improves the social well-being of beneficiary households, and supports environmental conservation, especially by reducing pressure on mangroves through the gradual replacement of wild harvesting with controlled farming.

B. Key Resources (KR)

The implementation of the oyster farming model in the Saloum Delta requires space, technical, and human infrastructure to ensure operational viability, product quality, and long-term system sustainability. The first key resource is the selection and acquisition of a marine concession with a minimum area of 2.5–2.7 ha, along with an estimated minimum onshore area with sea access of between 500–700 m².

Among the key material assets, the model requires a portable modular mini-hatchery (modified shipping container), designed to produce up to 1.5 million *C. tulipa* spat per year. This reduces dependence on natural spat collection, limits intervention in mangrove areas, and consolidates productive self-sufficiency.

In addition, the model includes a portable modular depuration plant for bivalves, with a maximum capacity of 1,000 kg per cycle, equipped with a cold chamber for storing fresh products awaiting dispatch. This facility plays a fundamental role in ensuring food safety and facilitating compliance with national and international health regulations and guidelines. A portable modular processing plant is also included, focused on producing dried oyster meat (washing, shucking, drying, and packaging), with a weekly production capacity of 200 kg.

To implement the farming system, 11 full longlines, each 100 meters in length, must be installed, including main, surface, and bottom buoys and anchors. In addition, the acquisition of a total of 1,930 lantern nets with 10 tiers and a diameter of 50 cm is planned, distributed according to the mesh size required for the different oyster growth phases: 191 lanterns of 3 mm, 324 of 7 mm, 617 of 12 mm, and 798 of 21 mm. A boat equipped with a 40 to 50-hp engine, longline rollers, and diving gear is also required.

Additional equipment to be installed on land includes: two tumblers, one 7-meter mechanical inspection belt table, one mechanical lifting belt, and a 60–70 KVA generator.

Finally, the model requires human capital (beneficiaries) as an essential resource, including a team of trainers with experience in farming techniques, spat production, depuration, processing, and operational management.

C. Key Activities (KA)

The first stage involves site selection, processing, and management of permits. Initial and ongoing technical training of personnel in farming operations is focused on the installation and maintenance of longlines, working with lantern nets, stocking, tumbling, thinning, removing epibionts, and harvesting. This training must include occupational risk prevention, marine pollution, and basic oyster biology and marine environmental knowledge.

Epibiont control of oysters has been a key element to sustain culture efforts in Ecuador when located near rocky areas where Cirripedia are abundant. Near sandy beaches, the problem diminishes.

Technical training to operate the mini-hatchery will cover all stages of *C. tulipa* spat production, from controlled spawning to larval rearing and settlement, as well as microalgae production in photobioreactors.

In addition, a continuous training program is planned for depuration operations, hygiene, processing, and marketing. This comprehensive training also includes content on business management, basic economics, and accounting, promoting an organizational culture focused on efficiency, traceability, and product quality.

These key activities enable the professionalization of artisanal oyster farming, improve access to formal markets, and ensure compliance with sanitary regulations, thereby strengthening the economic, social, and environmental sustainability of the model.

D. Non-Targeted Stakeholders (NtS)

Although they are not directly part of the group of beneficiaries or the customer segment, the model includes a network of non-targeted stakeholders whose involvement is essential. This group includes suppliers of specialized equipment and materials for suspended farming, such as longlines, buoys, lantern nets, and boats, as well as international hatcheries of triploid *M. gigas* spat. Local suppliers of basic inputs—such as fuel, drinking water, telecommunications, and other logistical services necessary for the daily operation of the system—are also considered relevant stakeholders.

At the institutional level, the model requires partnerships with academic centres, technical training institutions, or companies, both national and international, in order to strengthen local capacities through continuous training programs.

Financial institutions, government agencies, and national and international public or private organizations that provide funding are identified as strategic stakeholders. Other key institutional support stakeholders include entities such as the National Aquaculture Agency of Senegal (ANA), non-governmental organizations (NGOs), and marine environmental and health authorities responsible for monitoring the presence of marine biotoxins in farming areas and on products destined for market.

These institutions can act as key allies during the permitting and project implementation phase, by issuing the necessary licenses and authorizations, as well as supporting the provision of seed funding, grants, technical assistance, or tailored credit lines—especially in the context of a production model focused on social inclusion, environmental conservation, and job creation in vulnerable areas.

E. Customers and Beneficiaries (C&B)

The model identifies the coastal communities of the Saloum Delta as its main beneficiaries, particularly women traditionally involved in the harvesting and marketing of wild oysters. These women, who have historically worked under informal (unregulated) conditions with limited access to technical training or social protection, are actively integrated into the oyster farming project. This enables them to improve their incomes, access more dignified working conditions, and develop new productive and managerial skills.

As for customers, the model targets three distinct segments. The first is the HoReCa channel (Hotel, Restaurant, and Catering) for fresh live oysters with health certification and guaranteed traceability, associated with high-quality products. The second segment consists of supermarkets, retailers, and specialized wholesalers interested in both fresh oysters and processed products such as dried meat. The third segment includes local retail markets, where dried oyster meat represents a traditional product with high acceptance and accessibility for local populations.

This combination of beneficiaries and customers allows the model to balance social impact with commercial viability, ensuring inclusion, profitability, and sustainability.

F. Channels (Ch)

The model must include a diversified distribution strategy that allows for efficiently reaching both traditional markets and high-value-added segments. A direct sales channel should be established in local markets through the creation of fixed points of sale in fairs, marketplaces, or key commercial areas, primarily for the marketing of dried oyster meat, to maximize profit margins and reduce intermediaries.

In addition, indirect distribution channels should be developed through strategic partnerships with key stakeholders in the formal market, such as the HoReCa sector, supermarkets, and specialized wholesalers. These segments represent an opportunity to position value-added products with traceability and health certification, particularly in relation to fresh live oysters (*M. gigas*).

G. Customer and Beneficiaries Engagement (C&BE)

The model requires the establishment of strong and permanent mechanisms of interaction with both beneficiaries and customers, aimed at strengthening social impact and ensuring the quality and sustainability of the production system. In the case of beneficiaries, continuous training is promoted. This training is complemented with content on financial management, basic administration, and accounting, with the objective of empowering participants and strengthening their autonomy.

Active participation of beneficiaries is also encouraged in learning about operational and market decision-making, aiming to improve the model. Regarding engagement with customers, the model foresees the implementation of continuous feedback systems, especially with the HoReCa sector, supermarkets, and distributors. These mechanisms make it possible to adapt production and product presentation to market demands, while maintaining quality standards, traceability, and environmental sustainability.

H. Mission Values (MV)

To reduce poverty and promote stable and inclusive employment in coastal communities through sustainable small-scale oyster farming, with a particular focus on female inclusion by providing access to healthcare, social security, and financial services. To formalize the business from fiscal, labour, and commercial standpoints. To support mangrove conservation by reducing oyster harvesting from the wild.

I. Impact Measures (IM)

To assess the fulfilment of the mission values in social, economic, and environmental contexts, a set of impact measures was defined. In the economic dimension, the main indicator is the increase in the average household income of direct beneficiaries, reflecting the effect of the employment generated. In terms of health and well-being, access to basic medical services and improvement in the nutritional status of beneficiary households should be evaluated.

In the training dimension, the percentage of women trained and integrated into the oyster value chain should be measured. Regarding financial inclusion, indicators could include beneficiaries' access to banking services, microfinance, or savings systems, as signs of formalization and economic autonomy.

In the social and labour dimension, the integration of workers into the social security, labour, and pension systems should be measured. Finally, environmental impact could be assessed through the effective reduction in the harvesting of wild oysters from mangroves.

J. Objectives (OBS)

The model pursues specific and measurable objectives that make it possible to translate the mission values into tangible short- and medium-term results. First, the goal is to create 26 direct jobs, ensuring that more than 80% of the positions are filled by women oyster farmers from the Saloum Delta, to promote their socioeconomic inclusion. From a production perspective, the model sets a target of reaching an annual output of 10,000 kg of fresh live *M. gigas* (triploid) oysters and 8,000 kg of dried *C. tulipa* meat.

In addition, the implementation of a structured, ongoing technical training program for project beneficiaries is proposed. Finally, the model aims to consolidate its social, economic, and financial sustainability.

K. Output Measures (OM)

To assess the achievement of the objectives, variables are defined that allow for continuous monitoring of progress in the different areas of the project. In the labour dimension, the number and percentage of women employed on a stable basis should be monitored annually. In the production area, records should be kept of the annual volume of fresh oysters (*M. gigas*) and dried oyster meat (*C. tulipa*) produced, as the yearly quantity of spat stocked and produced locally.

Other indicators include the volume of oysters depurated and processed each year, reflecting the processing plant's capacity to meet production goals. Finally, in the financial dimension, periodic analysis of accounting balances, income statements, and cash flow should be carried out to verify the economic stability and financial sustainability of the project over time.

L. Income (I$)

The income structure of the model is based on two main commercial lines that combine fresh and processed products, allowing for the diversification of income sources and adaptation to different market segments. The first source corresponds to the sale of fresh live *M. gigas* oysters, with initial commercialization projected for the first year of operation and estimated revenues of €18.1 thousand, equivalent to 20% of the projected total production volume. This business line gradually reaches maturity, generating €88.1 thousand annually by year 7, representing 50.6% of the model's total income.

The second source corresponds to the sale of dried *C. tulipa* meat, a culturally valued product with high acceptance in local markets. The first sale is expected during the last quarter of the second year, generating €27.5 thousand, equivalent to 37.5% of the estimated production volume. This line reaches full production by year 7, with projected annual revenues of €86.2 thousand, representing 49.4% of the model's total income.

It is important to note that the current model does not include potential additional revenues such as the sale of spat produced in the mini-hatchery, provision of depuration services to third parties, or the commercialization of other molluscs caught and depurated. However, these activities are technically feasible and could be incorporated in a future expansion phase, contributing to the diversification and strengthening of the project's financial sustainability.

In addition to sales revenues, the model considers the need for an initial investment estimated at €572,4 thousand, required to finance infrastructure, equipment, and start-up activities (see economic-financial analysis). This investment could come from public or private funding sources, international cooperation, or local development funds.

M. Costs (C$)

The cost structure of the model includes two main components: fixed costs and variable costs. Fixed costs are primarily driven by staff salaries, which represent between 83% and 84% of total annual fixed costs. These expenses amount to €40.5 thousand in the first year and gradually increase to €49.3 thousand by the seventh year, based on an annual adjustment using an estimated average Consumer Price Index (CPI) of 3.3%.

Variable costs grow proportionally with the volume of production. The main component of these expenses is fuel, which accounts for 50% of total variable costs, due to the model being evaluated in the absence of connection to the electrical grid and the need to operate generators and boats. Other relevant elements include the importation of triploid *M. gigas* spat and the production of *C. tulipa* spat in the mini-hatchery, as well as the purchase of materials and supplies for farming, processing, depuration, and marketing activities. Altogether, variable costs amount to €16.2 thousand in the first year and reach €47.4 thousand by the end of the seventh year.

Finally, the model is not economically or financially viable based solely on the production and sale of dried meat.

N. Cash Flow Surpluses (CFS$)

The cash flow surplus block refers to financial resources generated from the model's profits, which should be managed with a focus on social reinvestment, internal improvement, and territorial scalability.

A first line of action should be the evaluation of increasing the salaries of contracted personnel, beyond the annual adjustment based on the CPI. Secondly, priority should be given to the technical and financial analysis for expanding production capacity and hiring new workers, allowing the project to meet higher demand, diversify lines to new products with greater added value or incorporate technological innovations.

Finally, part of the surplus could be allocated to the creation of a common or solidarity fund, managed by the implementing entity and the governance committee, with the aim of supporting the replication of the model in other communities or regions. This would contribute to its territorial expansion under a social economy approach and align with the aquaculture development objectives set by the Government of Senegal through the ANA.

O. Governance (GOV)

The governance of the model could be structured through a Foundation with a board of directors composed of funders, technical experts, beneficiaries, the National Aquaculture Agency (ANA), and a specialized NGO.

Table IV. Final summary panel of the project's social CANVAS model (SEMC).
Tabla IV. Panel final resumido del modelo CANVAS social (SEMC) del proyecto.

Governance (GOV): Foundation with a governing board

Non-Targeted Stakeholders (NtS)
- Suppliers of materials and equipment for farming
- International hatcheries of triploid spat (*M. gigas*) with disease-free health certification
- Local suppliers of fuel, water, telecommunications, etc.
- National or international academic institutions specialized in aquaculture
- Government bodies (e.g., ANA, environmental and health authorities)
- Financial institutions, government agencies, and public or private international organizations that provide funding

Key Resources (KR)
- Marine concession of 2.5 to 2.7 ha and a land area of 500 to 700 m²
- Modular mini-hatchery: 1.5 million *C. tulipa* spat/year
- Modular depuration plant with cold storage (capacity: 1,000 kg/cycle)
- Modular processing plant (capacity: 200 kg of dried oyster meat/week)
- 11 longlines, 1,930 lantern nets, and one boat
- Complementary machinery: tumbler, inspection tables, lifting systems, and generator
- Specialized human resources for continuous training in technical and operational areas

Key Activities (KA)
- Site selection (marine and land), license and permit applications
- Supplier selection
- Technical training of staff in farming operations
- Training in mini-hatchery operations
- Training in depuration, processing, hygiene, marketing, and management

Channels (Ch)
- Direct distribution in local markets through established sales points for dried oyster meat
- Indirect distribution through partnerships with the HORECA sector, supermarkets, and specialized wholesalers

Customer & Beneficiaries Engagement (C&BE)

Beneficiaries:
- Ongoing training for women in three areas: farming, depuration–processing–hygiene, and commercial–financial management
- Involvement of beneficiaries in operational and strategic management
- Gradual transfer of responsibilities to promote autonomy

Customers:
- Feedback mechanisms with customers regarding product quality
- Ongoing communication channels to monitor demand trends and preferences

Customers & Beneficiaries (C&B)

Beneficiaries: Women oyster farmers from the Saloum Delta

Customers:
- HoReCa sector
- Supermarkets, retailers, and wholesalers
- Local retail markets

Mission Values (MV)
- Reduce poverty and promote stable and inclusive employment for women oyster farmers through small-scale oyster farming
- Formalize the business in fiscal, labor, and commercial terms
- Support mangrove conservation by reducing wild oyster harvesting

Social Value Proposition (SVP)

Generate inclusive and sustainable employment with high female participation (>80%), contributing to poverty alleviation, economic and environmental development, and improved social well-being in vulnerable communities of the Saloum Delta through an oyster farming project.

Impact Measures (IM)
- **Economic:** Increase in the average household income of beneficiaries
- **Health and well-being:** Access to medical services and improved nutrition for beneficiaries and their families
- **Educational:** Percentage of women trained and integrated into the value chain
- **Financial inclusion:** Access of beneficiaries to banking services, financing, and savings mechanisms
- **Social and labor:** Integration of beneficiaries into the social security, labor, contributory, and pension systems
- **Environmental:** Reduction in the harvesting of wild oysters from mangroves

Objectives (OBS)
- Create 26 direct jobs (with over 80% for women)
- Annual production: 10,000 kg of fresh live oysters (*M. gigas* triploid) and 8,000 kg of dried *C. tulipa* meat
- Implement a continuous technical training program
- Ensure the model's economic and financial sustainability

Output Measures (OM)
- **Labor:** Annual number and percentage of women employed in stable positions
- **Production:** Annual volume produced of *M. gigas* and *C. tulipa*
- **Seed:** Annual quantity of spat stocked and produced locally
- **Processing:** Annual volume depurated and processed for commercialization
- **Financial statements:** Balance sheet, income statements, and cash flow

Costs (C$)
- **Fixed costs:** Year 1: €46,900/year. Year 7: €59,300. Salaries = 83–84%
- **Variable costs:** Year 1: €16,200. Year 7: €47,400. Fuel = 51%, imported spat, materials, and various inputs
- The model is not economically or financially viable based solely on the production/sale of *C. tulipa* dried meat

Cash Flow Surpluses (CFS$)
- Assess potential salary increases adjusted to inflation
- Evaluate expansion of production capacity
- Contribute to a common fund to finance new projects

Income (I$)
- **Live *M. gigas***: First income in Year 1: €18,100. Income in Year 7: €88,100. Represents 50.6% of total revenue
- **Dried *C. tulipa* meat**: First income at the end of Year 2: €27,500. Income in Year 7: €86,200. Represents 49.4% of total revenue
- No additional revenues (e.g., seed sales, third-party depuration services, or sale of other harvested mollusks)
- Minimum initial funding required: €572,400

Economic Evaluation of the Model

Table V shows the model's investments, which were divided into tangible fixed assets and intangible fixed assets. The total estimated investment in assets during year 0 amounted to €482.6 thousand + VAT, with reinvestments for the renewal of farming materials scheduled for years 3, 5, and 7. The depreciation rate applied ranged between 7% and 15%.

Table V. Investment overview expressed in euros. Dep (%) = Applied depreciation rate (thousands of euros).
Tabla V. Cuadro de inversiones expresadas en euros. Dep (%) = Porcentaje de amortización aplicada (miles de euros).

	Year 0	Year 3	Year 5	Year 7	Dep (%)
TOTAL PROJECT (I + II)	**482.6**	**8.8**	**17.0**	**17.5**	
I. Tangible Fixed Assets (A+B+C)	**459.6**	**8.8**	**17.0**	**17.5**	
A Farming systems (A1+A2)	**149.4**	**8.8**	**17.0**	**17.5**	
A1 Lanterns nets	60.9	6.1	13.8	13.9	15%
A2 Longlines	88.5	2.7	3.2	3.6	7%
B. Machinery (B1 + B2 + B3 + B4)	**289.6**				
B1 Mini-hatchery, depuration unit, processing plant, and office	149.7				7%
B2 Farming and processing equipment	99.8				10%
B3 Generator and electrical distribution system	22.0				
B4 Boat and internal transport	18.1				
C. Other investments and contingencies (C1+C2)	**20.6**				
C1 Plant installation	11.6				
C2 Contingencies	9.0				
II. Intangible Fixed Assets (D1+D2+D3)	**23.0**				
D1 Technical studies and training	15.5				
D2 Licenses and permits	3.0				
D3 Corporate branding and others	4.5				

Table VI shows the total cost structure of the model. Fixed costs increase progressively due to the annual CPI adjustment applied in the evaluation. Within this category, salaries represent an average of 83.5% of total fixed costs, while the remaining portion is distributed among general expenses, rent, maintenance, and advertising. The project includes a total staff of 26 full-time workers, with gross salaries and social security contributions in accordance with Senegalese labour legislation.

Of the total workforce, 85.7% are classified under the professional category of agricultural workers, with a gross monthly salary of €89.79 plus social security contributions. Three additional staff members receive a gross salary of €120, and two university-level professionals in charge of the project receive a gross monthly salary of €380 plus social security, in accordance with current legislation (MEDD 2019).

On the other hand, variable costs grow proportionally with the level of production and stabilize from the second year onward, averaging 44.5% of the model's total cost. Fuel consumption constitutes the main component of variable costs, accounting for an average of 49% of the total. The remaining costs are distributed across items such as the purchase of *M. gigas* spat, in-house production of *C. tulipa* spat, product processing, depuration, packaging, and marketing.

Table VI. Evolution of total costs (thousands of euros). Costs are updated annually with the CPI (3.30%).
Tabla VI. Evolución de los costes totales (miles de euros). Los costes son actualizados anualmente con el IPC (3,30%)

Total costs	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Fixed costs	46.9	49.7	51.6	53.4	55.3	57.3	59.3
Variable costs	16.2	31.3	41.6	42.9	44.4	45.9	47.4
Total	**63.1**	**81.0**	**93.2**	**96.3**	**99.7**	**103.2**	**106.7**

Table VII shows the evolution of net revenues generated by the model from the sale of the two products, *M. gigas* and *C. tulipa*. Revenues were calculated based on an initial average price, updated annually using the fixed CPI assigned to the project.

Table VII. Income evolution (thousands of euros). Prices are updated annually with the CPI (3.30%).
Tabla VII. Evolución de los ingresos (miles de euros). Los precios son actualizados anualmente con el IPC (3,30%).

Net income	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
M. gigas (live) in thousands of euros	**18.1**	**74.9**	**77.3**	**79.9**	**82.5**	**85.3**	**88.1**
Product quantity (kg)	2,500	10,000	10,000	10,000	10,000	10,000	10,000
Net price € / kg	*7.25*	*7.49*	*7.73*	*7.99*	*8.25*	*8.53*	*8.81*
C. tulipa (dried meat) in thousands of euros	**0**	**27.5**	**75.6**	**78.2**	**80.7**	**83.4**	**86.2**
Product quantity (kg)	0	3,000	8,000	8,000	8,000	8,000	8,000
Net price € / kg	*0*	*9.15*	*9.45*	*9.77*	*10.09*	*10.42*	*10.77*
Total in thousand of euros	**18.1**	**102.4**	**152.9**	**158.1**	**163.2**	**168.7**	**174.3**

Table VIII presents the detailed evolution of the cash flow from year 0 to year 7. The implementation of the model requires an initial capital contribution of €572.4 thousand in year 0, mainly to cover tangible and intangible investments (€482.6 thousand) and to absorb the operating losses of the first year. During year 1, the model experienced a negative operating cash flow of €43.7 thousand (see operating cash flow for year 1 in Table VIII), resulting from operating costs (€61.83 thousand) being higher than revenues (€18.13 thousand). Nevertheless, the adequate initial capitalization ensured the project's financial viability, maintaining a positive cumulative cash balance that grew consistently throughout the entire analysis period.

Annual cash flows increased significantly from the second year onward, coinciding with the rise in *M. gigas* production and the introduction of *C. tulipa* revenues, with operating income growing from approximately €18,130 in year 1 to approximately €174.26 thousand in year 7, while operating costs increased annually due to higher production volumes and the CPI adjustment. In years 3, 5, and 7, new reinvestments are recorded for partial renewal of farming materials, impacting extra-operating cash flow. The cumulative cash balance demonstrates the project's strong capacity to generate cash, reaching just over €343.29 thousand by the end of year 7. This reflects a sufficient margin to improve beneficiaries' wage conditions throughout the project, absorb unexpected losses, finance production expansions, or contribute to a co-financing fund for replicating new models.

Table VIII. Evolution of the treasury account, cash-flow (thousands of euros).
Tabla VIII. Evolución de la cuenta de tesorería, *cash-flow* (miles de euros).

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
I. Operating Cash-flow (A - B)	**0.00**	**-43.70**	**22.62**	**60.56**	**61.76**	**63.59**	**65.64**	**67.74**
A. Operating revenues	0.00	18.13	102.35	152.90	158.06	163.22	168.66	174.26
B. Operating costs	0.00	61.83	79.73	92.34	96.30	99.63	103.02	106.52
II. Extra-operating Cash-flow (C – D)	**89.83**	**-0.18**	**3.04**	**-7.60**	**0.15**	**-19.21**	**0.16**	**-21.10**
***C. Extra-operating revenues* (C.1+C.2)**	**659.30**	**3.81**	**18.60**	**27.54**	**28.45**	**29.39**	**30.36**	**31.36**
C.1. Capital	572.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C.2. VAT (collected + refunds)	86.87	3.81	18.60	27.54	28.45	29.39	30.36	31.36
***D. Extra-operating costs* (D.1+D.2)**	**569.47**	**3.99**	**15.56**	**35.14**	**28.30**	**48.60**	**30.20**	**52.46**
D.1. Investements	482.60	0.00	0.00	9.39	0.00	19.36	0.00	21.26
D.2. VAT (Input + Payment)	86.87	3.99	15.56	25.75	28.30	29.24	30.20	31.20
***Cash balance* (I + II)**	**89.83**	**-43.88**	**25.66**	**52.96**	**61.90**	**44.38**	**65.80**	**46.64**
Cumulative cash balance	**89.83**	**45.95**	**71.61**	**124.57**	**186.47**	**230.85**	**296.65**	**343.29**

Table IX shows the EBIT and EBITDA of the model, both of which report positive results starting from year 3 and year 2, respectively.

Table IX. Summary of results (thousands of euros).
Tabla IX. Resumen de resultados (miles de euros).

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
EBIT *(Earnings Before Interest and Taxes)*	-89.29	-22.87	14.48	16.22	15.71	18.05	20.55
EBITDA (*Earnings Before Interest, Taxes, Depreciation, and Amortization*)	-45.05	21.36	59.80	61.63	63.52	65.51	67.57

Break-even Point and Sensitivity Analysis

Table X shows the evolution of the break-even point calculated for the full model and each production line. The break-even analysis demonstrated a progressive shift toward economic sustainability. During the first two years, the break-even point reflected typical conditions of an aquaculture project startup, where production volumes and revenues were insufficient to cover fixed and variable costs as well as depreciation. From the third year onward, the break-even point decreased to an acceptable level, going from 87% in year 3 to 84% in year 7.

The species-specific break-even analysis revealed significant differences in the profitability of the two production lines. For *M. gigas*, the break-even point improved markedly from 376.5% in the initial year to a stable range of 57–55% from the second year through the end of the period, showing a rapid path to economic consolidation.

Unit production costs for *M. gigas*, calculated based on its isolated direct costs, experienced a significant reduction—from €16.22/kg in the first year to €5.95/kg by year 7. This line requires annual sales between 5,600 and 5,800 kg to reach its break-even point.

In contrast, *C. tulipa* displayed a different economic pattern, with no revenue in the first year due to its longer cycle, which includes in-house spat production in the hatchery. From the second year onward, its break-even point evolved from 331.8% to a range of 95–93% in subsequent years. Unit production costs for this species decreased from €21.09 in year 2 to €10.2 in year 7. To break even, this business line needs to sell between 7,600 and 7,500 kg from the third year onward, equivalent to 95–93% of the maximum production volume considered in the model.

The economic performance difference between the two species is mainly explained by their different commercialization formats: fresh sales of *M. gigas* offer a more favourable cost-benefit ratio than the processing of *C. tulipa* into dried meat.

Nevertheless, both lines contribute significantly to the model's overall operational and accounting viability, although dried meat production alone is not a viable standalone option.

From a financial perspective, the profitability targeted by this model was based on achieving an NPV = 0, indicating that the revenues generated would exactly cover the investment and operating costs, without producing financial returns beyond the discount rate—resulting in an IRR = 5%.

The univariate sensitivity analysis, under an optimistic scenario, identified the factors with the greatest impact on the model's financial viability. Both the selling price and production level were evaluated with a 10% increase. In both cases, a significant positive effect was observed on the NPV and IRR, with price having a more pronounced influence. In parallel, initial investment, variable costs, and fixed costs were each reduced by 10% to assess their influence. The impact of these reductions on financial indicators was smaller, with the reduction in fixed costs having the least effect on profitability (Figure 1).

Table X. Evolution of the break-even point of the model and by product line.
Tabla X. Evolución del punto de equilibrio del modelo y por línea de producto.

Model Break-even Point	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**
Revenues (thousands of €)	18.13	102.35	153.00	158.05	163.26	168.65	174.22
Variable Costs (thousands of €)	16.22	31.25	41.60	42.97	44.39	45.86	47.37
Gross Margin (thousands of €)	1.91	71.10	111.40	115.08	118.87	122.79	126.85
Fixed Costs + Depreciation (thousands of €)	91.19	93.97	96.91	98.85	103.16	104.74	106.29
Total Costs (thousands of €)	107.41	125.22	138.51	141.82	147.55	150.60	153.66
Break-even (%)	4774%	132%	87%	86%	87%	85%	84%
Break-even (thousands of €)	865.59	135.27	133.10	135.76	141.68	143.86	145.98
Break-even Point for *M. gigas* (live product sales)							
Revenues (thousands of €)	18.13	74.89	77.36	79.92	82.55	85.28	88.09
Variable Costs (thousands of €)	10.01	19.24	21.42	22.12	22.85	23.61	24.39
Gross Margin (thousands of €)	8.12	55.65	55.94	57.80	59.70	61.67	63.70
Fixed Costs + Depreciation (thousands of €)	30.55	31.38	32.26	32.84	34.14	34.61	35.08
Unit Price (€ / kg)	7.25	7.49	7.73	7.99	8.25	8.53	8.81
Production Cost (€ / kg)	16.22	5.06	5.37	5.50	5.70	5.82	5.95
Break-even (%)	376.2%	56.4%	57.7%	56.8%	57.2%	56.1%	55.1%
Break-even (thousands of €)	68.21	42.23	44.61	45.41	47.21	47.86	48.51
Break-even (tons of oysters)	9.41	5.64	5.77	5.68	5.72	5.61	5.51
Break-even Point for *C. tulipa* (dried meat sales)							
Revenues (thousands of €)	0.00	27.46	75.64	78.13	80.71	83.37	86.12
Variable Costs (thousands of €)	6.21	12.01	20.19	20.85	21.54	22.25	22.99
Gross Margin (thousands of €)	-6.21	15.45	55.45	57.28	59.17	61.12	63.13
Fixed Costs + Depreciation (thousands of €)	49.33	51.27	52.90	54.22	56.28	57.52	58.79
Unit Price (€ / kg)		9.15	9.45	9.77	10.09	10.42	10.77
Production Cost (€ / kg)		21.09	9.14	9.38	9.73	9.97	10.22
Break-even (%)		331.8%	95.4%	94.7%	95.1%	94.1%	93.1%
Break-even (thousands of €)		91.12	72.16	73.96	76.77	78.46	80.20
Break-even (tons of dried oyster meat)		**9.96**	**7.63**	**7.57**	**7.61**	**7.53**	**7.45**

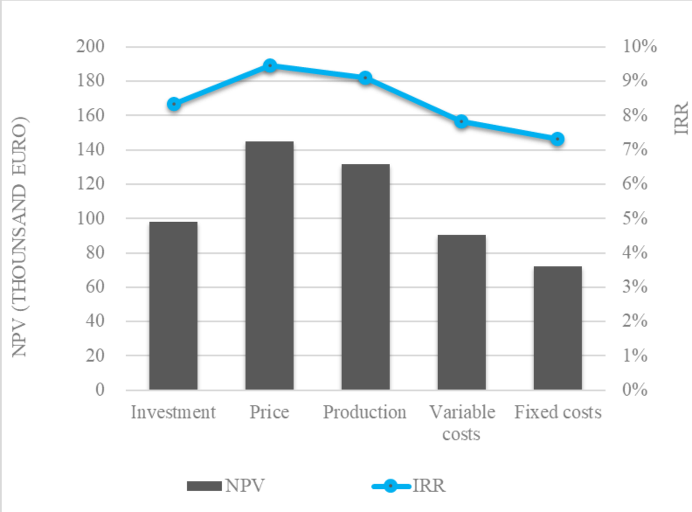

Figure 1. Univariate sensitivity analysis and its effect on IRR and NPV. Baseline scenario: NPV = 0 and IRR = 5%. Optimistic scenario: 10% increases in price and production volume and a 10% reduction in investments, variable costs, and fixed costs.
Figura 1. Análisis univariante de sensibilidad y su efecto sobre la TIR y el VAN. En un escenario base: VAN = 0 y TIR = 5%. Escenario optimista: incrementos de 10% en el precio y volumen de producción y reducción en una 10% en las inversiones, costos variables y costos fijos.

DISCUSSION

The CANVAS model has been widely used as a tool for designing business models in various productive sectors; however, in aquaculture, it remains an underutilized tool with few published studies and is virtually non-existent in social applications. In the present study, the social version of the CANVAS model (SEMC), proposed by Sparviero (2019), was applied due to the hybrid nature of the project, which combines economic objectives with a strong social, environmental, and inclusion-oriented dimension through oyster farming. This approach contrasts entirely with the conventional model, which focuses on value creation by identifying the best economic performance (Osterwalder and Pigneur, 2010). In this type of initiative, the SEMC model can help prevent "mission drift" and maintain consistency between social and economic values.

The final SEMC model canvas presented (Table IV) provided a broad overview of the proposal and may serve as a handy useful tool in defining and developing a social oyster farming project in Senegal. It allows for the completion of key aspects of the business model by clearly identifying, for example, the name and location of potential customers, the most viable distribution channels, product characteristics, and key activities, among others. When applied within a continuous improvement framework, this tool facilitates the strategic design of the business model and provides a structured foundation that feeds into the economic-financial evaluation while also allowing feedback to the SEMC model, thereby strengthening the overall coherence and feasibility of the project.

In this particular case, a small-scale oyster farming model was proposed for the Saloum Delta, with the capacity to produce the equivalent of 50–55 tons of live weight per year and the creation of 26 direct jobs. The value proposition, mission, and objectives are fully aligned with the goals outlined in Senegal's National Strategy for the Sustainable Development of Aquaculture 2026–2032, which aims to generate 2,500 tons of oyster production and 3,500 stable direct jobs (ANA 2023).

The model identifies material investments for farming infrastructure, modular depuration and processing plants, and machinery lines for oyster handling, which increases the overall investment required. The model is not exclusively focused on the native species; rather, it proposes the farming of two species: triploid *M. gigas*, which enables revenue generation to begin at least one year earlier, and the native species *C. tulipa*.

On the other hand, the developed model considered two sales formats: live oysters (*M. gigas*) and dried meat (*C. tulipa*), in line with the findings reported by Drago *et al*. (2023) in their study on the oyster value chain in Senegal, conducted within the framework of the FAO's FISH4ACP project. According to that study, national oyster production is estimated at around 16,000 tons per year, distributed across three marketing formats: fresh (mainly targeting tourism and representing less than 1% of total volume but commanding higher unit prices), and processed (boiled meat and dried meat), which together account for approximately 99% of the total volume.

However, the results of our analysis indicate that a similar project based exclusively on dried meat production (the traditional consumption format of *C. tulipa* in the country), without including a higher-value product format (live *M. gigas*), is economically and financially unviable. The revenues generated are insufficient to sustain positive operating cash flows, and the Net Present Value (NPV) becomes increasingly negative reaching up to 2.4 times the initial investment.

Our oyster farming development strategy, as derived from the proposed model, aligns with the recommendations of Nowland *et al*. (2020), who argue that in order to foster oyster aquaculture in resource-limited countries, it is essential to strengthen biological knowledge of local species and establish regional or centralized hatcheries that ensure a consistent and reliable supply of spat, thus reducing dependence on wild collection.

The use of *M. gigas* facilitates the initial implementation of the project; however, once this startup phase is completed, this species could be fully replaced by *C. tulipa* across all sales formats. Additionally, the model includes the sale of depurated live oysters from in-house facilities and incorporates a cost associated with commercialization. This strategy would allow greater control over the selling price and, in theory, improve profit margins. Nevertheless, it also entails additional costs related to the maintenance and operation of depuration infrastructure, as well as compliance with quality standards, food safety, and laboratory testing.

The study on the oyster industry in Maryland (Senten *et al*. 2019) suggests that in certain contexts, the viability of this type of model may improve through shared infrastructure schemes, which could help optimize costs without losing control over marketing. This aspect is especially relevant for small-scale aquaculture enterprises (SSAE), as it would help reduce the influence of intermediaries who, in many cases, benefit from the limited organizational and commercial capacities of small-scale producers (Lagno *et al*. 2023).

In the present economic evaluation, a 5% discount rate was used, explicitly seeking the condition under which the Net Present Value (NPV) of the project equals zero. Although this methodological choice may appear conservative compared to the international average observed in aquaculture projects—around 10.6% (Ruiz and Zuniga-Jara 2018)—it is supported by the conceptual framework proposed by Sokolov (2024), who argues that projects with an NPV equal to zero represent a critical threshold of minimum profitability, useful for assessing financial stability under various economic uncertainties.

In particular, Ruiz and Zuniga-Jara (2018) note that aquaculture projects developed in developing countries tend to apply higher discount rates (approximately 13.9%) due to additional perceived risks in these contexts. However, given that the primary goal of the analyzed project is social impact—specifically, alleviating poverty and reducing hunger through oyster farming—a lower discount rate was chosen to define the minimum required social profitability.

In line with Sokolov (2024), evaluating a social project at the precise point where NPV equals zero allows for a clear determination of its minimum viability, providing valuable insights into its sensitivity to changes in future cash flows or adverse socioeconomic conditions. This approach ensures that the resources allocated to the project generate effective social impacts, even if they limit purely economic returns.

CONCLUSIONS

This study demonstrates that the Social Enterprise Model Canvas (SEMC) is an effective tool for designing small-scale oyster farming projects with a social focus, providing useful guidelines for structuring the business model, economic evaluation, and operational plan. The approach integrated technical, social, and financial criteria, achieving operational sustainability under conservative profitability conditions (NPV = 0; IRR = 5%).

The inclusion of triploid *M. gigas* enables the anticipation of key revenues for financial viability, while *C. tulipa* contributes social and environmental value to the model. It is concluded that the exclusive production of dried meat is economically unviable. The proposed system is replicable, sustainable, and aligned with national strategies for aquaculture development and poverty reduction.

DECLARATION OF CONFLICTS OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Rodrigo Burgos-Vega: preparation of the database, economic-financial analysis, and manuscript drafting.
Javier Quinteiro-Vázquez: contribution to the CANVAS model and manuscript.
Manuel Rey-Méndez: CANVAS model, manuscript review, and discussion.

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