The Economics of Aquaculture with respect to Fisheries

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EVALUATION OF INTERNALISATION PROCESSES IN ENVIRONMENTAL MANAGEMENT SYSTEMS: AQUACULTURE AND OFFSHORE MUSSEL FARMING

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Abstract

In recent years, particular attention has been paid to fishing activities, and more specifically to aquaculture, a production process whose environmental impact at present is not being adequately submitted to any sort of serious assessment and control. The impact of aquaculture on the environment has nonetheless become an important issue for both potential customers and public opinion. The purpose of this study is to appraise environmental protection costs if and when a certified program of environmental management is put into effect in an attempt to change the present situation in which firms only comply with minimum environmental standards. A survey was conducted of all relevant information regarding production, organization, and budgetary aspects at the two firms participating in the study, i.e. an intensive fish farm, and a mussel farm. An environmental accounting methodology was applied to the analysis of the data obtained from the survey. Through the representation of qualitative and quantitative data assessing the impact of production processes on the environment, the study attempts to propose an economically viable and financially sustainable environmental planning program for safeguarding both enterprise and environment.

Keywords: environmental management system, aquaculture farming, economic sustainability, green accounting.

Jel classification: Q220, Q120

Introduction

Faced with growing social and institutional pressures, companies are finding themselves ever more obliged to include environmental factors among strategic management variables. In fact, the introduction of criteria and procedures to manage environmental problems correctly enables production management as a whole to be rationalised and simplified from both a technical and an administrative point of view, improving company image and prestige and optimising the positive spin-off associated with technological and organisational innovation.

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Internalisation of environmental variables is gradual and may be implemented at various levels. The first step for the company is to review its mission and the guiding principles behind its economic choices and to change the organisational structure. This leads to formulation of guidelines for the company's environmental policy and strategies for setting up, managing and communicating actions to achieve the established objectives. Depending on the complexity of the production process and intensity of the action planned, the various phases of implementation constitute a more or less advanced environmental management system (EMS) model, and require a commitment of financial, technological and human resources which the company must take into account and weigh according to its objectives and the pressures from its economic interlocutors.
In the aquaculture sector in particular, where there is a high degree of integration between economic activities and environmental performance, the development and evaluation of an active environmental policy giving priority to the prevention of environmental problems becomes a fundamental element in company management. Aquaculture, including mariculture, represents an important part of the Italian fish sector, both as a production activity in many coastal areas, and also as part of the demand for food.
Bearing this in mind, an economic analysis was carried out to quantify and evaluate the implementation of the various phases of an environmental management system, not just from an economic-financial point of view, but also in terms of the commitment of technological and human resources. In particular, after providing an overview of the principal implications with reference to a social, economic and political context ever more sensitive to environmental performance, with repercussions on the company's value chain and competitiveness, the study identifies and describes the economic effects produced by adoption of instruments to safeguard the environmental variable in two case studies in the aquaculture sector, through the measurement and processing of technical-economic data and the relative values associated with environmental planning.
The first case study involves the intensive farming of gilthead bream and sea bass, starting from in-house reproduction and continuing through the larva-rearing and pre-fattening phases to fattening of the fish to a marketable size. The second looks at a mussel-farming company using the long line technique, with a total line length of 23,000 m, four miles off the coast.

The study aimed, on one hand, to identify and quantify the procedures required to reduce the environmental impacts of developing aquaculture and therefore improve environmental aspects of company management, and, on the other, to provide public decision-makers with the elements required to evaluate effective action to develop environmental policies in the aquaculture sector.

The Environment in Company Strategies

A company which decides to internalise the environmental problem often makes this decision as the result of an environmentalist conscience deriving from a series of internal and external stimuli. These pressures may materialise in different ways - indirectly through the pressure of public opinion on the legislature, or directly through environmentalist associations and consumers.

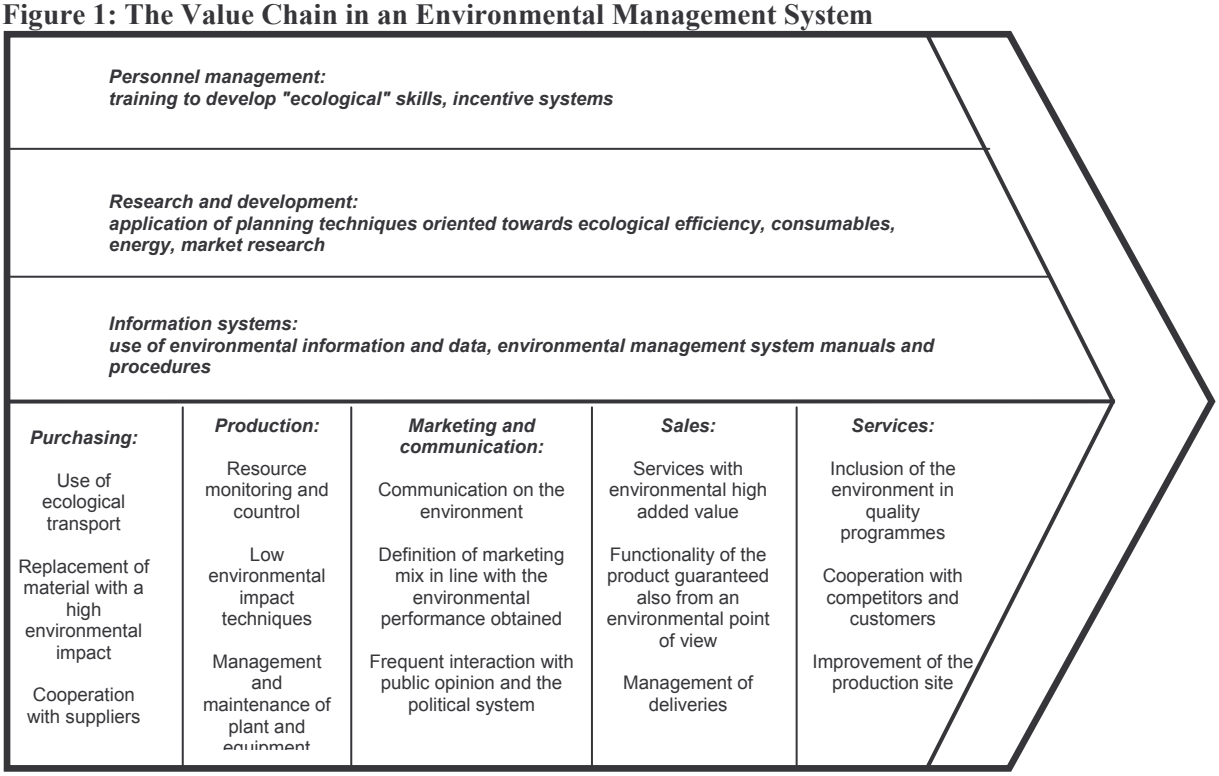
For the company, this may represent new opportunities, associated in particular with the market demand for environmentally friendly products. The characteristics of the economic system and market conditions without doubt influence company behaviour. For example, in the case of highly competitive markets, limited profit margins may result in low attention to the environment. It goes without saying that often the company is concerned with what the consumer is able to perceive (product positioning) rather than what cannot be seen (production processes).
The political and institutional context strongly influences the policies adopted by companies. However, it must be noted that the decisions made by national and supernational policy makers are not limited to imposing constraints on the activities of companies. They also aim to promote the creation of innovative products and processes with low environmental impact, to stimulate the development of new production and services activities and, finally, to encourage the birth and growth of environmentally compatible activities. As stated by Porter (1991), it is, in fact, precisely the introduction of more or less severe rules on environmental impact, product safety standards, etc., which gives nations a certain competitive advantage as they put pressure on companies to improve quality and technology and develop the sectors of greatest social interest, the sectors most attractive to customers.
Companies frequently interpret rigid constraints only as a short-term limitation to competitiveness, possibly compensated for by opportunities evident only in the medium term. From a more modern viewpoint, the change in not just culture, but also the market, with variations in the pricing system, changes in demand and the presence of more restrictive production and distribution constraints, has led many companies to consider the environmental dimension as a genuine strategic lever, redefining more effective processes and products oriented towards minimising impacts, maximising efficiency and creating added value by improving integration with the environment throughout the production chain. Over a more or less long period, this can lead to the creation of competitive advantages for the company, based not so much on cost leadership as differentiation of the company's behaviour and its integration with financial interlocutors in an ever-greater market which is increasingly sensitive to environmental issues. This behaviour brings about a gradual change in company organisation and its relationships with financial interlocutors both inside and outside the production system. These changes to the company's general structure generally result in modifications to production processes and products. Given this, it is possible to provide an overview of the principal implications with reference to a social, economic and political context ever more sensitive to environmental performance, with repercussions on the company's value chain (Figure 1) and competitiveness.
The environment may influence both the primary and secondary activities in the company system. Firstly, an important role in the improvement of environmental performance is played by purchase policies which require new selection criteria for incoming elements. In other words, greater attention must be paid to the environmental effects of the materials purchased, assessment of suppliers and storage of goods, and, in addition to the traditional factors of cost, quality and delivery times, the environmental performance of the products. Incoming logistics require more organisation to avoid an increase in traffic in the transport of goods with consequent pollution problems.

The growing importance of the environmental factor also has considerable repercussions on production activities, as numerous standards require a certain level of evaluation, obliging

companies to introduce clean technologies and adopt techniques with low environmental impact. Marketing and communication activities are also involved, with strengthening of the instruments used to publicise the environmentally friendly characteristics of the product and to heighten the market's awareness of the importance of the ecological dimension of products and processes. Sales do not only involve placing the goods on the market, paying attention to outgoing logistics, but also all the services with environmental added value for society as a whole. Finally, another primary activity involves the services performed in order to reinforce co-operation with competitors and customers, together with all the commitments aimed at integrating with society and the creation of landscape or environmental externalities.

Secondary activities come mainly under the heading of personnel management in the form of training courses to improve environmental performance, but also involve incentive systems to guarantee the medium- to long-term sustainability of environmental strategies. Information systems also require a certain effort, not just to produce documentation, but also to measure and continuously analyse environmental information and indicators of impact on the ecosystem, with quantification of the economic commitment, integrated with the general company information system. Finally, in the context of value-generating activities, the development of technologies is of particular interest, involving the adoption of techniques and technologies capable of reducing environmental impact and optimising use of resources in the production process.

Figure 1: The Value Chain in an Environmental Management System



Economic and Management Analysis of the Environmental Management System

The environmental management system is an evaluation and control procedure generating behaviours capable of guaranteeing compliance with existing legislation and producing continuing improvement in environmental performance, including through the application of the best available and economically feasible technologies. While in quality terminology one refers to "non-quality" costs, in the environmental sector it would be more appropriate to talk of "non-environmental" costs. Investments aimed at energy-saving or at the use of cleaner resources provide financial returns. Tax penalties on the generation of waste, air pollution, etc. also justify a commitment to the environment. Also avoidable are the costs associated with administrative and penal sanctions following violation of regulations or compensation for damage to the environment or people. Economic returns can be obtained by not creating hidden liabilities. For example, take a company which buries toxic waste in its own yard and whose processes do not comply with water discharge legislation, or companies using equipment which has not yet been amortised and does not comply with environmental standards, or again, companies who may well have saved money for a certain period of time, but in doing so have created hidden liabilities which could come to light during a health authority inspection, a request for a bank loan, or the signing of an insurance policy.

It should however be remembered that the environment is by its very nature predominantly a public asset, and few aspects of environmental safeguarding are even partially governed

by the laws of the market. A company which pollutes creates diseconomies for other parties, in other words, costs which are not attributed to the originator.

When evaluating the economic aspects of an environmental policy measure, all the costs and benefits for all the subjects directly or indirectly involved must be taken into account. When the negative effects cannot be quantified in financial terms, they must be considered using a suitable methodological approach, for example, cost-effectiveness analysis or multi-criteria analysis. The financial benefits of environmental actions are therefore not always easy to demonstrate and calculate. Sometimes it takes many years for them to become obvious, and they often involve intangible factors (e.g. improved company image) and frequently take the form of costs avoided rather than actual cash flows. Sometimes the potential benefits of an environmental management system and audit are therefore considered from a quality point of view only, considering the various parties concerned, starting with the company.

In short, the possible benefits for companies adopting an environmental management system can be summed up as:

1. benefits which reduce the current costs of mediocre environmental results (rationalisation of procedures, continuous monitoring of regulatory compliance, optimisation of resource utilisation etc);
2. benefits which reduce the potential future costs of mediocre environmental results (greater regulatory safety, prevention of the attribution of civil liability costs, reduction of risks, accidents and emergencies etc);
3. improved image with the public, customers, suppliers, the business system and operators;
4. facilitation of a partnership relationship with the public and local communities;
5. possible simplification of environmental controls by the competent authorities;
6. special terms for credit, insurance and financing;
7. benefits deriving from an increased market share and improved or protected opportunities (possible condition for access to work or supply contracts).

In particular, in the case of certified sites, there could be a number of current or potential opportunities, including:

a) special terms:

- voluntary self-assessment agreements by companies, reducing the burden of controls and/or simplifying authorisation procedures;

- reduction in the environmental tax burden for companies demonstrating significant improvements in discharges and environmental impacts;

b) contractual terms:

- obligatory adoption of the system as a condition for access to public contracts;

- obligatory adoption of the system as a condition for obtaining special terms for credit or financing aimed at safeguarding the environment;

- adoption of the system as a tool for verifying conditions defined as part of an environmental risks insurance contract;

- adoption of the system as a tool for verifying conditions defined as part of financing contracts between the company and financial institutions;

adoption of the system as a tool for verifying conditions defined as part of supply contracts between the company and its suppliers or contractors.

As regards the costs, these are easier to identify and quantify. The following can be identified:

- costs associated with consultancy and certification
- investments in equipment and instrumentation for monitoring and mitigating pollution or in intrinsically less polluting technologies. These costs could be ascribable to equipment management and maintenance costs if already included in the production cycle with a view to future compliance with specific environmental regulations. It is fundamental that, from that moment onwards, the environmental variable is included in all investment decisions and maintenance scheduling.
- costs associated with self-assessment.

Methodological Aspects

The effects of the action taken as part of an environmental management system (EMS) were measured using the environmental balance method. This is an accounting tool able to provide a systematic statement both of the relationships between the company and the environment and of the economic and financial burden borne by the company in order to safeguard the environment. During this phase, the aim of the study is to evaluate the incidence of environmental protection costs and their variation following implementation of a certified environmental management system with respect to an initial situation with minimum compliance of the company with environmental standards.

Environmental accounting is complicated by the fact that costs, particularly in small and medium-sized enterprises, and above all in those we are concerned with, are classified according to their nature and not by how they are allocated. It is therefore difficult to obtain all the information necessary for business accounting. As in our case, those elements of company costs and revenues with a certain relevance to environmental management and protection must be identified and reclassified. The costs relating to these activities were reclassified (ARSIA, 2000) as follows:

- measurement and control activities: largely consisting of the work of personnel involved in continuous monitoring and control of environmental conditions;

- pollution prevention activities (action to prevent the formation of pollutants): activities aimed at pollution prevention and the maintenance of instrumentation, amortisation of the machines and equipment used to prevent impacts on natural resources (purifiers, alternative energy generators, waste water disposal); certification costs;
- treatment and abatement of pollutant emissions (action aimed at reducing environmental impacts): environmental taxes, insurance for environmental risks, administrative costs for the issue of authorisations or certificates, the operating costs of specific equipment.
- mitigation of existing environmental pollution levels (water, land): the costs of reclaiming polluted sites.

From an operational point of view, these activities may either be carried out in-house or purchased on the market. In either case, the method involves gathering and recording the data by means of various procedures - in the case of in-house activities, the costs of producing the environmental service must be identified, while in the case of services bought on the market, the cost is much simpler to obtain. The analysis was carried out directly on the premises of the companies concerned by means of a technical-financial data collection sheet containing all information on production factors, organisational aspects and elements in the company balance sheet. The technical and financial values for production and product factors refer to 2003 and 2004, and were deduced partly from accounting documents and partly from other information obtained from direct interviews with company directors. Data acquisition largely concerned the times taken to perform the work in the various production phases, the type and cost of immobilizations, consumption of raw materials, tax and financial burdens, and all those costs which form part of general company management and enable the figures in the balance sheet to be determined. In the case of material immobilizations already present in the company, an amortisation schedule was adopted according to the presumed technical-economic working life. For capital account costs relating to planning activities and the implementation of certification procedures, a 10-year amortisation schedule was adopted. The information gathered was reclassified and arranged according to the company balance sheet scheme, following two hypotheses - one with the current situation of normal company management in compliance with regulations and the other hypothesising the application and certification of EMS procedures.

To evaluate the effects of applying ISO 14000 certification procedures, it was decided to retain the technical and financial values for the environmental aspects already defined in the previous situation and add the financial elements relating to planning activities and the changes made. The incremental investment and operating costs - namely those values varying with respect to the previous situation - were therefore identified and separated out. The same was done for the benefits.

To determine the results of the balance and relative environmental effects, the following procedure was adopted:

- During the first phase, a balance sheet was prepared enabling the general operating results of the companies concerned to be determined in the current situation.
- Subsequently, on the basis of the same balance sheets, the various components associated with environmental aspects were determined by identifying and reclassifying the items relating to practices associated with environmental aspects already adopted by

the company to guarantee regulatory compliance. This involved quantifying the actions and relative costs borne by the company to ensure compliance with current regulatory obligations and possible voluntary environmental safeguarding and respect of actions already undertaken at personal level by the company owner.

- Finally, it was hypothesised that an environmental management system was set up within the same companies and implemented in accordance with international ISO 14000 standards, with the definition of an operating and environmental planning programme. In this case, costs and revenue associated with the environment were identified and quantified, with the exception of those already calculated previously (added to calculation of the balance) or those which are explicit, implicit or indirect, in other words, not immediately perceptible.

The costs of improving environmental performance associated with expenditure in the capital account required or utilised to prevent and mitigate environmental impacts are kept separate from certification costs. During this phase, possible positive or negative environmental impacts outside the logic of the market, which are difficult to quantify or ascribe a monetary value to, were not identified, although, given the particular nature of the sector, the possibility was recognised of obtaining positive externalities affecting the local region and community as a whole from application of an environmental management system.

Companies Involved: Production Structures and Environmental Planning

Applying the standard ISO 14000 certification procedure, an economic evaluation was performed of two aquaculture companies. The first, located in Tuscany, is involved in intensive farming of sea bream and sea bass, starting from in-house reproduction and continuing through the larva-rearing and pre-fattening phases to fattening of the fish to a marketable size. The company is in a favourable position from a tourism and landscape point of view, but is without landscaping infrastructure and elements, with negative repercussions on visual impact. Production takes place in 20 tanks on land where the fish are raised during the fattening phase, and a large industrial building divided into two, housing 10 tanks for larva-rearing and 25 tanks for pre-fattening and maintaining the phyto- and zoo-plankton. The company has a phyto-purification plant, and water quality control is contracted out to an external company. It employs a workforce of eight including the company director. Production amounts to about 120,000 kg and is sold largely through wholesalers who place it on markets outside the region.

From an environmental point of view, the company respects current regulations on safety in the workplace, waste disposal and water quality control and complies with legislation. However, its objectives and action programme undertaken can be summed up as follows:

1. respect of legal limits, through monitoring and the yearly application of procedures and the documentation produced;

2. reduction in electricity consumption where technically possible, using a company specialising in the installation and operation of photovoltaic panels producing alternative energy;

3. where possible, replacement of polluting products with others with a lower environmental impact;

4. control and optimisation from an environmental and economic point of view of waste disposal and waste water discharges, with weekly verifications and implementation of procedures to improve the efficiency of waste management;

5. heightening the awareness and involvement of the workforce with regard to correct environmental behaviours and the safeguarding of health and safety in the workplace;

6. improvement of the landscape and environmental conditions of the site.

The mussel farming company, located in Emilia Romagna region, consists of a cooperative employing a workforce of six and producing exclusively mussels. It uses the long line technique with a total of 23,000 m of lines four miles off the coast. The production of about 440,000 kg, divided into socks, loose and seed, is sold directly by the cooperative to distributors, but also to wholesalers and other producers for finishing the young material.

From an environmental point of view, the mussel farming company intends to pursue the following objectives by means of a series of programmes:

1. respect of legal limits, through monitoring and the yearly application of procedures and the production of documentation:

2. mitigation of marine pollution from waste oil from hydraulic gears and boat engines through the control and separation of bilge waters;

3. where possible, replacement of polluting products with others with a lower environmental impact;

4. control and optimisation from an environmental and economic point of view of on-board operations and better management of the installation by means of constant verification of correct balance between the load on the buoys and the weight of the socks, and a reduction in resocking operations;

5. mitigation of the environmental impact on the waters surrounding the installation through water quality monitoring by specialised companies;

6. heightening the awareness and involvement of the workforce with regard to correct environmental behaviours and the safeguarding of health and safety in the workplace.

The environmental certification project will be developed in the following phases:

- initial environmental analysis
- planning
- design and implementation of the environmental management system
- information and training
- in-house environmental audit

- management review.

As regards certification alone, three broad categories of cost can be identified:

- design: the costs of consultancy provided by an external company in support of implementation of the EMS. These costs cover carrying out the environmental analysis, defining the environmental programme, drawing up operating procedures, defining responsibilities and tasks, preparing working documents for the auditing and drafting the environmental report;
- training of in-house personnel, with the involvement of the quality manager;
- initial certification by the organisation.

Economic Results

As already described, the aquaculture establishments involved already apply environmental measures as part of normal company management, as they aim to guarantee compliance with current environmental protection legislation.

Case 1: Intensive Fish Farm

In the situation existing before adoption of the certification procedure, the analysis performed made a distinction between economic elements associated with environmental aspects and those relating to ordinary activities. From these, it can be seen that the company produced revenue of €824,922 from the sale of about 120,000 kg of sea bream and sea bass. The environmental costs, direct or real costs in compliance with rules, amounted to about €41,000, representing approximately 6% of operating costs and 4.9% of production value. It must be emphasised that the environmental costs refer to the company's current operating costs and cover in particular:

- depreciation of the phytopurification tanks.
- waste management involving a register recording the loading and unloading of dangerous materials, as the company stores the waste temporarily then subsequently disposes of it once a month through an external company. Other waste weighing less than 10 kg per day is disposed of through the usual urban channels. Exhausted oils and batteries come under the heading of ordinary maintenance through the services of the mechanic directly responsible for their transport.
- the work of in-house personnel for operations with the highest impact such as cleaning the larva rearing and fattening tanks, water quality analysis and in-house maintenance of equipment.
- monitoring of waste water. The plant complies with the provisions of current legislation and control and monitoring activities are delegated to an external company.
- general expenditure, in particular waste disposal tax.
- maintenance carried out by external companies, in particular, fire prevention and maintenance of the heat generator plant.

As regards environmental planning actions, Table 1 gives the costs broken down by category and type of action taken and the direct benefits for the company deriving from certification, together with the percentage variation of the economic results with respect to the previous situation. Non-marketable and long-term benefits have not been included. Concerning costs, we considered direct and implicit costs, for avoiding potential future expenses.

The costs include the creation of guided walkways and hedges, planting of bushes and plants along the access roads and boundaries and in the most exposed zones, and construction of photovoltaic panels for the production of clean energy. In terms of costs, there are therefore no great savings as the reduction in conventional energy costs is largely compensated for by the costs of installing the panels. However, the possibility of replacing conventional energy of high environmental impact with alternative renewable energy with positive effects on the environmental system is nevertheless interesting. Installation represents an investment of about €77,468, taking account of regional financing to encourage use of alternative energy.

The cost of certification depends largely on the initial environmental situation of the company and the complexity of its activities. If it is already the practice of company personnel to draw up procedures, organise meetings and define criteria for responsible behaviour, if the company management is already orientated towards respect for the environment and sensitive to application of an EMS, or if the production process is not greatly diversified and of limited dimensions, then certification costs are lower. In this case, it is easier to implement the certification procedure, and the implementation and management costs are therefore lower. The total investments required to obtain certification amount to €28,498.

Certification management costs are relative to the time dedicated to the environmental management system by the EMS officer and company personnel. This includes time spent on analysis and control of water quality and the use of resources, monitoring energy consumption and internal verification and control during the various phases of the production process. The immediately calculable effect resulting from installation of the photovoltaic panels derives from the savings in energy costs. The calculated savings amount to 75,000 kW, equivalent to €7,600, relating in particular to the use of equipment such as oxygenators and feeders with low current absorption. However, the greatest benefit derives from the type of energy consumed, in other words, the fact that it is clean renewable energy with low environmental impact. Account must be taken of the fact that the training and attention of personnel to environmental aspects also enables waste to be limited through prudent use of equipment (oxygenators and food distributors in particular), enabling consumption to be reduced by around 10,000 kW, namely €1,024, equivalent to about 8% of the consumption of low-absorption equipment.

Another benefit derives from savings in the cost of the services provided by external companies to control and monitor the water in the phytopurification process. Preparation and implementation of the procedures in the manual enable the cleaning and monitoring of

inflow and outflow water to be improved. Continuous verification also reduces the costs of verification by the external company.

Finally, an important effect of implementation of the certification procedure derives from the systematic management of documentation, enabling all management information to be kept in an orderly and complete fashion, improving the efficiency and prevention capabilities of personnel. This results in a saving in resources (work time in particular) of about €1,756, equivalent to 180 hours of work. The share of environmental assets in total farming assets is about 18.7%.

Table 1: Costs and Benefits by Category and Type of Action: Intensive Fish Farm

Benefits (€)		12,446.6
Savings - energy costs	8,624.8	
Savings - personnel management	1,756.8	
Savings - control and services external company	2,065.8	

Incremental Environmental Costs (€)	Investment Cost	Operating Cost*
Energy photovoltaic	77,468.5	5,164.6
Landscape management	26,855.8	1,861.3
Implementation of certification	28.498.1	0.0
Management of certification	0.0	3,899.2
Management and control of water and production processes	4,028.4	5,526.1

* Excluding amortisation related to environmental planning

The results obtained from the reclassified income statement show that the environmental operating costs increased by 73% with respect to the original situation, amounting to around €71,500, about 10% of operating costs and 9% of production value. The amount of production increases slightly due to savings obtained by certification, as the revenue from fish sales remains unaltered. The result for the financial period naturally drops to about €66,000. No account was obviously taken of possible financing or special terms for which the company may be eligible as a result of adopting an environmental certification programme, nor were the positive externalities possibly rising in the long term and representing a future target for the company determined or estimated.

Table 2: Revised Income Statement after Intervention: Intensive Fish Farm

	Values €	*Values €€*	Values	% value of production	% difference. before/after
Value of production			837,369.0	100%	1.5%
Revenue		824,922.3			
Benefits deriving from certification		12,446.6			
Total operating costs			727,267.3	86.8%	4.3%
Raw materials and services		371,054.8			
Amortisation and depreciation		51,176.6			
Maintenance		40,903.4			
Insurance		0.0			
General expenditure		56,810.3			
Wages and salaries		135,797.2			
Environmental operating costs		*71,525.1*		8.5%	72.8%
Raw materials and services	23,113.5				
Amortisation and depreciation	17,031.7				
Maintenance	6,300.8				
Wages and salaries	24,562.7				
General expenditure	516.5				
Operating result			*110,101.6*	*13.1%*	*- 13.8%*
Financial charges		41,538.9			
Taxes		2,557.0			
Income			*66,005.8*	*7.9%*	*-23.7%*

Case 2: Mussel Farm

The structure and organisation of the mussel farm are relatively simple, and this facilitates the application of an EMS. The action envisaged in the environmental plan involves monitoring the impact of the mussel farm on the concession area, performed by an external company for a cost of €7,750. As a greater guarantee of the company's propensity for prevention, to make the socks, it is buying in supplies of better-quality polypropylene net than before. This material is more resistant to temperature change and adapts better to sea water. This increases net purchase costs by 8%. A further precaution regards bilge discharges from the vessel. The company is adopting sediment filters to separate the bilge water from the oil produced by the hydraulic gears and motors, thus preventing the discharge of oil into the sea. This increases the work input, with repercussions on the cost of personnel and the purchase of equipment and material.

One of the prevention and control operations considered by the company is socking (???), which involves a certain environmental impact. In fact, an excessive number of sockings increases the possibility of rubbing of the material being handled, and as a consequence increases production of waste which is dispersed in the water. Given the structural and

organisational characteristics of the production process, which is simpler than the previous case, the cost of certification amounts to €23,000 with annual management costs of about €2,300. The costs of maintaining and managing certification are ascribable to the time spent on the analysis and control of water and the use of resources and on in-house verifications, and amounts to €7,813 per year.

The direct and immediate benefits for the mussel farm studied derive from in-house management of the installation. Preparation of an EMS would enable the balance between the number of floats and the weight of the socks to be improved by reducing the use of buoys and therefore also their operating costs with a reduction in loss and wear. As the weight of the sock increases, so does the number of buoys used. But excessive use of buoys increases the resistance, leading to damage to the sock, with dispersion of the material in the water. The cost saving is calculated at about €1,300. Finally, the acquisition of greater competence and familiarity with regard to environmental protection practices leads to savings in the work involved in cultivation operations. The share of environmental assets to total farming assets is about 5.3%.

Table 3: Costs and Benefits by Category and Type of Action: Mussel Farm

Benefits (€)		2340
Installation management	1300	
Personnel management	1040	
Incremental Environmental Costs (€)	Investment	Operating Cost*
Water control by external company		7746.8
Implementation of certification	22997.8	
Management of certification		2788.8
Management and control of water and production processes	2220.7	5081.9

* Excluding amortisation relative to environmental planning

The final result given in the reclassified income statement shows an increase in environmental operating costs of 283%. With an increase of €24,574, the environmental costs represent about 13.7% of company operating costs. Given the considerable increase in costs, the income for the financial period is negative, as no type of financing or public intervention to encourage and support this orientation was considered.

Table 4: Revised Income Statement after Intervention: Mussel Farm

	Values €	Values €	Values €	% value of production	% difference before/after
Value of production			188.600.6	100%	1.2%
Revenue		186.260.6			
Benefits deriving from certification		2.340.0			
Operating costs			178.788.5	94.8%	11.3%
Raw materials and services		19.017.2			
Amortisation and depreciation		34.720.2			
Maintenance		1.504.4			
Insurance		1.032.9			
General expenditure		9.472.9			
Wages and salaries		88.497.3			
Environmental operating costs		24.543.6		13.0%	233.2%
Amortisation and depreciation	2.986.7				
Maintenance	3.098.7				
Wages and salaries	6.992.8				
General expenditure	361.5				
Raw materials and services	11.103.8				
Operating result			9.812.1	5.2%	-61.7%
Financial charges		15.121.8			
Taxes		510.0			
Income			-5.819.8		-159.2%

Conclusions

In aquaculture companies, introduction of an environmental management system (EMS) produces a series of adaptations and changes in the production process, modifying the relationship between the company and the surrounding economic environment, and placing it in a new competitive position in relation to partners. Internalisation of environmental variables in company management makes operators more responsible in mitigating environmental impacts associated with the development of aquaculture and at the same time maintains a high level of confidence among stakeholders, reinforcing cooperation with private and public institutions. In particular, it reduces the level of uncertainty and information asymmetry often facing the consumer when exercising his demand for fish products. However, these conditions result in an increase in costs, leading businessmen to lose sight of the effectiveness and relevance of applying an EMS with regard to the potential individual benefits and sustainability of aquaculture as a whole.

The reported study highlights the high incidence of environmental protection costs and their variation following implementation of an environmental management programme in the two aquaculture companies considered. In the case of the intensive fish farm, environmental

operating costs increase by 73%. The incidence of environmental costs on total costs amounts to 5.6% before and 9.3% after implementation of the EMS. Environmental costs with respect to revenue rise from 5.3% to 8.5%. In the case of the mussel farm, the environmental operating costs increase by 283%, with total costs rising from 2.5% beforehand to 12.3% after implementation of the EMS. The incidence of environmental costs on revenue goes from 3.4% before to 13% after. Finally, the average product price in intensive aquaculture farming is 6.86 €/kg, with an incidence of environmental operating costs on average price about 8.6%. Concerning mussel farming, the average product price is 0.42 €/kg and the incidence of environmental operating costs on average price is about 14.6%. The analyses demonstrate the relationships existing between aquaculture and the environment, and therefore the weight of environmental variability in the economy of fish farming. However, it must be stressed that the presumed advantages of eco-compatible behaviours on the market, not considered by this study, must be added to the results obtained.

Finally, identification of the environmental planning actions in the fish farms enabled the amount of investment required in the two case studies to be determined. In the intensive fish farm, the amount is relatively high, as the activity is more complex, while the investment cost of certification has a relatively lower incidence than in the case of the mussel farming where certification activities have a predominant place in total investment. This calculation was one of the main aims of the study; in other words, through analysis of the private costs incurred by the company in implementing environmental protection measures, to quantify the conditions for public authority intervention in order to establish the correct level of taxes and subsidies to effectively limit externalities and encourage preventive pollution abatement or avoid the production of pollutant factors. This orientation requires the involvement of all parties involved in the sharing of responsibilities for consumption and behaviour towards the environment and natural resources, as stated in the 5th European Community Environmental Action Programme in 1992 and confirmed in the 6th Programme in 2000. Implementation of this orientation must include the economic involvement of the Commission in support of eco-compatible products, with specific contributions to encourage the planning and certification of products with a low environmental impact and improve information for consumers on the characteristics of the products and production processes. In this context, it is particularly important to extend the concept of integration, in the sense of integrated certification, to include not just the product, quality system and environmental management system, but also an integrated land and water management policy in which aquaculture activities are considered in relation to other activities capable of increasing economic and environmental sustainability.

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