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ARTICLE

AQUAM—A Decision Support Software for Fish Farm Management

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ABSTRACT

In this paper, a software for management and decision support in a fish farm is presented. The software called AQUAM is dedicated to fresh water fish farms. Its aim is to make an efficient management of resources through planning, monitoring, analysis and decision support. Successful planning and management requires the integration of data related to ponds, fish species, fish growth, water and energy and economic analysis. AQUAM computes farm budgets relating various costs and returns in order to determine short and long term profitability. A simulation of the profit, as a function of the fish holding density, is performed with AQUAM. The data used in the simulation are from a fish farm of semi-intensive type, located in the region Danube Delta, at village Jurilovca, Tulcea county, Romania. The fish species that were taken into account were carp and sanger.

1. Introduction

The worldwide harvest of fish has stagnated at around 79 million tons per year and is not expected to rise[1]. At the same time the demand for fish products has continued to rise. The result is a fast-growing aquaculture industry with the highest growth rates in the animal food-producing sector, which had an average annual growth rate of 8.8% up until 2004[2]. With 5.8 percent annual growth rate since 2010, aquaculture continues to grow faster than other major food production sectors. In 2016, aquaculture production increased by 4 million tones over the previous year. By 2030, the world will eat 20 percent more fish (or 30 million tones live equivalent) than in 2016. Aquaculture production is projected to reach in 2030 at 109 million tones, a growth rate of 37 percent over 2016. Aquaculture (also known as aqua farming) is the farming of aquatic organisms such as fish, crustaceans, mollusks and aquatic plants. It involves cultivating freshwater and saltwater populations under controlled conditions. It is different from commercial fishing, which is the harvesting of wild fish.

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The ability of the aquaculture farmer to manage these resources including the know-how, water, capital and time, to the best advantage, for achieving his goals, will determine the performance of the farm. The term „farm management" is used by different people to convey different concepts. Aqua culturists often tend to consider it as the overall technical operation of the farm and supervision of day-to day activities. Good farm management expertise is often considered to have the same value as the practical experience in application of aquaculture technologies in the field. Proper and timely maintenance of the farm and of its installations, successful methods of brood stock manipulation, breeding, seed production, stocking, feeding, disease and pest control, proper water management, including the maintenance of water quality, harvest and marketing are the major elements of this concept of management. The science of farm management was recently applied to aquaculture. It is based on the concept of a farm as a business and consists in the application of scientific laws and principles to the conduct the farm activities.

The managerial activities can be divided in three categories[3,4]: (a) Strategic planning——long-term planning to direct future activities based on available knowledge, (b) Implementation——conversion of plans into reality, (c) Control——measuring process performance and comparing it to standards. Due to the diversity of skills, a farm manager has to have different areas of particular interest: (1) production, (2) marketing, and (3) finance[5]. While production is the most basic area, marketing is also important. Since profit maximization is a common goal in business it is important to keep in view the current market price of the produced product. Furthermore, financial activities require management decisions on capital acquisition and financial funds need to be available on demand[5]. By means of data bases the farm manager is able to compare the actual outcome of the production process with the average performance data[6]. A successful farmer will combine the different areas of management to achieve a maximum overall result.

To manage fish farm have been developed Decision Support Systems - DSS. However, DSS and data analysis cannot completely replace the manager's activities of decision making. They can help the manager to make rational decisions.

Decision support systems provide software for collecting, organizing, and analyzing the information in a consistent manner. Decision support tools can capture current state-of-the-art knowledge of system dynamics, processes, and interactions, and organize these in manner that allows manager a convenient ability to understand the system.

A broad range of aquaculture decision support systems was developed. Some of them have taken into account environmental impacts such as those for selecting and licensing aquaculture sites[7-14] and for planning nutrient removal[15]. Others are used for designing aquaculture facilities[16], managing hatchery production[17], forecasting aquaculture products[18], facilitating aquaculture research and management[19], and evaluating economic impact[20]. In[21] are developed a decision support tool for cage aquaculture. It covers various activities starting from classifying a site, selecting the best site from several site alternatives, calculating a sustainable holding density from a chosen site, and finally performing an economic appraisal of a site.

The 'FISHBASE' system is a comprehensive database system about fish information and it is available for scientific research and teaching. It was supported by the European Committee. The FISHBASE had been exploited by International Center of Aquaculture Resource Management (ICARM), Food and Agriculture Organization (FAO) and other partners.

In this paper, we present a software for management and decision support in an aquaculture fish farm. The software is called AQUAM and is dedicated to fresh water fish farms for the efficient management of resources through planning, monitoring, analysis and decision support. Successful planning and management requires the integration of data related to ponds, fish species, fish growth, water and energy and economic analysis. AQUAM computes farm budgets relating various costs and returns in order to determine short and long term profitability. A simulation of the profit as a function of the fish holding density is performed with AQUAM. The data used in the simulation are from a fish farm of semi-intensive type, located in the region Danube Delta, at village Jurilovca, Tulcea county, Romania. The fish species that were taken into account were carp and sanger.

2. AQUAM——A Decision Support Software for Fish Farm Management

2.1 Overview

According to the *Operational Program for Fisheries, Romania 2014-2021*, Romania has an exclusive economic zone of 25,000 km² at the Black Sea and a coastline of 250 km. The hydrographic network has an area of 843,710 ha, which represents approximately 3% of the total area of the country. The production capacity of Romanian fisheries sector includes: 400,000 ha of natural lakes (including the Danube Delta) and reservoirs, 84,500 ha of fish farms, 15,000 ha of nurseries, 66,000 km of rivers, of which 18,200 km are in the mountains and 1,075 km is the Danube river[22].

Romanian fisheries sector includes aquaculture, marine

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fishing and inland fishing activities as well as processing and marketing activities. However, the most important activity is aquaculture in fresh water, followed by fishing in inland waters[22].

Currently, more than 70,000 hectares of landscaped pools are used in Romania for semi-intensive aquaculture. These production capacities are considered a great advantage in view of developing the aquaculture industry in Romania. However, they should be re-orientated and upgraded in order to increase productivity per unit area. Despite the development of aquaculture in Romania, the development of management software systems has been slow. Information flows have been partially identified; data were not included in large databases. Exploitation and analysis of existing data is partial. There are a few simple applications for accounting or for tracking the production. This situation had motivated the interest for developing a software for the fish farms management, adapted to the existing conditions from Romania. In this paper is presented a software called AQUAM for fish farm management and decision support. The use of the computer software for decision support in a fish farm has advantages compared to the conventional operating farms. The major advantages are connected to: (1) increasing the fish farm performances: higher profit and production, (2) decreasing of the efforts, (3) reducing the water and energy losses and (4) increasing the quality of management.

The main resources in a farm are the material resources and the financial resources. AQUAM takes into consideration the main resources (material and financial) in a fish farm. Examples of resources considered are: ponds, fish species, staff, feed, water, energy, money, etc. The system manages resources in a dynamic manner, taking into account the time parameter. AQUAM calculate financial indicators and indicators of economic performance.

The structure, data base, models base, modules and links between modules are shown in the software system architecture AQUAM (Figure 1). The database contains a structured information about the fish farm. The models base contains bio-economic models and a minimum risk model. In this paper one of the bio-economic models is presented.

The minimum risk model was presented in [23,24].

The AQUAM modules are: Fish Farm Information, Planning, Monitoring and Analysis.

The module Fish Farm Information contains important information about fish farm:

(1) General information: name and address of the fish farm, total area (land and water), legal consideration;

(2) Ponds of the fish farm: number, name, water area, mean depth;

(3) Fish species raised in the fish farm: name, age, scientific name, caracteristics, etc.;

(4) Technical equipments from the fish farm: name, number, caracteristics;

(5) Products of the fish farm: fresh fish, frozen fish, etc.;

(6) Suppliers for seeds, feed: name, address, phone and fax number, email, caracteristics;

(7) Buyers: name, address, phone and fax number, email;

(8) Staff: permanent and mobile staff, studies, etc.

This information is stored in the AQUAM database and is used in other modules of the AQUAM software. An important aspect in a management of a fish farm is elaboration of an efficient production plan. In the Planning module are considered: fish density planning, feeding planning, aeration and water schedule, annual and monthly costs estimation, incomes and budget estimation. Depending on the estimated plan the expected profit will be computed. Based on a bio-economic model a profit simulation is realized. An important module is the monitoring (tracking) module. The monitoring is realized for feeding, aeration and water, annual and monthly costs, incomes and budget, profit and losses. Costs can be tracked monthly. Revenues come mainly from selling fish. A realized budget and profit are calculated in this module. An analysis refers to profit and production analysis.

The planning, monitoring and analysis are realized for various levels of detail. For planning and monitoring the level of detail refers to all or selected species and all or selected age. The analysis of the level of detail refers to a period of time (in years), all or selected species and all or selected age. The link between the database, the models, modules AQUAM and the manager is provided by the component "User Interface".

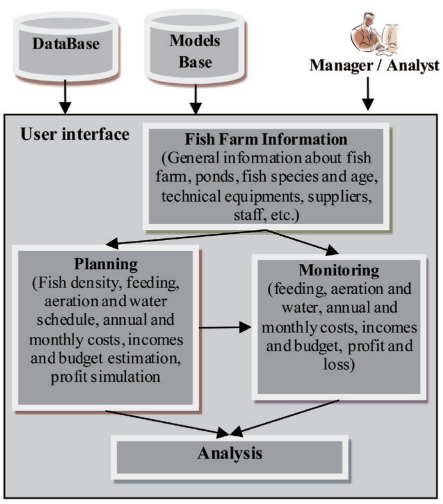

Figure 1. The System Architecture of AQUAM

2.2 Profit Simulation

The bio-economic model is presented in Table 1 and Table 2. In Table 1 are presented the inputs in the model and in Table 2 the equations of the model. In Figure 2 the costs, profit and return of an investment in a fish farm of semi-intensive type are computed. The date come from a fish farm located in the region Danube Delta, at village Jurilovca, Tulcea county, Romania.

Table 1. Inputs in the bio-economic model

Name	Measure unit	Symbol
Mean fish seed weight	Kg	FWS
Holding density at harvest	Kg/ha	HD
Ponds surface	Ha	PV
Survival rate of fish seed	percent	SR
Mean fish weight at harvest	Kg	FW
FCR (food conversion ratio)	-	FCR
Seed cost	Euro/kg	SC
Feed cost	Euro/kg	FC
Other costs	Euro	AC
Interest rate for borrowed funds to cover the cost	percent	IRC
Fish price at harvest	Euro/kg	FPH

Table 2. Profit and return of the investment calculation

Name	Measure unit	Symbol	Formula
Holding density at harvest	Nr. of fish/ha	HDN	HDN=HD/(FW-FWS)
Total weight of fish	Kg	WH	WH = HD x PV
Total fish biomass	Nr. of fish	BH	BH =WH/FW
Number of seed	Nr. of seed	NS	NS = BH/SR
Feed needed to produce biomass at harvest	Kg	FN	FN = FCR x WH
Total costs for seed	Euro	TSC	TSC = SC x NS x FWS
Total costs for feed	Euro	TFC	TFC = FC x FN
Total cost	Euro	TC	TC = (TSC + TFC + AC) (1 +IRC/100)
Break-even price	Euro/kg	BEP	BEP = TC/WH
Revenue	Euro	REV	REV = FPH x WH
Profit	Euro	PRO	PRO = REV – TC
Return of the investment	percent	ROI	ROI = 100 x (PRO/TC)

Suppose that exists a functional dependence between the fish survival rate *SR* and the fish holding density *HD*, that is $SR=f(HD)$. Note that the function f should be decreasing since the higher will be the fish holding density *HD*, the lower will be the fish survival rate *SR*. Suppose that the function is strictly convex and not monotone. Then the profit *PRO* will be a non-monotonic strictly concave function of *HD*. Consequently, *PRO*, as a function of *HD*, will have a unique maximum. Denote by HD_{opt} the fish holding density that maximizes the profit. The graph of the profit *PRO* as a function of holding density *HD* is displayed in Figure 3.

Note that at the beginning, the profit is increasing as the holding density increases. There exists an optimal holding density HD_{opt} for which the profit attains its maximum. If the holding density is greater than the optimal holding density HD_{opt} the profit begin to decrease. This is explained by the fact that higher fish densities imply higher risks.

In the case $f(HD)=\dfrac{k}{k+HD}$, $k>0$, k constant, the profit *PRO* is a polynomial of degree two of the holding density *HD*.

The dependence of *SC* and *HD* is displayed, for our example, in Figure 4. The profit simulation is realized for carp and sanger species.

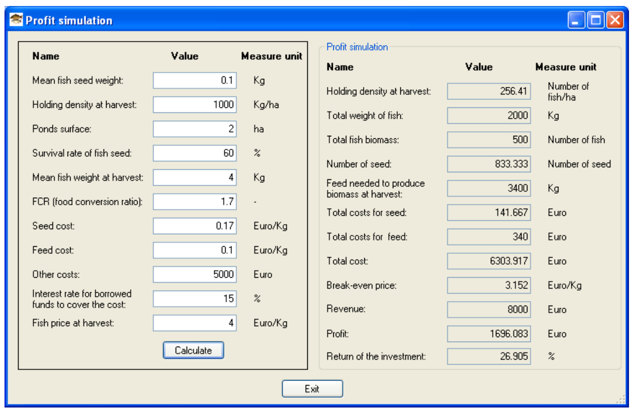

Figure 2. Costs, profit and return of the investment

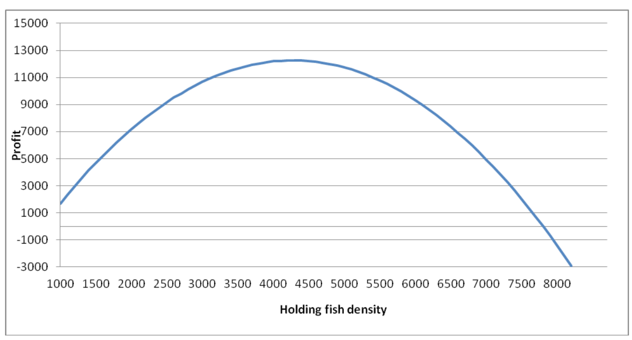

Figure 3. The profit as a function of fish holding density

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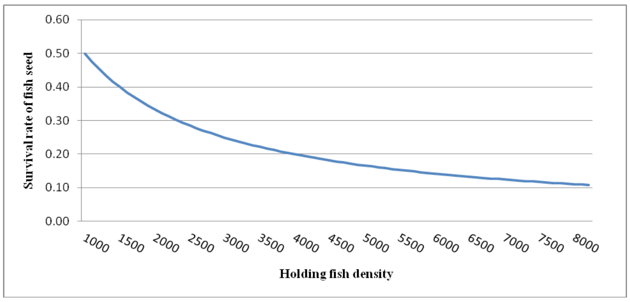

Figure 4. The fish survival rate *SR* as a function of the holding fish density – *HD*

3. Conclusion

The number of software applications for fish farms has increased in the last few decades. In the paper a software application, called AQUAM, for fish farm management is presented. The software system architecture shows the structure, data base, models base, modules and links between modules. A simulation of the profit as a function of the holding density is performed with the software AQUAM. The simulation is based on a bio-economic model that supposes that there exists a functional dependence between the fish survival rate *SR* and the fish holding density *HD*. The data used for the simulation come from the Jurilovca fish farm. Farm managers have recognized the advantages of using decision-support tools for farm management and decision planning. The use of such a system has many advantages for fish farmers. It allows him to obtain higher profits and production, to reduce the labor costs, and make optimal decisions.

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