

# Aqui AID – User Guide

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Artificial Intelligence Decisions in Aquaculture



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# 1. Introduction

AquiAID is a web-based decision support tool developed in the context of the MedAID project as part of the Work Packed 6, coordinated by the research group in Economic management for the primary sector sustainability (Ides) from the University of Cantabria (UC).

MedAID (Mediterranean Aquaculture Integrated Development) is a Horizon 2020 four-year project that aims to increase the overall competitiveness and sustainability of the Mediterranean marine fish-farming sector, throughout the whole value chain. Within MedAID, Work-package 6 addresses aspects of production economics and markets, including the assessment of the economic efficiency and economic optimization of Mediterranean aquaculture production.

MedAID project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727315.

Online access: <http://www.ides.unican.es/aquiaid/login.html>

## 1.1. Scope and Purpose

Over time, the competitiveness in aquaculture markets is increasing. On parallel, there is an increase on the size of companies, producing fish in more and bigger farms. To better manage those farms and companies, bigger amount of data of zootechnic and economic nature is collected. However, the advancement of data collection technologies mean that managers have difficulties to process the information available in an efficient way. In order to increase production efficiency, it is necessary to facilitate the work of these managers through the development of more powerful methodologies to support decision-making.

In WP6 the decision making process in seabream and seabass production is improved through the application of innovative artificial intelligence simulation and optimization techniques. These new combination of models allows the optimization of operational strategies in seabream and seabass production at sea cages with multiple batches according to multiple objectives (economic, environmental and quality factors) and multiple decisions, such as the seeding and harvesting dates or the feed selection.

The research also addresses one of the critical points in the generation of knowledge, the transfer and exploitation of results. The work has provided a planning web-tool, AquiAID (Artificial Intelligence Decisions in Aquaculture) in which the stakeholders of the sector can take advantage of these innovations through a simple interface.

## 1.2. Initial assumptions

This tool is intended for professionals who want to test the possibilities that Artificial Intelligence methods offers to decision-makers in aquaculture regarding their strategic planning and priority setting.. For that reason, the simulation and optimization processes are carried out in a simplified way:

- ❖ This tool addresses the problem for one cage at a time.
- ❖ There is space for comparing the utilization of two different feeds at a time.
- ❖ No complex fattening functions can be used in the standard tool.
- ❖ The time horizon of the strategic plan is restricted to the short-to-medium term,

This allows complex methods to take place in just a few minutes. In case more complex processes were needed it could be done with a custom development (see section 4)

### 1.3. Process Overview

The overall processes managed by this tool are focused on collecting the necessary data for simulating the decision-making scenario with regard to not only the internal and external factors that have considerable influence on the farm production processes, but also the decision-maker preferences and objectives.

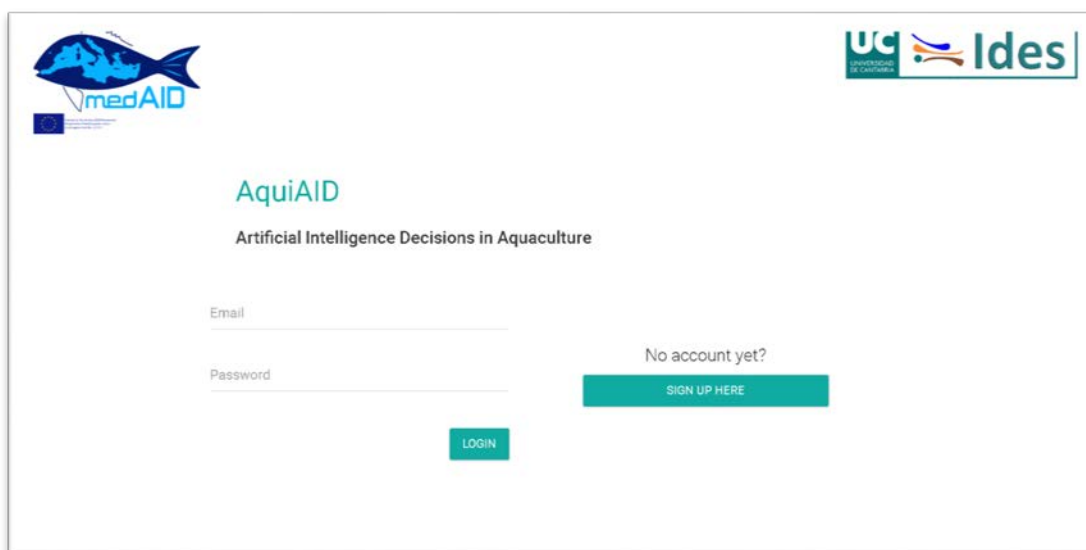
With this aim, users must register first, by completing the registration sub-process, to access the tool. This process includes filling the user details, such as the password or the organization to which he or she belongs, and the user preferences regarding the decision criteria.

Once the user is registered, the user obtains access to the three main processes:

1. Data entry: Each decision-maker have at their disposal a method to introduce their own data in order to apply the methodologies to its production units. This is constituted by six different tabs.
2. Simulation process: For the information available, this tool is capable of simulating the economic, environmental and quality results for a base strategy. This only requires to select the time horizon and the number of batches to carry out during that time. This results are quickly generated and shown in the main page of the web.
3. Optimization process: Lastly, planning the production strategy for the production unit requires a complex optimization process. This takes a few minutes and generates a complete strategic plan with monthly data and graphs. For that reason, the user will automatically receive and excel file with the results by email.

## 2. Login process

As is the norm in these cases, the users must access to this tool using their personal user credentials, due to privacy and security issues. The user credentials are a "username" and a matching "password". Furthermore, this allows users to save their preferences and information to future accesses to the tool, which saves huge amounts of time.



The screenshot shows the login interface for AquaiD. At the top left is the 'medAID' logo featuring a blue fish. At the top right is the 'UC Ides' logo. The central text reads 'AquaiD' in green, followed by 'Artificial Intelligence Decisions in Aquaculture' in a smaller font. Below this, there are two input fields: 'Email' and 'Password'. To the right of the 'Password' field, there is a link that says 'No account yet?' and a green button labeled 'SIGN UP HERE'. Below the 'Password' field, there is a green button labeled 'LOGIN'.

In this way, the first time the tool is used all users will be asked to complete an on-line registration process.

## 2.1. Registration sub-process

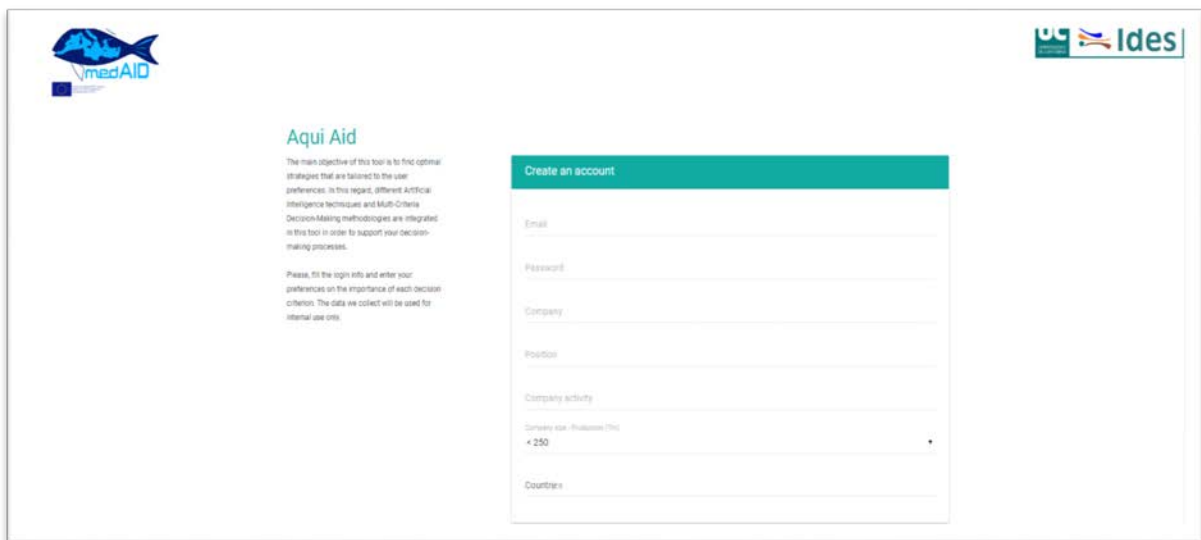
Every time a new user access to the web-app, the registration process must be carry out. The users will be asked to fill the same mandatory fields than traditional login pages and the information needed to make the decision-maker profile.

In this regard, this process has been divided in two steps

### 2.1.1. Step 1 – User details.

In order to make the user account, each user has to respond questions regarding the following aspects.

1. User and password: This secure login system allows the users to use the same login for future activities on this tool.
2. Country of residence.
3. Company/Organization information: Data such as their job, company, etc. will be also collected only for statistical purposes.



The screenshot shows the 'Create an account' form within the Aquai Aid web application. The form is titled 'Create an account' and includes the following fields: Email, Password, Company, Position, Company activity, Company size (with a dropdown menu showing '250'), and Country. The background features the Aquai Aid logo and a brief description of the tool's purpose: 'The main objective of this tool is to find optimal strategies that are tailored to the user preferences. In this regard, different Artificial Intelligence techniques and Multi-Criteria Decision-Making methodologies are integrated in this tool in order to support your decision-making processes. Please, fill the login info and enter your preferences on the importance of each decision criterion. The data we collect will be used for internal use only.'

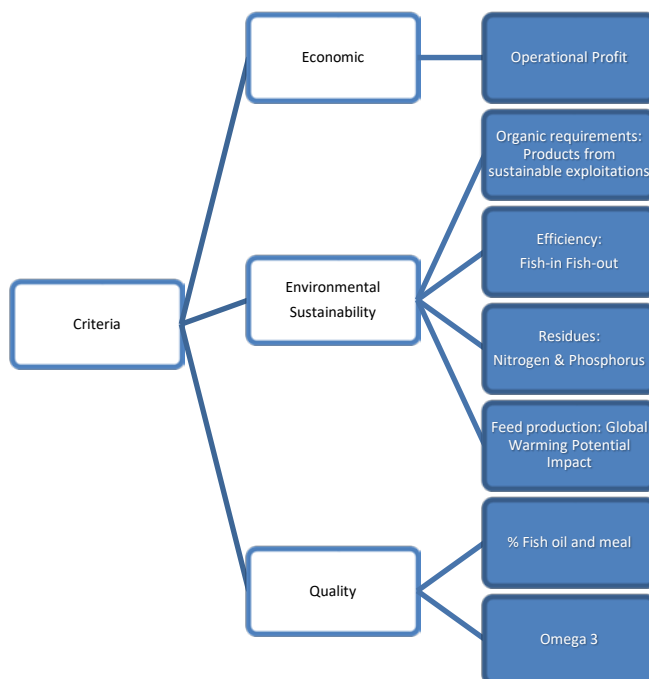
**NOTE: The data collected will be used for internal use only. (see data protection information)**

### 2.1.2. Step 2 – User's decision preferences.

Once the user account can be created, users have to introduce their own preferences regarding the relative importance of the decision criteria. This tool uses the three main categories of common objectives when taking decisions in aquaculture:

1. Economic criteria: We consider the operational profit, which is mainly influenced by the feeding cost and the growth, feed and mortality rates.
2. Environmental sustainability criteria: Four sustainable/organic production criteria have been proposed in this group, focused on the reduction of the negative environmental effects of some production procedures.

3. Product quality criteria: Two criteria have been included as an approach to two different points of view about the use of feed components to maximize the organoleptic characteristics of the fish and, hence, the perception of quality.



To facilitate the process, users are asked to assess the importance of the criteria by pairs. To do this, they have to move horizontally the bar to the criterion they put more importance when taking decisions in a scale of -9 (left criterion is extremely more important) to 9 (right criterion extremely more important):

**Assessments on the importance**

**Decision Criteria**  
This tool uses the three main categories of common objectives when taking decisions in aquaculture:

- 1 - Economic criteria: We consider the operational profit, which is mainly influenced by the feeding cost and the growth, feed and mortality rates.
- 2 - Environmental sustainability criteria: Four sustainable/organic production criteria have been proposed in this group, focused on the reduction of the negative environmental effects of some production procedures.
- 3 - Product quality criteria: Two criteria have been included as an approach to two different points of view about the use of feed components to maximize the organoleptic characteristics of the fish and, hence, the perception of quality.

To facilitate the process, the following is asked to assess the importance of the criteria by pairs.  
Please, move horizontally the bar to the criterion you put more importance when taking decisions in a scale of 1 (equal) to 9 (extremely more important).

Preferences between groups of criteria when taking decisions ( -9 = Criterion on the left is extremely more important | 1 = Both are equally important | 9 = Criterion on the right is extremely more important )

CREATE ACCOUNT

NOTE: Preferences between groups of criteria when taking decisions ( -9 = Criterion on the left is extremely more important | 1 = Both are equally important | 9 = Criterion on the right is extremely more important)

This will generate a table with the different relevance, between 0% and 100% that each criterion has for each manager according to their selections. This importance will be used in order to select the optimal strategic plan for each user.

### 3. Main process - Simulation and Optimization.

In third place, the user will find the main screen. It is the "centre" from which everything that occurs throughout the tool is controlled.

Once here, it is possible to carry out three different sub-processes: the introduction of specific data to customize the tool results, the simulation of the performance of a basic strategy and the initialization of the optimization process in order to find a near-optimal strategy.

**Artificial Intelligence Decisions**

This tool results can be personalised by introducing your own data, otherwise default tables will be used.

#### Simulation and Optimization

Please, select the time horizon and the number of batches to carry out.  
After that, choose one of these options:

- Clicking "simulate" will generate a graph and a table that summarize the results of the base strategy, which distributes the number of batches equally throughout the time horizon.
- Clicking "optimize" will carry out a process of searching for optimal strategies, optimizing the seeding and harvesting dates and the feeding strategy of each batch. When it is found, a complete report will be send to you email.

Use the menu at your left to see a description of the data used and modify it. We especially recommend go over the cage info.

*\*The maximum number of batches fixes the number of batches seeded, but the optimization process considers the possibility of leaving the last one unfinished in order to make better use of the time available.*

**SIMULATE OPTIMIZE**

This tool is intended for professionals who want to test the possibilities that Artificial Intelligence methods offers to decision-makers in aquaculture. For that reason, the strategic planning is only carried out in a simplified way (only one cage and two feeds, no complex fattening functions, etc.) and in the short-to-medium term, allowing complex methods to take place in just a few minutes.

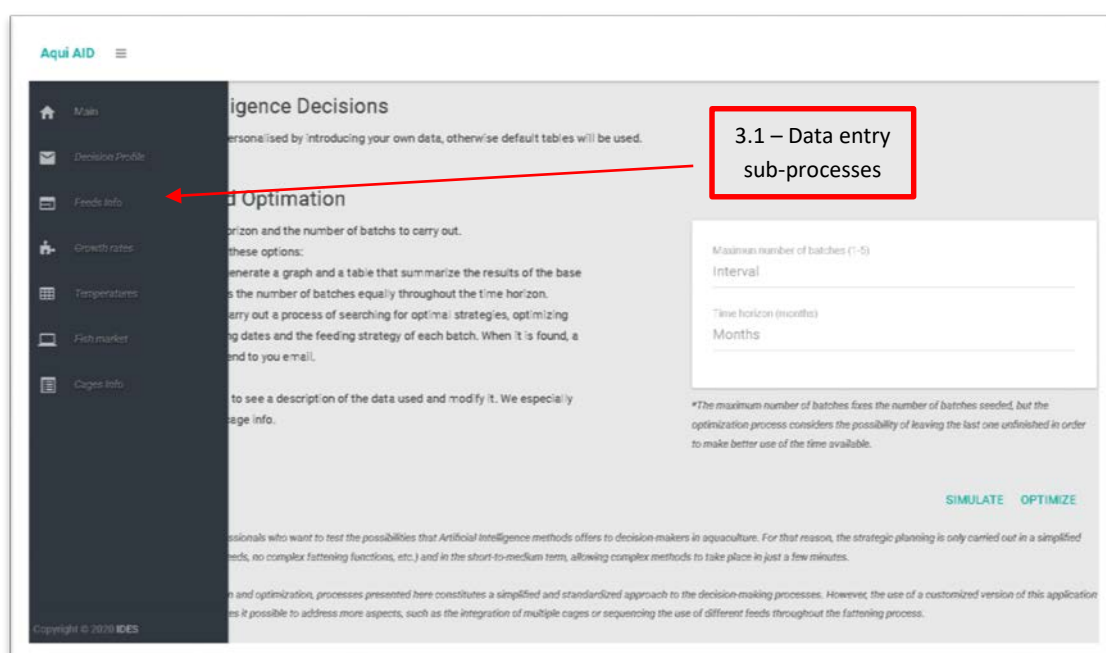
In this regard, both, simulation and optimization, processes presented here constitutes a simplified and standardized approach to the decision-making processes. However, the use of a customized version of this application to specific cases already makes it possible to address more aspects, such as the integration of multiple cages or sequencing the use of different feeds throughout the fattening process.

#### 3.1. Data entry sub-process

The aim of this tool to provide expert and non-expert users with a tool that allows them to analyse the possibilities that Artificial Intelligence methods offers to aquaculture companies and to their particular case, with regard to the strategic decision-making process.

For that reason, the introduction of data is optional, thus allowing them both to enter its own information or to use the default data. In this regard, the tool developed is also connected with a database.

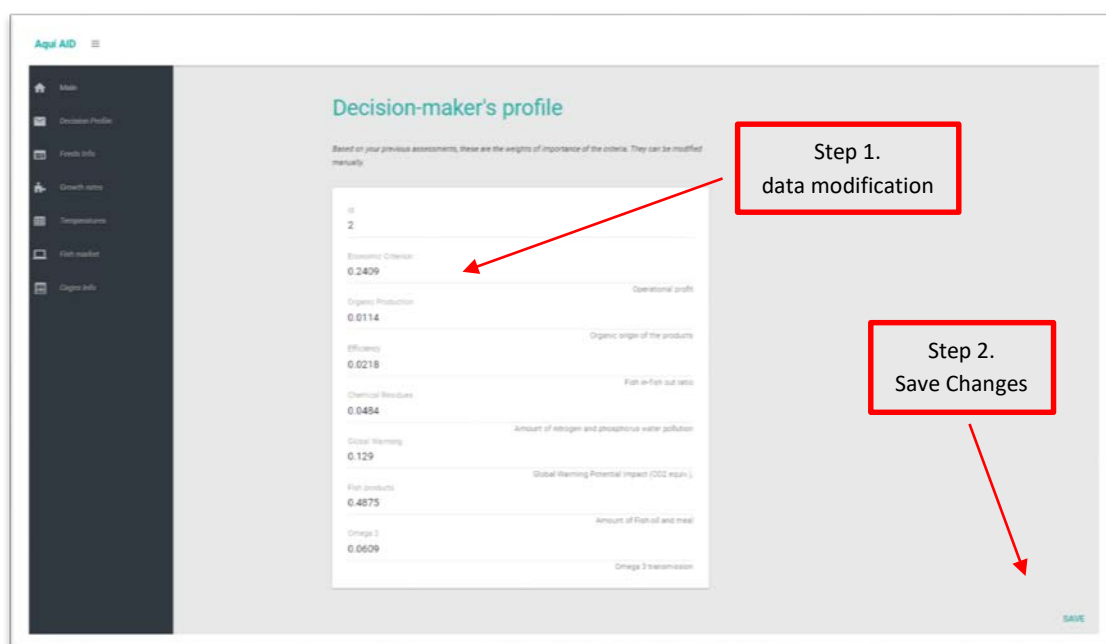
To access the data, users can use the menu on the left.



As can be seen, the data entry menu is structured in the following tabs. In order to facilitate the introduction and modification of data, this tool displays default data for each field.

### 3.1.1. Decision profile.

Firstly, the decision-maker profile is generated from the assessments that each user has done on the relative importance of each criterion. Although this data comes from the previous process, the user could change them. As in the following sections, these changes can be done in two steps: first the data is modified in the table below and, then, the changes are saved for future uses.



NOTE: Since these numbers represent the importance of each criterion, the sum of them must be 1.

### 3.1.2. Feeds info.

The appropriate use of this tool requires to incorporate the main information of at least one feed, and up to two different ones, to use in the fattening process. This information includes data on the feed price, components and origin that will be used to simulate the economic, environmental and quality results of each strategy.

To facilitate the data entry process, the tool incorporates a set of summary tables of the characteristics of two different feeds that can be easily adapted for specific characteristics of others.

**Feeds info**  
Description of the main characteristics of the feeds (max 2 feeds).

**Feed 1**

Feed price	0.98
Feed price in €/kg	
Fish meal	0.17
Amount of fish meal per kg of feed	
Fish oil	0.08
Amount of fish oil per kg of feed	
Fish origin	0.25
Amount of fish meal and oil per kg of feed	
Animal origin	0.5
Amount of products of animal origin per kg of feed	
Plant origin	0.5
Amount of products of plant origin per kg of feed	
Nitrogen total	0.0775
Amount of Nitrogen per kg of feed	
Phosphorus total	0.0163
Amount of Phosphorus per kg of feed	
Omega 3	0.01
Omega 3 transmission	
Organic prod	0
Organic origin of the products (1 = Yes, 0 = No)	
CO2eq	1.51
Global Warming Potential impact (kg CO2 eq/kg)	

**Feed 2**

Feed price	1.32
Feed price in €/kg	
Fish meal	0.5
Amount of fish meal per kg of feed	
Fish oil	0.05
Amount of fish oil per kg of feed	
Fish origin	0.55
Amount of fish meal and oil per kg of feed	
Animal origin	0.55
Amount of products of animal origin per kg of feed	
Plant origin	0.45
Amount of products of plant origin per kg of feed	
Nitrogen total	0.099
Amount of Nitrogen per kg of feed	
Phosphorus total	0.0175
Amount of Phosphorus per kg of feed	
Omega 3	0.02
Omega 3 transmission	
Organic prod	1
Organic origin of the products (1 = Yes, 0 = No)	
CO2eq	1.7
Global Warming Potential impact (kg CO2 eq/kg)	

### 3.1.3. Growth Rates.

In addition to the previous point, the simulation of the fattening process is based on three rates: the feeding rate, the growing rate and the mortality rate. These rates can be introduced in this section related to the use of each of the feeds available.

Once again, this section presents default data of the three rates for two different feeds.

**Main rates**  
Expected Feeding, Growth and Mortality rates by weight and temperature range for the use of each feed.

**Feeding**

	20	60	150	300	450
14 17	1.35	0.8667	0.7	0.55	
17 21	1.65	1.25	1.1	0.85	0.7
21 25	1.975	1.55	1.2667	1.0333	0.85
25 28	2.4033	1.9444	1.6	1.2778	1.0333

**Growth**

	20	60	150	300	450
14 17	0.68	0.4267	0.3	0.1967	0.145
17 21	1.09	0.6917	0.4603	0.3183	0.2275
21 25	1.6025	1.0583	0.6833	0.4667	0.355
25 28	1.91	1.2622	0.8144	0.5567	0.405

**Mortality**

	20	60	150	300	450
14 17	0.02	0.02	0.019	0.0184	0.0181
17 21	0.0186	0.0186	0.0177	0.0171	0.0168
21 25	0.0168	0.0168	0.016	0.0155	0.0152
25 28	0.0148	0.0148	0.0141	0.0136	0.0134

**Feeding**

	20	60	150	300	450
14 17	1.35	1	0.8667	0.7	0.55
17 21	1.65	1.25	1.1	0.85	0.7
21 25	1.975	1.55	1.2667	1.0333	0.85
25 28	2.4033	1.9444	1.6	1.2778	1.0333

**Growth**

	20	60	150	300	450
14 17	0.7823	0.49	0.3325	0.2275	0.1628
17 21	1.2463	0.7963	0.546	0.3605	0.2704
21 25	1.848	1.2268	0.7823	0.546	0.4069
25 28	2.1963	1.4313	0.9345	0.6393	0.4673

**Mortality**

	20	60	150	300	450
14 17	0.02	0.02	0.019	0.0184	0.0181
17 21	0.0186	0.0186	0.0177	0.0171	0.0168
21 25	0.0168	0.0168	0.016	0.0155	0.0152
25 28	0.0148	0.0148	0.0141	0.0136	0.0134

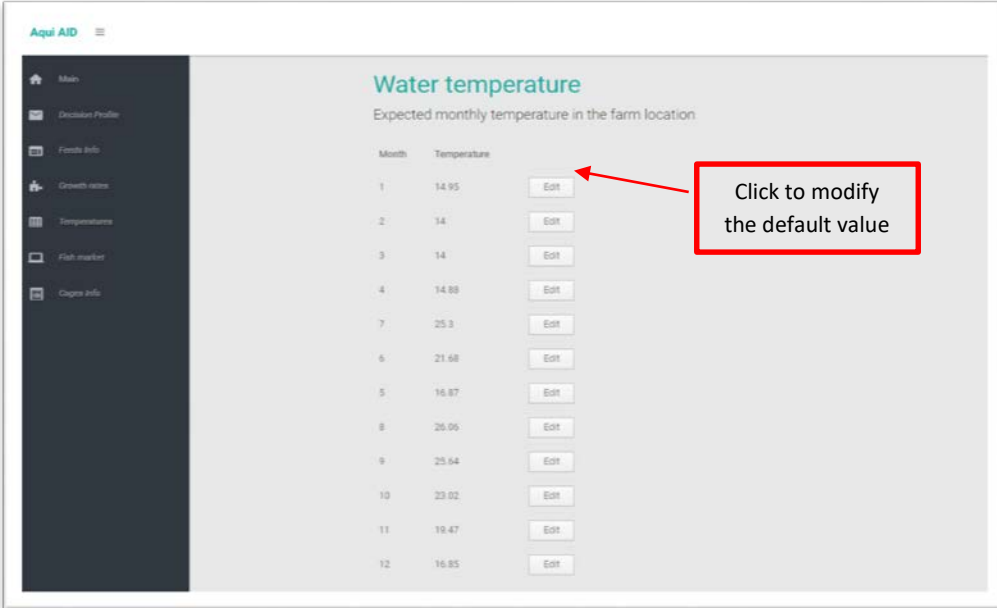
Click to modify any value

**NOTE:** Data is presented in percentage of the fish weight.

### 3.1.4. Temperatures.

The temperature is an external factor with a crucial influence in the fattening process and a factor that changes a lot depending on the farm location. For that reason, although this section presents an example of the average data on the Mediterranean Sea, the users should introduce their previsions in order to adapt the tool developed to their particular case.

In order to facilitate its collection and introduction, environmental data is used on a monthly basis.

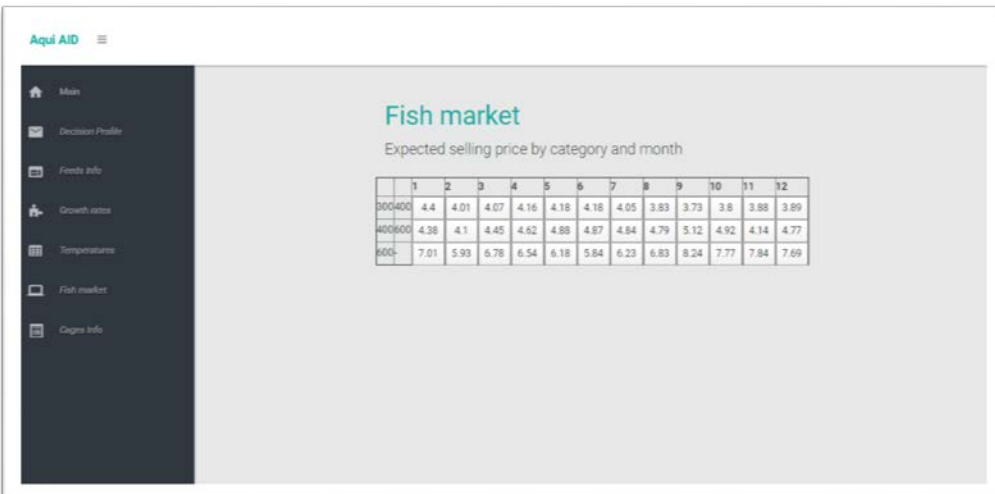


Month	Temperature	Edit
1	14.95	Edit
2	14	Edit
3	14	Edit
4	14.88	Edit
7	25.3	Edit
6	21.68	Edit
5	16.87	Edit
8	26.06	Edit
9	23.64	Edit
10	23.02	Edit
11	19.47	Edit
12	16.85	Edit

### 3.1.5. Fish market.

In order to approximate the economic profitability of the strategic plan, the expected selling price for each month of the year according to fish size have been included.

An approximation to the selling prices of the last year have been included, but it is once again an external factor that changes a lot.



	1	2	3	4	5	6	7	8	9	10	11	12
300-400	4.4	4.01	4.07	4.16	4.18	4.18	4.05	3.83	3.73	3.8	3.88	3.89
400-600	4.38	4.1	4.45	4.62	4.88	4.87	4.84	4.79	5.12	4.92	4.14	4.77
600+	7.01	5.93	6.78	6.54	6.18	5.84	6.23	6.83	8.24	7.77	7.84	7.69

### 3.1.6. Cage info.

Lastly, the user should indicate the characteristics of the cage in which the fattening process will be carried out. This information has to be always introduced to adapt all the values to the particular case, since it includes aspects such as the volume or the maximum biomass density.

The screenshot shows the 'Farming Cage' form in the Aquil AID application. The form is titled 'Farming Cage' and 'Main characteristics of the cage.' It contains several input fields for cage parameters:

- Cages:** A dropdown menu with the value '2' selected.
- Volume:** A text input field with the value '101' and a unit '(m<sup>3</sup>)'.
- Max Density:** A text input field with the value '20' and a unit '(kg/m<sup>3</sup>)'.
- Maximum stocking density (kg/m<sup>3</sup>):** A text input field with the value '5000'.
- Fingerlings:** A text input field with the value '5000' and a unit '(initial number of fingerlings (0 if empty))'.
- Fingerlings Weight:** A text input field with the value '30' and a unit '(g)'.
- Organic Price Premium:** A text input field with the value '0.15' and a unit '(Expected increment over the selling price when the production is organic)'.
- Species:** A dropdown menu with the value '1' selected.
- Starting Date:** A text input field with the value '2020-04-01' and a unit '(Starting date for the activity (yyyy-mm-dd))'.

## 3.2. Simulation sub-process

Once all the required information is available, either default or new data, the process of estimating the results for the economic, environmental and quality criteria can start. In this step, the user must indicate the time horizon and the number of batches for which he would like to simulate the results. For the present example, the following parameters have been used.

The screenshot shows the 'Artificial Intelligence Decisions' form in the Aquil AID application. The form is titled 'Artificial Intelligence Decisions' and 'Simulation and Optimisation'. It contains several input fields for simulation parameters:

- Maximum number of batches (1-5):** A text input field with the value '2'.
- Time horizon (months):** A text input field with the value '24'.

Two red boxes with arrows point to the input fields, indicating the steps:

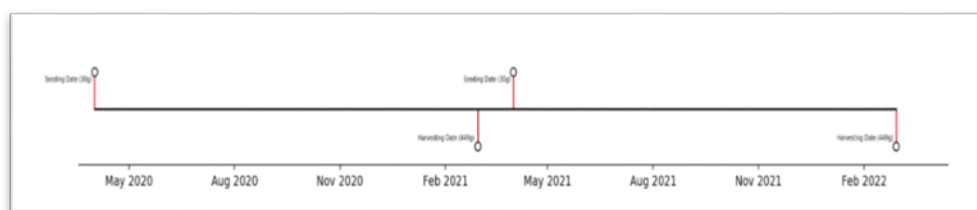
- Step 1. Set the simulation parameters** (points to the 'Maximum number of batches' field).
- Step 1. Start simulation** (points to the 'SIMULATE' button).

The 'SIMULATE' button is highlighted in green. Below the input fields, there is a note: '\*The maximum number of batches fixes the number of batches seeded, but the optimization process considers the possibility of leaving the last one unfinished in order to make better use of the time available.' At the bottom, there is a 'SIMULATE OPTIMIZE' button.

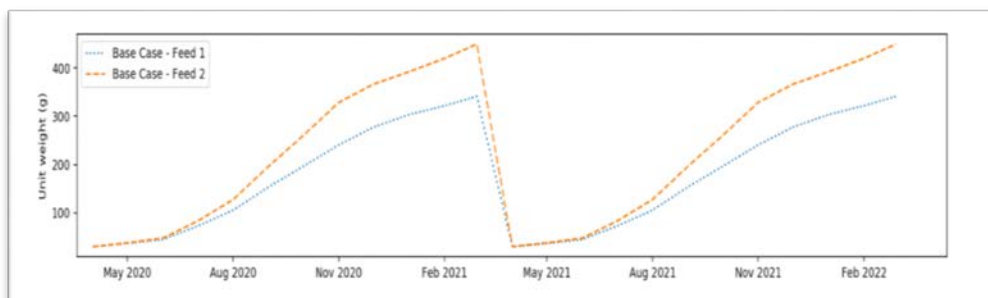
From this information the methodology is capable of conducting the multi-criteria simulation process for that production scenario in a few seconds. Since the user is in charge of selecting the initial date, the number of batches and their duration and there are two different feeding options, the methodology focused its work in estimating the results in a base case scenario for the use of each feed and provide them in a clear and easy to see way. The base case scenarios are always created in the same way; they start from the assumption that the fattening process is carried out trying to fully utilize the time allocated to it by dividing the time horizon by the number of batches, with the only exception of the last month of each batch that is reserved for the sales.

In this way, the results of the simulation and optimization processes are always organised in a structure of four modules. For the present example, the four modules would be the following:

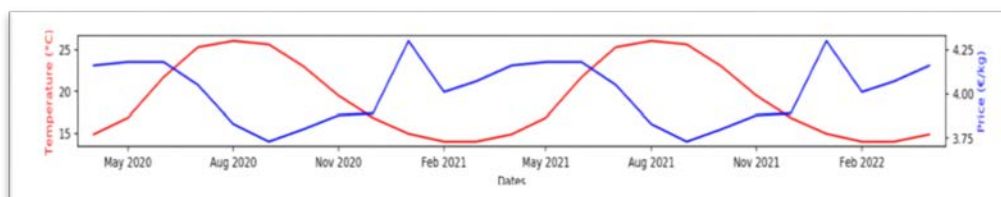
- ❖ The timeline of the plan with the seeding and harvesting dates for each batch.



- ❖ The graphical representation of the temporary evolution of the fish growth, for each of the feeds available.



- ❖ The graphical representation of the expected monthly data on selling prices and water temperatures.



- ❖ A summary table of the results of each case, listing all the decision criteria.

Operational Profit (€)	11274.29	Operational Profit (€)	19080.61
Organic Feeding (%)	0	Organic Feeding (%)	1
Efficiency (%)	0.44	Efficiency (%)	0.88
Residues (Kg)	802968.16	Residues (Kg)	1190111
GWP (kg CO2 equiv.)	12926.57	GWP (kg CO2 equiv.)	17366.43
Fish Protein (%)	0.23	Fish Protein (%)	0.5
Omega 3 Transmission	0.01	Omega 3 Transmission	0.02

### 3.3. Optimization sub-process

In addition to the simulation process, the tool developed provide the opportunity to carry out the optimization process in order to find a production alternative that improves the above results as much as possible (referred to as near-optimal strategy) with the same data and execution parameters (starting date, time horizon and batches). This process uses methodology that integrates Multi-criteria decision-making methods and the Particle Swarm Optimization methodology.

In this case, the number of batches is used as a maximum, thus being able to consider both completing the maximum number of batches or leaving the last one incomplete to extend the others, in which case it is specified and the stock left at the end of the period is valued with a reduction depending on how far the unit weight is from the minimum selling price (300 g).

The screenshot shows the 'Artificial Intelligence Decisions' interface. The main content area is titled 'Simulation and Optimization' and contains instructions. A form on the right allows users to set optimization parameters. Two red boxes with arrows highlight the steps: 'Step 1. Set the optimization parameters' points to the input fields for 'Maximum number of batches (1-5)' (value 2) and 'Time horizon (months)' (value 24), and 'Step 2. Start optimization' points to the 'OPTIMIZE' button.

This optimization process is more complex and time consuming than the simulation process. For that reason, the execution of this section results in a document that is automatically sent by email to the user. This allows to generate a more comprehensive report ensuring that users have a thorough understanding of the production strategy.

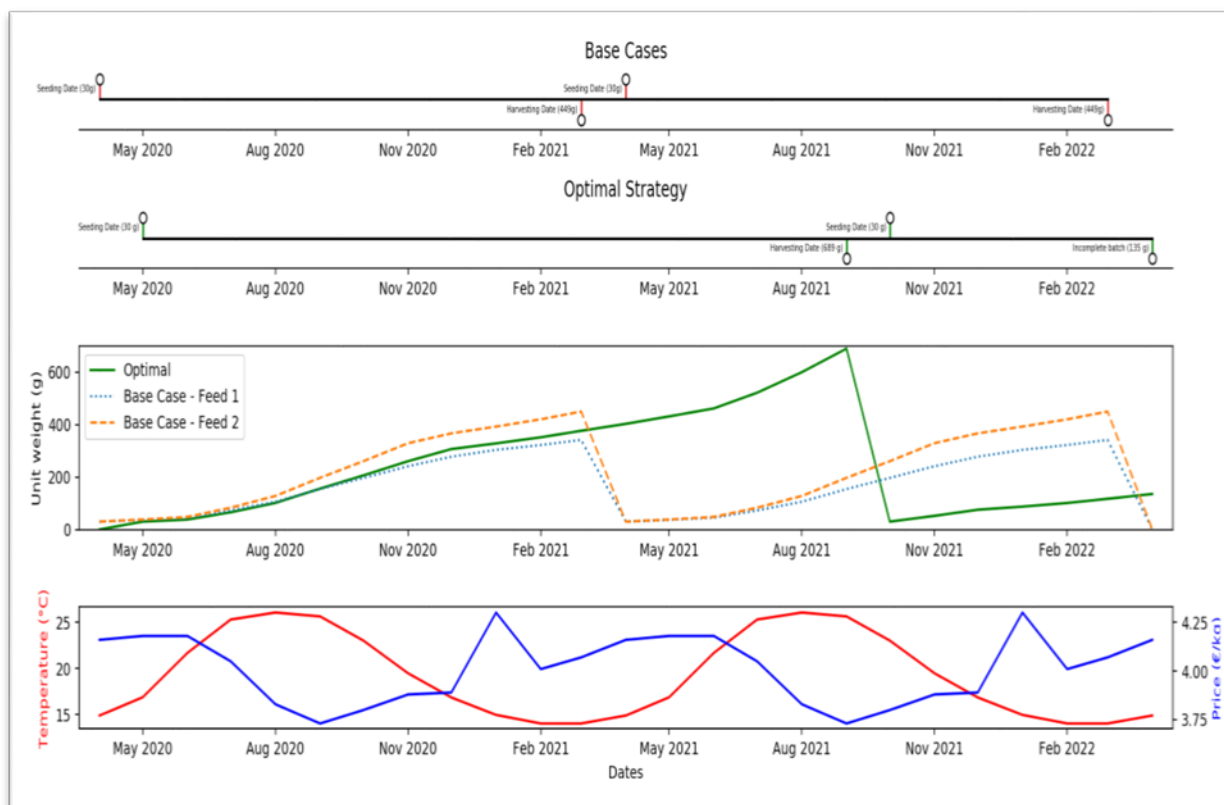
That document is composed of three sections:

- ❖ Intro: This first section summarizes the input data and the potential results of the strategy found with regard to each decision criterion.
- ❖ Results: In the same way, this section presents the results of the optimal strategy in an extended form, describing the monthly data for the following aspects:

Variable	clarification
Starting Date	Results have been aggregated by months, from the start date of the strategic plan to its conclusion.
Temperature (°C)	Expected montly temperatures in °C.
Price <400g	Expected prices (€/kg) for fish under 400g.

Price <600g	Expected prices (€/kg) for fish under 600g.
Price >600g	Expected prices (€/kg) for fish over 600g.
Unit Weight (g)	Evolution of the fish weight based on the growth rate of the feed used in each batch.
Number of Fishes	Evolution of the number of fish based on the expected mortality.
Total weight (g)	Expected total weight in the cage.
Selling Price (€/kg)	Estimation of the final selling price, using the fish weight and the expected price at the time of sale and the increase/reduction in their price depending on other factors, such as the incompleteness of the batch or the existence of an organic price.
Sales revenue (€)	Total revenue from sales (only available on months when there is any sale)
Feed Amount (g)	Amount of feed used each month.
Cost (€)	Monthly cost of the feeding activity depending on the feed price.
Organic Feeding	Boolean variable (can only be either 1=True or 0=False)
Total Nitrogen (g)	Expected amount of nitrogen residues.
Total Phosphorus (g)	Expected amount of phosphorus residues.
Fish Protein	Average proportion of fish oil and meal in the feed used.
Omega 3 Transmission	Expected Omega 3 transmission with the utilization of the feed.
Global Warming	Carbon footprint calculation in kg CO2 equiv.

- ❖ Graphs: In addition, the optimal strategic plan is presented and compared with the base cases. To do this, it is structured in the previous four modules again.



## 4. Extended applications

As already mentioned in previous paragraphs, the simulation and optimization processes presented here constitutes a simplified and standardized approach to the decision-making processes. However, the use of a customized version of this application to specific cases already makes it possible to address more aspects such as:

- ❖ One of them is the incorporation of market restrictions, such as weekly supply agreements with a large wholesaler, or the incorporation of productive restrictions, such as the number of vessels or workforce available to carry out the harvesting.
- ❖ Another example is the evolution from the optimization of the multi-batch production strategy for one cage to the optimization of the multiple-cage production strategy, which would allow these tools to be used to manage a farm as a whole.
- ❖ In addition, it is also possible to evaluate the possibility of sequencing the use of different feed throughout the fattening process.
- ❖ Likewise, these systems are sometimes reproached for not considering the potential deviations that may occur throughout the farming process. The inclusion of methodologies such as fuzzy numbers would allow uncertainty to be considered and managed through these systems.

## Further information and contact details

*For more information about this tool, see the deliverable 6.1 of the MedAID H2020 project. There you can find the main processes and findings explained in detail.*

*Otherwise, please contact the developers of the tool through this email: [manuel.luna@unican.es](mailto:manuel.luna@unican.es)*

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