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GIS in Aquatic Animal Health Surveillance: A Transdisciplinary eLearning Initiative Integrating Education, Research, and Methodology (The Aquae Strength Project)

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ABSTRACT

The Aquae Strength initiative is an international cooperation project between countries, whose activities include the realization of an e-learning course on Geographic Information Systems (GIS) and veterinary epidemiological surveillance in aquaculture. The course is an example of a synergetic relationship between training, research and methodological innovation that makes the knowledge, acquired by experts during the project, available to international learners through user-friendly technology. The advanced training proposal is not based on pure theory, but integrates practical applications that learners are likely to encounter in their daily work. The initiative contributes to a future-ready veterinary workforce equipped with the tools to navigate both digital and ecological complexity.

Keywords: E-learning course, international cooperation, Geographic Information Systems, Transdisciplinary educational initiative, Aquae Strength.

1. INTRODUCTION

Aquaculture is a growing sector worldwide contributing significantly to improve human nutrition and the essential development of fish stocks [1]. For this reason, expanding the collaboration network between international institutions and research centers is necessary to adopt a shared approach to both fish production, health status and disease management. In this context, the AQUAE STRENGTH project "Strengthening capacity on aquatic animal health and epidemiological surveillance" has been launched as a strategic international cooperation initiative designed to support and enhance the capacities of partner countries [2]. It represents a powerful convergence of education, applied research, and methodological innovation, addressing pressing global challenges in aquaculture health management through international cooperation and digital learning. The project is funded by the Italian Ministry of Health, implemented with the support of the World Organization for Animal Health (WOAH) and coordinated by the Istituto Zooprofilattico Sperimentale delle Venezie (IZSVe). It involves, as experts, seven of the Italian National network of Veterinary Public Health Institutes (INVPHI), three advisors (Centre for Environment, Fisheries and Aquaculture Science; Norwegian Veterinary Institute; Technical University of Denmark), and four beneficiary countries (Cambodia, Israel, Morocco and Tunisia).

In recent years, the adoption of Geographic Information Systems (GIS) in Aquatic Animal Health (AAH) has surged, with major bodies such as the Food and Agriculture Organization of the United Nations (FAO) [3]. GIS supports epidemiological studies, enables early detection, prevention, and forecasting of disease spread [4, 5], as well as facilitates the creation of thematic maps along with outbreak-reporting tools [6, 7].

However, despite the advantages, GIS remains relatively underemployed in the sector [8]. To mitigate this issue during the three-year project period, both webinars and face-to-face training were conducted for the beneficiary countries, with a view to educating and training new specialized personnel in the AAH sector. As a final goal, it was decided to create, on behalf of WOAH, two e-learning courses (WOAH's e-modules): one course aimed to clarify the concept of animal health surveillance in aquaculture, and the other to introduce the fundamentals of GIS. This essay presents the second e-learning course titled "Introduction to Geographic Information Systems (GIS) applied to Aquatic Animal Health", designed to support veterinary services and AAH professionals worldwide by providing structured, accessible, and research-informed training. The course is part of the activities developed within Work Package 1 (WP1) of the Aquae Strength project, which is dedicated to building GIS capacity across a broad audience that extends beyond the beneficiary countries. The course was developed and refined based on the experience gained through in-person activities and was optimized for users with limited or no prior experience in GIS, both in general and within the specific context of the AAH sector.

2. COURSE OBJECTIVES, STRUCTURE AND FEATURES

1. Target audience for the e-module

In order to be applicable in any country that needs to implement its knowledge in the field of aquaculture and since the subject matter is already intrinsically transversal, the course has been designed and targeted at various professional figures, all those who may be involved in the management and health control of an aquaculture farm:

- Veterinarians, pathologists, and animal health experts;
- Professionals involved in animal disease surveillance and management, with a focus on AAH and aquaculture management.

With the aim of disseminating knowledge on the subject as widely as possible, the content has been prepared to be as simple and understandable as possible for everyone.

2. Learning outcomes and learning objectives

The course introduces foundational concepts and basic functionalities of QGIS software, with a focus on practical applications in aquaculture health management and disease surveillance. These themes were central to the project and reflected the core knowledge the experts tried and intended to share with the beneficiary countries and the individuals they engaged abroad. The educational exchange was reciprocal, as the experts also found themselves in different situations and were able to apply, and sometimes adapt, their knowledge to the different context, in turn learning new skills.
In order to create a structurally effective path for the e-learning course, the outcomes that each learner should achieve have been defined. In detail the learning outcomes are:

- recognize the key principles and variables necessary for a successful GIS project;
- understand how to implement GIS systems for AAH management and surveillance activities;
- install and navigate QGIS software, understanding its basic functions and interface;
- use QGIS software for (basic) AAH management and surveillance activities.

To achieve these results, a methodology based on sequential training units was used to structure the course. The data presented in a simulated context reflects potential scenarios encountered by animal health professionals in the real work context within aquaculture. Accordingly, the small projects embedded in each unit as screencasts include attributes relevant to fish farm activities, such as the farm code, the quantity of fish raised in tons, the species being raised and the number of tanks. Additionally, there are attributes related to disease outbreaks, which highlight the date of occurrence and the type of disease was present. Furthermore, each unit prepares students for the following and guides them towards a full understanding of the subject matter.

For the principle of replicability, to allow anyone to build an educational path similar to the one proposed or to take it as an example and customize it, the units are listed below, specifying the learning objectives and content for each one:

1. <u>GIS in aquaculture animal health</u>

This unit outlines the fundamental principles of GIS, outlining its development from historical origins to modern day applications, with a focus on aquaculture. It emphasizes how GIS supports aquatic animal health.

- *Unit learning objectives (L.O.):*
  Identify the main applications of GIS tools in managing aquaculture activities, especially in fish health emergencies.
- *Unit contents:*
  - Course presentation: overview of the course objectives and structure;
  - Introduction to GIS principles;
  - How GIS can be practically used in AAH;
  - Control and prevention of animal disease, the spatial aspects;
  - Practical applications: Using GIS to monitor fish health, assess outbreaks, and analyze environmental variables.
  -

2. <u>Introduction to QGIS</u>

This unit introduces learners to QGIS software interface and key functionalities. It covers the installation process, navigation of menus, toolbars and panels, as well as basic interactions with spatial data through the attribute table.

- *Unit learning objectives (L.O.):*
  - Understand the main functions of the QGIS software user interface;
  - Learn how to install and explore QGIS software.
- *Unit contents:*
  - Downloading and installing QGIS;
  - Explore QGIS (overview of QGIS interface and primary functionalities):
    - the QGIS interface;
    - Menus, toolbars, and panels.
  - Basic interaction with spatial data;
  - Practical examples (screencast):
    - Load and explore a simple aquaculture GIS map and identifying layers and attributes;
    - Examine features-attribute relationships.

3. <u>The use of vector and raster data</u>

This unit presents the essential characteristics of vector and raster data, which are the primary data models used in GIS software, emphasizing their structures, formats and functional differences.

- *Unit learning objectives (L.O.):*
  - Define the characteristics and peculiarities of vector and raster data;
  - Import vector and raster data into a QGIS project.
- *Unit contents:*
  - Introduction to vector and raster data:
    - The main available vector and raster data formats, such as ESRI shapefile and Geotiff;
    - Understand their structure and functionality.
  - Practical examples (video cast):
    - Load and explore vector and raster data.

4. <u>Coordinate Reference Systems</u>

This unit focuses on the concept of Coordinate Reference Systems (CRS), emphasizing their importance in accurately locating spatial data, and it addresses common challenges encountered when working with CRS and offers strategies to resolve them.

- *Unit learning objectives (L.O.):*
  - Understand the concept of coordinate reference system and identify its types;
  - Set the CRS in vector and raster layers in our QGIS project.
- *Unit contents:*
  - Get familiar with coordinate reference systems (CRS):
    - Introduction to the concept of CRS and spatial reference;
    - Learn about different types of CRS;
    - How to set the CRS in both vector and raster layers.
  - Common issues encountered when working with CRS and how to avoid them.

5. <u>Querying geographic data</u>

This unit introduces the techniques for data querying and selection in QGIS. It provides an understanding of how to apply both attribute-based and spatial queries to extract relevant information from geographic datasets.

- *Unit learning objectives (L.O.):*
  Understand and apply the functions "query" and "select" data in a QGIS project.
- *Unit contents:*
  - Introduction to data querying and selection in QGIS (screencast):
    - Selecting and querying data by attributes;
    - Querying data based on spatial location.
    -

6. <u>Editing geographic data</u>

This unit offers an overview of data editing functions in QGIS, highlighting the modification of both spatial and attribute data. It covers how to edit geometries, including points, lines and polygons and how to update attribute information.

- *Unit learning objectives (L.O.):*
  Understand and apply the function "edit" data in a QGIS project.
- *Unit contents:*
  - Overview of editing tools in QGIS:
    - Edit geometries (points, lines and polygons).
  - Edit attributes data.

7. <u>Geoprocessing</u>

This unit introduces the fundamental principles of geoprocessing and emphasizes the use of the buffer tool to enhance GIS-based decision-making. It includes screencast demonstrations on creating buffer zones and applying them to analyze the spread of fish diseases in aquaculture settings.

- *Unit learning objectives (L.O.):*
  - Understand geoprocessing concepts and apply them to GIS analysis;
  - Use the "buffer" tool in QGIS for analyzing fish disease spread.
- *Unit contents:*
  - Introduction to geoprocessing;
  - How to generate a buffer (screencast);
  - Create buffers for analyzing the occurrence of fish diseases.

8. <u>Aquaculture GIS project and mapping</u>

The focus of this unit is to develop skills for creating effective thematic maps related to AAH. There is also guidance dedicated to exporting maps in various formats, as well as practical tips and best practices for map presentation.

- *Unit learning objectives (L.O.):*
  Learn how to print an aquaculture thematic map.

- *Unit contents:*
  - Symbology and layout for effective map presentation;
  - QGIS print layout with an effective aquaculture map (screencast):
    - Print layout interface;
    - Title;
    - Scale bar;
    - Legend;
    - Overview;
    - How to export a map (jpeg, png, pdf);
    - Practical tips and Best practices.

9. Case study: GIS applications in aquaculture epidemiology

This unit aims to introduce learners to some practical uses of GIS in aquaculture, while also providing some basic concepts of epidemiology. This to enable a better understanding of the steps involved and to provide the appropriate tools to perform certain procedures.

- *Unit learning objectives (L.O.):*
  Comprehend the practical aspects of GIS in the aquaculture epidemiology from a veterinary point of view.
- *Unit contents:*
  - Aquaculture Epidemiology concepts: definition and purposes;
  - Data collection and Input: importance and management, sources and types of data;
  - Examples of GIS tools application for epidemiology: infected and protective zones, epidemiological investigations, routine surveillance programs.

The structure of the various units shows how each concept has been addressed appropriately and in the simplest possible way. There is a good balance between theory and practice, drawing on the experience of the experts involved in the project.

3. DELIVERY METHODS

The course will be developed with Articulate Rise, an authoring tool, and each unit, as specified in the previous paragraph, will have specific contents and learning objectives but a common structure with the other units. This choice was made to simplify the content, as offering the same study plan will make it easier for learners to memorize the concepts provided.
In detail, each unit will include:

a. a navigation index with an integrated overall progression display;
b. lectures based on diagrams and summaries;
c. interactive exercises simulating real situations to test and practice the knowledge gained;
d. downloadable audio reading.

In addition, lessons will be enriched with animations, videos, and content designed to facilitate enjoyment and learning.

4. LEARNING ASSESSMENT MECHANISMS

The course includes both a training component as well as an assessment component. This allows learners to evaluate and track their knowledge acquisition through practical exercises and real-world case applications.

The assessment system includes exercises and two tests with close-ended questions. At the very beginning of the course, participants will need to complete an ex-ante questionnaire, which by the end, once they have answered the ex-post test, will serve as a basis for establishing their level of learning (the gap between ex-ante and ex-post questionnaire). Participants will see their results by checking each quiz page (ex-ante and ex-post), or by checking the platform's gradebook. The ex-ante quiz will return just the list of correct and wrong answers. In contrast, the ex-post quiz will also include compensatory answers for wrong choices, explaining why the selected option was unsuitable. This approach supports both summative and formative evaluation.

Briefly, ex-ante and ex-post questionnaires will serve two purposes. The first one allows participants to check their starting level and their "finishing" learning level; the second one, allows the trainers to check which topics are most known, which are less familiar, and where the course is most effective in addressing knowledge gaps.

Additionally, each unit will have self-assessment tools based on the contents delivered and learning objectives. Some units will have more practical exercises, simulating an activity they might face in their profession. What follows is a brief description of units' exercises built:

- Unit 3 - The use of vector and raster data
  In this activity, participants will be tested on their understanding of the main differences between raster and vector data through their interaction with various geographical objects. These objects include basic hydrographic elements such as rivers, lakes, and transitional waters, as well as specific veterinary entities like fish farms, aquaculture areas, and monitoring sites. Other variables involve environmental data such as water salinity, ocean chlorophyll concentrations, sea surface temperature. An interactive scenario will display the geographical features mentioned above. As students pass the mouse cursor over the figures, descriptions will appear to help them select the appropriate label. The task involves matching the data type with the corresponding geographic object or other variables by dragging the labels "raster" and "vector" to the correct object.
- Unit 4 - The coordinate reference systems
  In this interactive activity, participants will be tested on their ability to differentiate between geographic and projected coordinate systems in various aquaculture animal health scenarios. Participants will work with map representations and receive guidance to help them choose the correct answer. These guidance/questions include the type of projection, determining if it involves a reference system (ellipsoid or flat surface), identifying the unit of measurement (latitude and longitude or meters), and understanding whether it maintains the Earth's curvature or utilizes distortion.
- Unit 5 e 6 - Querying and editing geographic data
  This interactive simulation focuses on assessing QGIS skills relevant to editing, selecting, and querying spatial data for epidemiological aquaculture. The simulation includes an interactive user interface (UI) that mimics the original QGIS UI and displays an aquaculture area with elements such as fish farms and disease outbreaks. Users may click on these elements to view the attribute tables for each one. For the editing task, users must enter editing mode and adjust the geometry to cover a designated fish

farm. Then, they will move on to a task that involves selecting attributes by location, using the "select by location" option and setting parameters to select outbreaks that fall inside the fish farms represented by polygons. Regarding the query tasks, users will be presented with questions i.e. "selecting only the fish farms registered after the year 2022", and they will have to write the appropriate query in a blank space. To help participants build the query, a dialog box will be provided, and operators will be displayed.

- Unit 9 - Case study: GIS applications in aquaculture epidemiology
  In this interactive activity, participants will engage with a hypothetical scenario involving a veterinarian working in the aquaculture sector who needs to manage a disease outbreak case. The scenario is inspired by common situations that professionals often encounter during their working day activities. Participants will be evaluated on their understanding of integrating GIS applications with epidemiological data.

The exercises were structured and implemented to put the learners in a realistic situation that they might have to face during their day. The simulation in unit 9 creates precisely a simulation of a health emergency that often needs to be managed methodically and quickly in aquaculture, in order to prevent the spread of disease, protect livestock, and reduce the economic profit that local populations may incur from this activity
.

5. ACCESSIBILITY STANDARDS COMPLIANCE

All the contents will be accessible and readable for users. Audio, transcriptions as well as schemes and diagrams will be available for download, allowing learners to save the material and be able to consult it later, without having to log in to the course platform and avoiding the loss of time in situations that can be an emergency. It will work on the most used web browsers and it will be responsive, allowing usability on devices other than personal computers. Not all learners may have access to the same resources, so it was decided to use technology that was adaptable and accessible to everyone.

The language chosen for the lessons was English, the most widely spoken international language in the world. Offering the course in other languages would have made it more accessible, but this was not possible due to the costs and work force required. In any case, the English used is simple and easy to understand, precisely to eliminate language barriers and avoid hindering training in different countries.

6. TECH STANDARDS AND SOFTWARE VERSIONS

The course will be HTML5 compatible and it will be fully responsive to guarantee optimal accessibility across different devices. Images, audio, video and animations developed will take into account all the features that can facilitate and improve their use by the learner (weight, format, dimensions, etc.).

A brief English guide, showing course structure and its basic functions will be developed and made available for learners. In addition, a technical guide will be provided to help learners to overcome the recurrent issues. In any case, assistance will be guaranteed within 48 hours for any problem users may encounter.

The whole course will be developed and configured to work with Moodle LMS (v.4.3), and to be compatible with the most used internet browsers, not to restrict accessibility.

7. DISCUSSION

The idea of creating an e-learning course arose partly from a proposal by WOAH and partly as a continuation of a face-to-face course attended by participants from beneficiary countries [9]. Holding a face-to-face course is certainly more effective from certain points of view: learners have direct contact with trainers, they can get instant feedback on any doubts or problems, and they can follow a course together sharing experiences. On the other hand, this type of event is limited by the number of people who can be involved and by the logistics of having to gather everyone in one place.

From an educational perspective, the project exemplifies contemporary shifts in capacity building: moving beyond traditional instruction to digitally mediated, modular, and interactive learning. The GIS e-course democratizes access to technical knowledge by offering foundational GIS training to learners, regardless of their prior exposure, via a flexible and device-agnostic platform (i.e., one that works equally well on desktops, laptops, tablets, and smartphones regardless of brand or operating system).

Simultaneously, the course functions as a vehicle for applied research translation. Drawing from in-person international collaborations and expert insights developed during the project, it systematizes field-tested approaches into structured educational content. This reinforces a bidirectional relationship between research and education: research informs the curriculum, while education disseminates research outputs across borders and contexts.

What relates education, research, and methodology in this context is a transdisciplinary orientation. The project is not limited to veterinary science or epidemiology; it integrates geospatial science, digital literacy, animal health, and international development, coalescing into a unified learning framework that addresses both technical proficiency and public health governance. This holistic approach enables professionals in different regions, particularly those with limited access to in-person training, to participate in knowledge ecosystems that are both inclusive and globally coordinated. This e-learning course is a clear example of Transdisciplinary Communication, where the efforts and skills of several people with different professional backgrounds have come together to create an educational tool, based on scientific research and structured according to a precise methodology.

8. CONCLUSIONS

The Aquae Strength Project exemplifies how transdisciplinary educational strategies can amplify the impact of scientific research and methodological rigor. By embedding GIS within the broader educational goals of One Health and sustainable aquaculture, the initiative contributes to a future-ready veterinary workforce equipped with the tools to navigate both digital and ecological complexity.

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