

A pilot study to evaluate the spatial factors that affect the status of biosecurity in quarantine station and exporting farm in China

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Table of Contents

Credits.....	2
Terminology.....	2
1. Introduction.....	3
Purpose of Document.....	3
2. Master Plan.....	4
2.1 WebGIS tool.....	4
2.2 On-site POI detection and data collection protocol.....	4
2.3 Data analysis.....	4
2.4 WebPortal.....	5
3. Pilot Study.....	5
3.1 Identification of the study area.....	5
3.2 POI detection and data collection.....	5
3.3 WebGIS function test.....	6
3.4 Data analysis protocol.....	6
Preconditions.....	7
Weight calculation.....	7
Impact reclassification schema.....	7
Threshold values.....	7
Process.....	8
1 st step – Intensity calculation.....	8

A pilot study to evaluate the spatial factors that affect the status of biosecurity in quarantine station and exporting farm in China

<i>2nd step – impact calculation</i>	8
<i>3rd step – Total impact</i>	8
<i>4th step – Evaluation</i>	8

Credits

This document has been produced in the framework of the OIE Cooperation Project “Capacity development for implementing a Geographic Information System (GIS) applied to surveillance, control and zoning of avian influenza and other emerging avian diseases in China”.

Terminology

Quarantine station

An establishment under the control of the Veterinary Authority where animals are maintained in isolation with no direct or indirect contact with other animals, to ensure that there is no transmission of specified pathogen(s) outside the establishment while the animals are undergoing observation for a specified length of time and, if appropriate, testing and treatment [ref. OIE - Terrestrial Animal Health Code].

Candidate quarantine station

A farm that has submitted the request to become a quarantine station.

POI (Point Of Interest)

Facility that exposes or is exposed to a risk of infection or contamination due to the presence of an exporting farm or a quarantine station located nearby.

Impact

The effect that the presence of a POI in the study area produces in the evaluation process of the facility performance.

Total impact

The cumulative effect of the whole POI impacts in the study area.

WebGIS

A technology used to display and analyse spatial data on the Internet. It combines the advantages of both the Internet and GIS. It offers public a new means to access spatial information with no need of expensive GIS software.

Exporting farm

Farm organised to export its livestock production.

Candidate exporting farm

Farm that has submitted the request to become an exporting farm.

A pilot study to evaluate the spatial factors that affect the status of biosecurity in quarantine station and exporting farm in China

1. Introduction

The CAIQ GIS office is in charge of the evaluation of the requests received from the candidate quarantine station and the candidate exporting farm. The evaluation encompasses several factors such as:

- physical or spatial factors that affect the status of biosecurity in a compartment;
- infrastructural elements;
- biosecurity issues.

At present, the analysis of physical or spatial factors is based on a process that exploits a desktop GIS software, a set of spatial data acquired by a private company (this set of data presents information on the spatial location of POI and, under certain circumstances, the type of activities), and a set of information collected by means of a survey performed by the GIS coordinator (this survey has been performed for a limited number of candidate quarantine station). The analysis of the available data is based on a visual spatial analysis.

To improve the reliability of the spatial analysis outcomes, a framework based on the adoption of a webGIS to collect data, a process for field data collection made by the local CIQs and a spatial analysis based on Multi Criteria Method are proposed.

Purpose of Document

Proposal for the implementation of a protocol for the analysis of the spatial factors that affect the status of biosecurity in a candidate quarantine station and a candidate exporting farm.

The proposal consists of a master plan that describes the possible implementation of the system once the whole elements are made available to users and administrators, and a protocol for the pilot study that should be used to test the feasibility of the protocol described in the master plan.

A pilot study to evaluate the spatial factors that affect the status of biosecurity in quarantine station and exporting farm in China

2. Master Plan

The framework to perform the analysis of the spatial factors that affects the status of biosecurity in the candidate farm or candidate quarantine station (candidate facility) is based on the following elements:

1. webGIS tool for the collection of POI's spatial/no-spatial information;
2. protocol for POI detection and the collection of related data made by the local CIQ operator;
3. protocol for the spatial data analysis at central level;
4. Web portal for the publication of relevant information.

2.1 WebGIS tool

The webGIS tool will be used by the local CIQ to edit the relevant POI that surrounds the candidate facility.

The webGIS will allow the collection of POI's coordinates by means of two methods:

1. Indirect. The indirect method consists on marking the place directly in the map. The local CIQ is able to recognise the POI facility/ies by looking at the map presented by the webGIS. He/she uses the webGIS mark tool to place a point in correspondence of the facility/ies.
2. Direct. The local CIQ records the coordinates by means of a GPS and then he/she edits the point in the webGIS at the duty station.

The webGIS will allow to edit the no-spatial data directed in the webGIS while the local CIQ performs the survey on site (this option requires a mobile device). The webGIS can also allow to edit the collected information once the operator returns to his/her duty station.

This tool requires the availability of georeferenced background maps.

2.2 On-site POI detection and data collection protocol

A well defined protocol for the on-site data collection integrated with the webGIS tool will be developed.

The protocol aims (i) to define the sequence of steps that a local CIQ should follow in order to detect POIs that surround the candidate facility and (ii) to collect the relevant data for the detected POI.

The method for the detection combines the visual target detection method with the surface survey one. The visual target detection aims to detect possible POI by means of an image made available by the webGIS. Once the local CIQ has detected possible POI then he/she plans the route to reach the identified location. The route should be designed to cover as much territory surrounding the candidate facility as possible (unsystematic survey). Along the path, every time he/she recognises a POI (POI that was not possible to recognise from the aerial image or he/she reaches one of the targeted POI), he/she stops the vehicle and performs the identification of the POI and the related data collection.

This protocol requires the availability of route map and background maps.

2.3 Data analysis

The data collected by the local CIQ are stored in a centralised geodatabase. The CAIQ GIS experts use the data to perform the spatial data analysis. The spatial data analysis is based on two steps:

1. ESDA (exploratory spatial data analysis);
2. MCM (multi criteria method).

The ESDA analysis aims to identify the presence of critical POIs in the study area. Critical POIs are the POIs that, in case they are located nearby the candidate facility, lead to reject the request.

For the no-critical POIs a calculation based on the Multiple Criteria Methods (MCM) is made with a dedicated script developed in the GIS software. The result of the calculation will be a value that will be compared to a defined threshold. If the calculated value is above the define threshold, the request is rejected, vice versa the request is accepted.

Two different threshold levels are defined, one for the evaluation of the candidate quarantine station and one for the exporting farm.

A pilot study to evaluate the spatial factors that affect the status of biosecurity in quarantine station and exporting farm in China

2.4 WebPortal

A dedicated web portal will be developed to publish the relevant information related to the collected and analysed information. Different type of user profile will be defined.

3. Pilot Study

The pilot study aims to verify, and eventually rectify, the process for the analysis of the spatial factor that affects the status of biosecurity in a candidate facility.

The pilot study encompasses the following elements:

- identification of the study areas;
- test of the on-site POI detection and data collection protocol;
- test of the pilot webGIS functionalities;
- test of the data analysis protocol.

3.1 Identification of the study area

For the identification of the study area, the following elements are required:

1. location of the candidate quarantine station;
2. the extent of the areas that surrounds the candidate station;
3. POIs considered for the spatial evaluation;
4. background maps (aerial images and road maps).

The CAIQ GIS operator is in charge to upload the location of the candidate facility into the webGIS and the polygon of the study area (ie. Buffer of 3Km and 10Km)¹.

The presentation of the study area to the local CIQ can be implemented in two ways:

- a) presentation of the available information on the **pilot webGIS** and development of the spatial evaluation on an on-line condition;
- b) presentation of the available information on a **QGIS document** and development of the spatial evaluation on an off-line condition.

3.2 POI detection and data collection

This phase is based on the following elements:

- the location of the already available POIs;
- a form for the on-site data collection;
- a method to plan the unsystematic survey;
- a procedure to collect the coordinates and the POI information.

The critical point in this phase is the method to plan the route. We can identify two possible solutions based on the presence or absence of a comprehensive² road map.

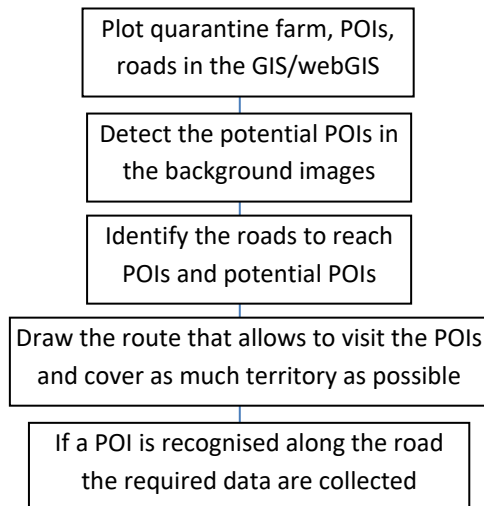
1. In case background maps and road maps are available, the proposed protocol is the following.

¹ The identification of the study areas is a cornerstone issue because it implies the decision/discussion about the following elements:

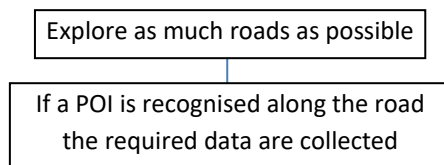
- which CRS. WGS 84, GCJ-02, other?
- which background map. Tiles from the “Chinese version of Google Maps”, tiles from Bing, access to an image repository made available by a Chinese institution, create an image repository from the ESRI World Imagery basemap, other?
- any road map?

² With the term “comprehensive” we refer to the qualitative characteristic of the map to represent, with a geographical coherence, as much road as possible.

A pilot study to evaluate the spatial factors that affect the status of biosecurity in quarantine station and exporting farm in China



2. In case background maps and road maps are not available, the method is the following.



To collect the information related to the POI a paper form must be defined. The form should contain at least the following information (core data):

- POI location;
- POI code assigned by the user based on a well-defined format;
- type of POI (the value is derived from a code list);
- species breded;
- for POI farm, this value specifies the amount of animal breded;
- for POI different than a farm, this value specifies the dimension of the facility. The value is derived from a well defined code list;
- open text.

About the POI location, the information can be captured in two different ways:

1. with a GPS. In this case the local CIQ identifies a convenient location (ie.: the POI gate) and records the coordinates presented by the GPS in the paper form. Once he/she returns to the duty station he/she edits the POI location by means of the webGIS/GIS direct georeferencing tool.
2. the local CIQ, by navigating through the images provided by the webGIS/GIS detects the POI and, by means of the indirect georeferencing tool, edits the POI location.

Once the local CIQ has edited the POI location, he/she adds the core data in the form made available by the webGIS/GIS.

3.3 WebGIS function test

This phase is dedicated to test the pilot webGIS in the CAIQ server.

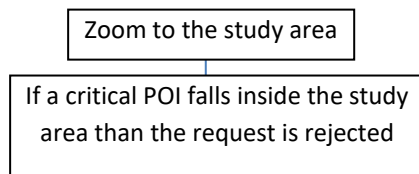
Once the pilot webGIS will be operative in a test configuration a list of webGIS functionalities will be tested by the CAIQ GIS expert and local CIQs.

3.4 Data analysis protocol

This phase is dedicated to a series of off-line operations made by the CAIQ GIS expert.

A pilot study to evaluate the spatial factors that affect the status of biosecurity in quarantine station and exporting farm in China

A GIS desktop software will be used to access the collected information. The GIS document will be organised according to a well defined set of layers that are portrayed according to a well defined thematic schema. This type of data organisation is oriented to allow the first explorative spatial analysis:



In case one or more no-critical POIs fall inside in the study area, the analysis of the spatial factors that affect the status of biosecurity in the candidate facility is stopped and a map, plus a message about the presence of critical point, is produced.

In case no critical points are within the study areas, the spatial analysis will be developed manually by means of a GIS software. It is clear that the sequence of steps can be embedded in the GIS software in order to create some automatic operation (i.e. a script in Python for QGIS or a schema in Model Builder for ArcGIS).

The spatial analysis consists of the following steps.

Preconditions

Three preconditions must be implemented before starting the analysis: (i) weight calculation, (ii) impact reclassification schema and (iii) threshold values.

Weight calculation

A weight represents the importance of a given type of POI with respect to the idea of accepting or rejecting the request of the candidate facility.

The proposed method for the weight calculation is based on a reduced version of the analytic hierarchy process (AHP) method. The AHP is a structured technique for organizing and analysing complex decisions, based on mathematics and psychology. The AHP exercise requires the participation of an expert that systematically evaluates the type of POIs by comparing them two at a time. The AHP converts these comparisons to numerical values for each POI. The result of the AHP exercise consists of a set of values (one for each type of POI) that represent the importance of each type of POI respect the other POIs.

The weights will be different for the two types of scenario: the candidate quarantine station and the exporting farm.

The decision tool software will be used to perform the AHP analysis.

Impact reclassification schema

The observed POI characteristics have values that are not comparable among them. A reclassification is necessary. A reclassification schema, based on expert opinion elicitation, shall be performed. The reclassified value shall be used in the spatial analysis.

Threshold values

For each scenario a specific set of values shall be defined in order to evaluate whether or not to approve the request of the candidate facility: the threshold values.

To establish the threshold values a “scenario analysis” is adopted. For each of the two scenarios, a set of the already approved and rejected candidate facilities is selected. For these real case pictures, the total impact calculation is performed. The obtained values are organised in a discrete distribution from which extract the rejected and approved threshold values.

A pilot study to evaluate the spatial factors that affect the status of biosecurity in quarantine station and exporting farm in China

For each scenario, two values will be derived: one value to approve the request (the lowest) and one value to reject the request (the highest).

Process

1st step: for each POI that falls inside the study area the intensity is calculated;

2nd step: for each POI that falls inside the study area the impact value is calculated (intensity x weight);

3rd step: calculate the total impact of the surrounding POIs;

4th step: comparison of the summed value with the threshold value.

1st step – Intensity calculation

The information collected for each observed POI are used to derive their intensity. The intensity represents the size of the observed POI.

The intensity calculation of the observed POI is performed by a re-classification operation. In lay terms, for each observed POI value the reclassification schema will be used to calculate the value intensity. For example, the observed value collected to express the “amount of animal housed in a farm” or the “dimension of the slaughterhouse” is transformed in a value that has a range from 1 to 5 according to the reclassification schema.

2nd step – impact calculation

The calculation of the weight times the intensity provides the impact of the observed POI. Clearly, the weight used in this calculation is compatible with the scenario under analysis.

Variations of the impact calculation can take into account the distance from the candidate feature and the presence of specific hot spots (calculate for instance the Getis ord G_i^*). These possible extensions are not presented in this document.

3rd step – Total impact

Since the values of the type of POI and intensity are dimensionless and have been calculated with the same range of magnitude, the values can be added together. This value represents the impact of the surrounding POIs. The value can be used to evaluate the “risk” associated to their presence with respect to the candidate facility.

4th step – Evaluation

The calculated total impact is compared with the threshold values in order to establish whether or not to accept the request submitted by the candidate facility.