Application of geographic information system (GIS) and WEB GIS for monitoring and surveillance of FMD and PPR diseases in Algeria

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Abstract

The study aimed to describe the evaluation and implementation of a spatial database that are directly or indirectly related to animal health in GIS and a web-GIS and the visualization of the spatio-temporal distribution of animal disease such as peste des petits ruminants (PPR) and foot-and-mouth disease (FMD) in Algeria. A methodology has been adapted based on the classical steps of GIS; and performed using freely available Qgis 3.10, this methodology can be largely applied to touch different types of diseases. We have also created a model of a website «VETALGIS» (Veterinary Algerian GIS) in order to digitalize the veterinary sector and minimize the problem of lack of data, organize them and facilitate access to them which will improve networking and communication between institutions responsible for livestock disease management. GIS spatial analysis techniques have proven to be a useful tool that can support the decisionmaking process in planning, implementing and monitoring FMD and PPR control strategies in endemic and high-risk areas.

Introduction

The livestock sector is one of the most important agricultural sectors, particularly in developing countries. However, the subsistence of pastoral livestock is limited by the frequent presence of trade-sensitive diseases that can affect the economic aspect of any country. Which make their potential for infection a further challenge to control and one of those diseases are PPR and FMD (Paton et al., 2009; Knight-Jones & Rushton, 2013; Gitonga, 2015 and Amaral et al., 2016).

In recent years, New and modern tools are therefore essential for monitoring and surveillance of these diseases (Mfmf et al., 2018). the geographic information systems (GIS) is one of those tools and which has been used for a wide variety of purposes, in different fields among them the veterinary medical sciences (Hay, 2000; TS & AW, 2017) especially in veterinary epidemiology (Rinaldi et al., 2006).

This paper describes the evaluation and implementation of a spatial database in GIS and a web-GIS application that allow the management of animal disease like FMD and PPR in Algeria. Also, visualization and analysis of data that are directly or indirectly related to animal health and its future projections in Algeria.

The study aimed to describes the evaluation and implementation of a spatial database that are directly or indirectly related to animal health in GIS and a web-GIS and the visualization of the spatio-temporal distribution of animal disease such as FMD and PPR in Algeria. It also aimed to show the utility of application of GIS/Web GIS techniques as tools that can be used in the planning, and implementation of disease monitoring and control programs in endemic and high-risk PPR and FMD areas in Algeria and as a decision support tool.

We have also created a model of a website «VETALGIS " (Veterinary Algerian GIS) that constitutes a platform that brings together all animal health dealers (administrative bodies - veterinarians - breeders) in order to digitalize the veterinary sector and minimize the problem of lack of data, organize them and facilitate access to them.

Materials And Methods

Literature Approach

Literature review and research was conducted by reviewing published articles, doctoral theses, reports and grey literature. Online search were used: ScienceDirect, Google scholar and Google web were searched for papers containing “FMD” or “foot and mouth disease” and “PPR” or “peste des petits ruminants” and “GIS” in veterinary sciences (Knight-Jones et al., 2017).

Study area

Representing the territory is necessary for being able to make any decisions, communicate with the exterior and supervise the evolutions caused by interventions (Godfrey, 2009). The selection of areas to be included in the study was made intentionally and on the basis of available financial resources and the following criteria: (1) The area is classified as an endemic or high-risk area for PPR on the basis of DVS recordings and official disease reports (Elsawalhy et al., 2010; Gitao et al., 2014; FAO, 2015; Gok, 2015), (2) The inhabitants are pastoralists with high sheep and goat populations (KNBS, 2009), (3) Is an important route for small ruminant stocks to neighbouring countries (Aklilu, 2008). On the basis of the above criteria, our study has been divided on two scales: Small scale and large scale. The large scale represents our whole country Algeria, while the daïra of Kser El Boukhari was selected for the small scale (Gitonga, 2015).

Materials used in the research

The materials used in this study include: a computer I.5, Software: Qantum GIS (version 3.10.5), Excel and storage media (USB, hard drive... ect).

Presentation and software choice

Quantum GIS (QGIS)

Quantum GIS or "QGIS" is an open source geographic information system. Founded by Gary Sherman in May 2002 and established as a project on SourceForge in June of the same year. It is developed using the Qt toolkit and C++. This means that QGIS is fast and has a nice and easy to use graphical user interface (GUI). The name "Quantum GIS" has no special significance, except that it starts with a Q indicating that it uses the Qt library. The main purpose of QGIS is two-dimensional interactive visualization of spatial data. However, there are also features for editing vector data, analytical features (GRASS plugin) and a large number of extension modules (plugin). QGIS allows the user to open Excel, Access files and work on Oracle data, and handles a large number of vector and raster formats including PostGIS, GRASS, Shapefile, GML, WFS, GPX, WMS, GeoTiff, PNG, JPG and many others. It also supports on-the-fly re-projection for vector datasets using the PROJ4 library. Qgis has made GIS software (which is traditionally expensive proprietary software) a viable prospect for anyone with basic access to a personal computer.

Currently it runs on most Unix, Windows and MacOS platforms. QGIS is available under the GNU General Public License (GPL). Developing QGIS under this license means that the public can inspect and modify the source code, and guarantees that users will always have access to a free and openly modifiable GIS program (Shekhar & Xiong, 2008; Gabriele Garnero & Ingrid Vigna, 2018; Project, 2020).

Microsoft Excel

The use of Excel software is required to export and edit the depth stations in Excel text format (CSV), necessary for their integration in QGIS. Excel also offers the possibility to perform descriptive statistical operations such as selection, filtering, sorting by ascending or descending order, and the graphical presentation of data (Curves, Histograms, Clouds of points, etc).

VETALGIS Web application

Objective and preparation framework

VETALGIS (Veterinary Algerian GIS) web application is a digital and evolutionary platform, developed within the framework of a graduation project in veterinary sciences following a remarkable need in this field, where digitization and the speedy circulation of information has become indispensable and remains unsatisfactory in relation to current technological development. The main objective of this platform is to bring together the various partners involved in the veterinary field in Algeria and all animal health dealers, namely administrative bodies - veterinarians, farmers, in order to ensure the following objectives:

- Determine the spatial distribution of animals in relation to the agricultural potential (vegetation cover) and the socio climatic and economic aspect;
- Real-time monitoring of diseases and simplifying intervention and precautionary measures;
- To know the animal potential and their concentrations;
- Build a reliable and fast database;
- Bringing together the different partners (farmer, administration, veterinarian, laboratory) in a single platform;
- To know the needs and the gaps that can have in the cycle of the stakeholders;
- Ensuring good sensitivity;
- The design of a digital and scalable database;
- Simplify the data collection process;
- To know in detail the spatio-temporal characteristics of each region;
- Ensure good management (reliable, fast and efficient);
- Allows the update and updating of data in real time;
- Allows the visualization of data;
- To know the variation and spatio-temporal distribution of each disease in real time;
- Bring the administration closer to the breeders and farmer;
- Improve networking and communication between institutions responsible for livestock disease management (Kuldeep et al., 2013; FAO, 2015; Gitonga, 2015).

As it's already said this platform brings together different partners, so we have devised this application into different area (Veterinary area- Administration area- Agricultural area) and each one play a principal role in the veterinary field.

- **Veterinary area:** is a space distinguished to all the veterinarians (state or private) that they can participate by filling in the boxes containing all the necessary information that are georeferenced and send to the stakeholders (figure 2).
- **Administration area:** A space dedicated to the collection of administrative data, facilitating the preservation and exchange of information with different partners, Knowing the needs and gaps that may exist in the stakeholder cycle (figure 3).
- **Agricultural area:** A space dedicated to farmers and stockbreeders to enable them to express their concerns and to disclose to the relevant authorities the diseases and problems they face (Figure 4).

Methodology

This work focused on distribution analyses, which were performed using freely available Qgis 3.10.5 (https://www.qgis.org/en/site/).

To design a GIS, a methodology has been adapted based on the classical steps of GIS implementation, inventory and analysis of the existing situation, data acquisition, processing, production of value-added products, in this case the maps of livestock distribution and production, animal diseases and (FMD; PPR) according to the following flow chart: (Figure 5).

Data Acquisition

In Algeria livestock disease surveillance information is largely lacking, due to under reporting of disease incidence (Prattley, 2009; FAO, 2011; Catley et al., 2012) and where the information is available it is available in different formats (papers, reports, Excel spreadsheet, Geographic coordinates...) and is distributed among different governmental and private institutions that do not have a sharing mechanism (FAO, 2011; Kuldeep et al., 2013).

Based on the definition of (Office Québécois de la langue française, 2004), spatial data acquisition can be defined as follows: "measuring spatial data, representing phenomena to be studied and intended for computer processing".

Data Sources

Administrative data

Administrative data are derived from the record-keeping activities of various organizations and/or the public sector. In our case data were collected from the Ministry of Agriculture and Rural Development of the People's Republic of Algeria (http://madrp.gov.dz/). These records include information such as animal population, disease outbreaks and are linked to geographical data by being captured at a particular address or region (hence the usefulness of relational databases). In this study the detailed information contained in the reports was structured in data bases and divided it into two scales (large and small scale).

Large scale : In order to investigate the distribution characteristics of FMD and PPR in Algeria, data of FMD and PPR cases from different years (2014-2015-2016-2018 for FMD and 2011- 2012-2013-2016-2018 for PPR) were collected from the Veterinary Services Direction of the ministry of agriculture of Algeria.

Small scale : Number of affected animals in the daïra of ksar el boukhari in 2019 were collected from (agriculture direction of media province "kasar el bukhari subdivision").

Survey data

Data were collected for a specific purpose, often in a single procedure. Updating the data requires significant effort and can only be done occasionally. One of the main difficulties with survey data is that information quickly becomes obsolete, especially in countries with rapidly growing development and populations (Vinodhkumar et al., 2016). In our case they are represented by geographical coordinates (x,y) derived from the addresses obtained from the direction agriculture direction of media province " kasar el bukhari subdivision.

Internet data

Data of FMD and PPR cases reported in the last few years were collected from the World Organization for Animal Health (OIE) (http://www.oie.int/).

Data structuring and integration

This step is essential for the establishment of a database, it refers to the assembly of data. The objective here is to manipulate the necessary data. The databases will be integrated into the GIS, they correspond to the data including the information on the study areas. The data entry component converts data from its existing form into a form that can be used by the GIS. Data for use in a GIS may be available in a variety of formats :

The input of geographical data: The concepts of georeferencing are necessary to understand how each collected information is referred at area or point of the earth into a two-dimensional plane otherwise; geographical data represents a relatively complex entity of the real world.

Entering descriptive data: it can be done in two ways: interactively, by selecting a spatial entity and directly assigning descriptive attributes; or through data files created elsewhere (in Excel).

The entry of map holdings: Data integration requires a good resolution background map in order to better locate the sampling stations and the different data of the study areas, and we opted for DZ Admin 0;1;2 ......

Data combination

Both spatial and geographical data are combined with epidemiological data allowing the analysis of variables. This data combination is essential for health policy planning, decisionmaking and ongoing surveillance efforts (Bhatt & Joshi, 2012; TS & AW, 2017).

In this case, the vector layer “DZ Admin” download from national institute for mapping and remote sensing (INCT) (http:// www.inct.mdn.dz/webinctsim/telechargement.php). The second vector layer is in the form of a point, contains the information collected on the ground and/or acquired from the Minister of the Ministry of Agriculture and Rural Development (MADR) concerning the fields of information shown; In this case, they are :

- Number of the municipalities;
- Number of the parcel;
- Disease type;
- Area;
- Type of breeding;
- Number of affected animal.

Data analysis and processing

There are several categories of processing and analysis, that can be carried out by a GIS in various ways; either according to:

- The type of object (point, line, surface, volume)
- The structure of the data (vector, raster)
- The modified characteristic (geometric, thematic, temporal or topological)
- The level of measurement of the variable (univariate, multivariate)
- The scale of measurement (quantitative or qualitative)
- To their purpose (descriptive, exploratory and confirmatory)

To explore how cases are distributed in each province and analyze the distribution of FMD and PPR cases where all provinces were considered as a whole, Global spatial autocorrelation was applied Spatial autocorrelation analysis was used to investigate the presence of clustering and its type. FMD incidence rate was taken as attribute value for each province (Jeefoo et al., 2010).

Converting the Data to Web map information's

The first step in publishing GIS services is to create the GIS resources that will be the basic parameter of any web service. Once the database is created, a GIS service allows access to the database via a local area network (LAN) or the Internet using the QGIS server. Authorized users can also use Geo-data services to periodically synchronize changes to databases on the Internet. When the publication process is complete, a map service and a geo-data service with the same name are created and can be managed independently. Consequently, the present work was formulated and generated on the basis of a tabular data model (Das et al., 2019).

Qgis2Web

It is an important operation of GIS, that can be installed giving us the ability to share data over the net, allowing rapid long-distance exchange and optimizing economic resources (Andreopoulou, 2011). Qgis2Web allows creating an employment web-map, in which the user can easily find information. It can be attached, for example, to the web site of the disease animal with an informative aim. Even though the complexity of the process increases with the number of the layers shown, the process of creation of the map remains fast and doesn't require a complicated training of the operator and The result is an html file, which can be opened with a web browser (Gabriele Garnero & Ingrid Vigna, 2018).

The Qgis2Web plugin provides an easy way to distribute and view Qgis work as a web map using Open Layers or LeafLet extensions. With this plugin, you can export your Qgis project as an html page by creating a directory containing the index.html page and subdirectories with everything you need to view the map, as well as the data used. The Qgis2WEB plugin exports the vector layers in GeoJSON format, creates the basis of the web map using the current version of Leaflet or OpenLayers (optional). In addition, the plugin adds raster data as image overlays with an opacity slider.

Results

Mapping results

Large scale

PPR results

Goat PPR

The maps (figure 6), show that goat PPR cases in Algeria were concentrated in saharian states (Tamanrasset, Bechar, Tindouf, Adrar) in 2011 while some cases have been reported in Ghardaia in 2012 and 2013 and in Beyedh in 2016. For 2018 we've record the highest level of cases in Khenchela, Ghardaia, Bejaia and Boumerdas.

Sheep PPR

The figure 7 show a random distribution of cases over the years (2011, 2012, 2013,

2016, 2018 respectively). The highest number of cases was reported in 2018 in Illizi, Ghardaia, Tebessa, Khenchela, Medea and Oran.

Cattle FMD

Cattle FMD cases were recorded in the northern and interior states in 2014 while we record just one case in El Oued in 2015 and for 2017 and 2018 we recorded cases from different states of the coast, the interior and the north of Sahara. The highest number of cases was reported from Setif (figure 8).

Ovine FMD

No sheep FMD cases were registered in 2014 while we record the highest number of case in El Oued in 2015 and in 2017 and 2018 we recorded cases from different states of the interior and Sahara (figure 9).

Goat FMD

No case goat FMD was registered in both 2014 and 2015, while in 2017 we registred some cases in Beyedh and we recored the highest number of case in 2018 in Souk Ahras, Skikda, Medea, Tizi Ouzou and Tlemcen (Figure 10).

Small scale

Refer to figure 11 and 12.

The FMD outbreaks were declared in Saneg, mfatha, and kser Kser El Boukhari.

E/ Web map results

Figure 13 shows the map that we've completed and exported in the web and how we can have all outbreaks informations with one clic.

Statistical results

Large scale

Table 1 Statistical results of PPR and FMD in sheep, goat and cattle

			2011	2012	2013	2014	2015	2016	2017	2018
PPR	Sheep	Min	0	0	0	-	-	0	-	0
		Max	65	2	6	-	-	4	-	569
		Average	1.8	0.042	0.125	-	-	0.08	-	17.85
	Goat	Min	0	0	0	-	-	0	-	0
		Max	20	17	26	-	-	3	-	62
		Average	1.15	0.35	0.54	-	-	0.0625	-	2.83
FMD	Cattle	Min	-	-	-	0	0	-	0	0
		Max	-	-	-	1009	1	-	95	120
		Average	-	-	-	54.31	0.02	-	12.54	12.66
	Sheep	Min	-	-	-	0	0	-	0	0
		Max	-	-	-	0	142	-	130	611
		Average	-	-	-	0	3.291	-	5.5	110.68
	Goat	Min	-	-	-	0	0	-	0	0
		Max	-	-	-	0	0	-	14	57
		Average	-	-	-	0	0	-	0.33	7.25

Table 2 Average of PPR and FDM cases in sheep, goats and cattle

	PPR		FMD		
	Sheep	Goat	Cattle	Sheep	Goat
Min	0	0	0	0	0
Max	114	15.6	286.25	197	14.25
Average	4	1	19.885	29.29	1.896

Sheep PPR was present in Algeria in the years 2011, 2012, 2013, 2016 and 2018 and the largest number of cases were recorded with an average of 17.85 cases. While goat PPR was present in Algeria in same years and the largest number of cases were recorded with an average of 2.83 cases.

For cattle FMD, it was present in Algeria in the years 2014, 2015, 2017 and 2018. The largest number of cases was recorded in 2014 with an average of 54.31 cases. The sheep FMD was present in Algeria in the years 2014, 2015, 2017 and 2018 where, have we recorded the largest number of cases with an average of 110.68 cases (Table 1 and 2).

Discussion

Small-scale results revealed that most FMD cases are located along the main road, pasture and communal water points. Therefore, it can be estimated that the directional distribution of the disease may be related to animal transport from breeding areas, shared pastures and watering points. It is also well known that biological, ecological and meteorological factors can influence the emergence of infectious diseases.

Algeria is a vast country and there are obvious climatic differences between the different regions. Thus, weather conditions may also influence the transmission of FMD virus and PPR virus. The specific factors that explain this directional transmission pattern need to be further investigated (He et al., 2015; Ma et al., 2017).

In the current study, the lack of information at the level of the Director of the Veterinary Office; which is the official institution mandated to have information on notifiable diseases in the country, was largely attributed to the lack of disease notification at the county level (Gok, 2015); leading to a breakdown in the already weak surveillance and reporting structure (Catley et al, 2012; Gok, 2014); this is what makes people think of a new institutional reporting structure that will improve county disease reporting, which is a mobile and web-based disease information sharing platform to facilitate and improve information sharing on livestock diseases and this is what the idea of the VETALGIS website aims at.

PPR and FMD outbreaks and cases were reported by the Ministry of Agriculture of the People's Republic of Algeria. As shown in the statistical result, the number of FMD outbreaks reported in 2018 was lower than the previous years, which is a reminder that more effective measures have been be implemented to prevent future outbreaks. The number of PPR cases is high compared to previous years, which means that there was some gaps at the level of the preventive system.

In fact, this study has revealed a great amount of information, particularly on the distribution and contribution of different species on disease transmission, between and within farms. But, it is difficult to determine to what extent these findings can be generalized to other situations, with different animals, livestock systems, livestock and human networks, climates and pre-existing levels of immunity.

The three main limitations constraining livestock disease control efforts in Algeria are the lack of inclusion and correlation when planning livestock disease control programs, the under reporting and the luck of veterinary services and a powerless livestock identification system.

The first difficulty faced was due to the under-reporting of the PPR and FMD epidemics at the county level. This affected the information available in the offices of the Director of Veterinary Services (DVS). Reports were only available for few (2014-2015-2016-2018 for FMD and 2011- 2012-2013-2016-2018 for PPR). Due to these limitations, maps of the spatial and temporal distribution of PPR and FMD outbreaks in Algeria could not be well generated, and show an heterogeneity in the analysis. The other challenge was to identify the areas to be included in the study, without official outbreak reports.

Accordingly, the following recommendations are made:

The appropriate government agency should develop and support the application of GIS in veterinary science to prevent and reduce the spread of disease and its economic impact;

The clinical veterinarian and their staff must know how to use GIS in the office and in the field;

It is strongly recommended that GIS tools and their application be used to produce maps for slaughter site selection in urban areas of Algeria;

The policies for livestock disease control should not be applied as general interventions, but need to be based on the ecological, social, cultural and economic context of the target communities;

It is strongly recommended that the government strengthen prevention and control measures the sensitive areas, and that the export of animals and livestock products be strictly limited;

Veterinary surveillance can reinforce by several actions implemented in the region, such as the geo-localization of holdings and the individual identification of all animals in the region;

One of the main problems in obtaining the status of 'free zone with vaccination' is the maintenance of this health status, due to the permanent surveillance procedures required;

As eradication of FMD is not predictable in many endemic countries, it is necessary to assess the cost-effectiveness of control if the incidence of the disease can be reduced by continuous mass vaccination;

There is a need to explore opportunities to share GIS applications and innovations specifically focused on veterinary science;

It also recalls that the restriction on the transport of animals from FMD-affected areas and high-risk areas needs to be reinforced;

The application of GIS in veterinary science is progressing rapidly and it is necessary for every veterinarian to understand the basics of GIS. To support and advance the use of GIS in veterinary science; for this purpose, the potential of GIS applications in this field is recognized to be enormous. However, the community of users of GIS in veterinary science is rather small compared to other sectors;

Due to the transboundary nature of FMD and PPR, a single country in an endemic area is unable to control and progressively eradicate PPR unless its neighboring countries share a similar objective. The Global Strategy also recommends the establishment of regional roadmaps for PPR. These strategies aim to reduce the PPR burden in endemic countries while developing strategies to prevent its entry into those;

The following recommendations should take into account, as PPR control strategies in pastoral areas of Algeria should be adapted to specific geographical regions taking into account prevalent diseases of small ruminants, existing disease control practices, the socio-economic status of communities and access to veterinary services.

PPR annual vaccination program should also include CCPP vaccination of goats as well as target animals aged 6 to 12 months. Policy makers should adopt the use of GIS and post-vaccine serological surveys to monitor the effectiveness and coverage of PPR vaccination campaigns in pastoral areas of Algeria;

For endemic areas, it is necessary to examine the current impact of FMD and then to evaluate possible control measures, their effectiveness and cost. A cost -benefit analysis can then assess the impact over time when control measures either are in place, Benefits and costs will vary between groups over the long term of a control program.

More investigators need to adopt the use of GIS spatial analysis techniques in the design, impact monitoring and development of control strategies for infectious livestock diseases;

Other studies should be conducted using GIS techniques to monitor the evolution and distribution of animal diseases in Algeria, to detect the different problems and to solve them later in order to preserve the public health and animal wealth in Algeria;

Conclusion

GIS represents a new technology in veterinary sciences which provides significant added value in animal health, by studying, reporting information and by modeling animal disease problems.

As routine data are usually taken into low consideration for either epidemiological or management purposes in veterinary sciences, a GIS can considerably increases the efficacy of communication to exploit those data. In the field of veterinary science, this methodology can be largely applied to touch different types of diseases and there are three situations in which it is suggested that GIS will play an increasingly important role in the future: the need to solve epidemiologically complex disease problems, the need for rapid surveillance of highly contagious diseases that could cross international borders, and the need to deal with politically sensitive diseases for which rapid and accurate notification is essential. However, applying sophisticated spatial techniques to poor-quality data will not create an insightful investigation. The people working in GIS should keep in mind that maps cannot be an alternate for better data collection and recording. The maps will never be better than the original input data. It’s a mere translation of information in a language which is easy to understand.

Impact of FMD and PPR is high for some regions but low for others. This impact varies according to the incidence of the disease and also the positive and negative impact of control measures levels of access to veterinary services, animal health inputs and livestock markets.

GIS spatial analysis techniques have proven to be a useful tool that can support the decision-making process in planning, implementing and monitoring FMD and PPR control strategies in endemic and high-risk areas.

Declarations

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Conflict of interest

The authors declare that they have no conflict of interest

Ethics approvals

Not applicable

Author’s contribution

All authors read and approved the final manuscript.

Data availability statement

All data generated or analyzed during this study are included in this published article

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Figures

Figure 1

QGIS openning software plateform

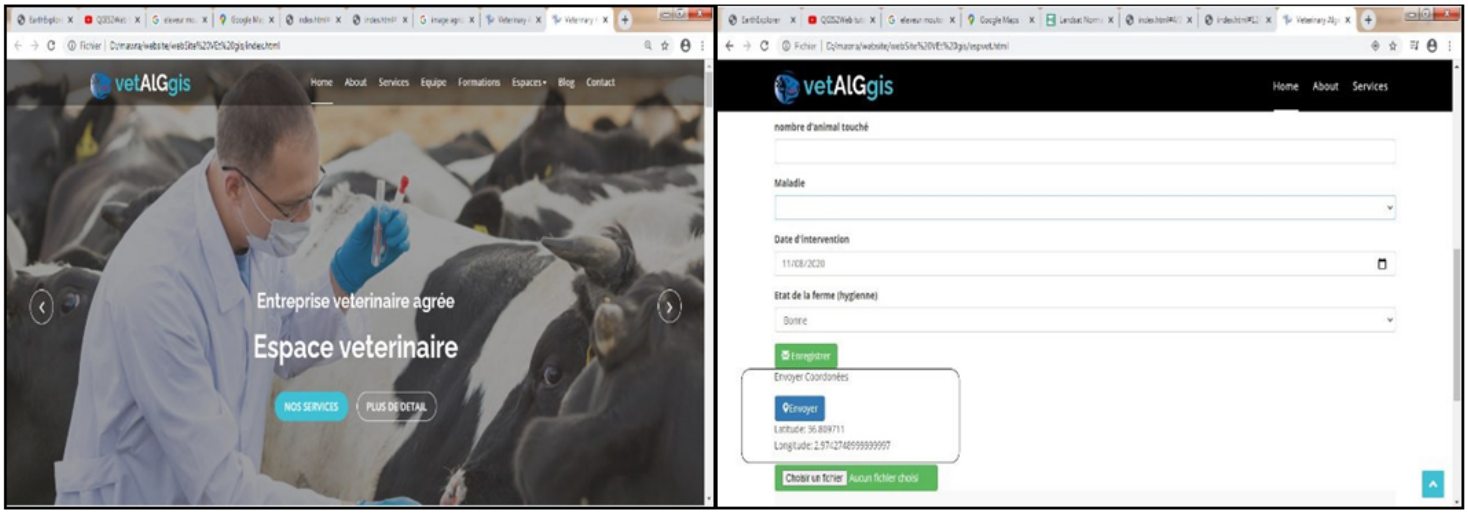

Figure 2

Veterinary area in VETALGIS Web application

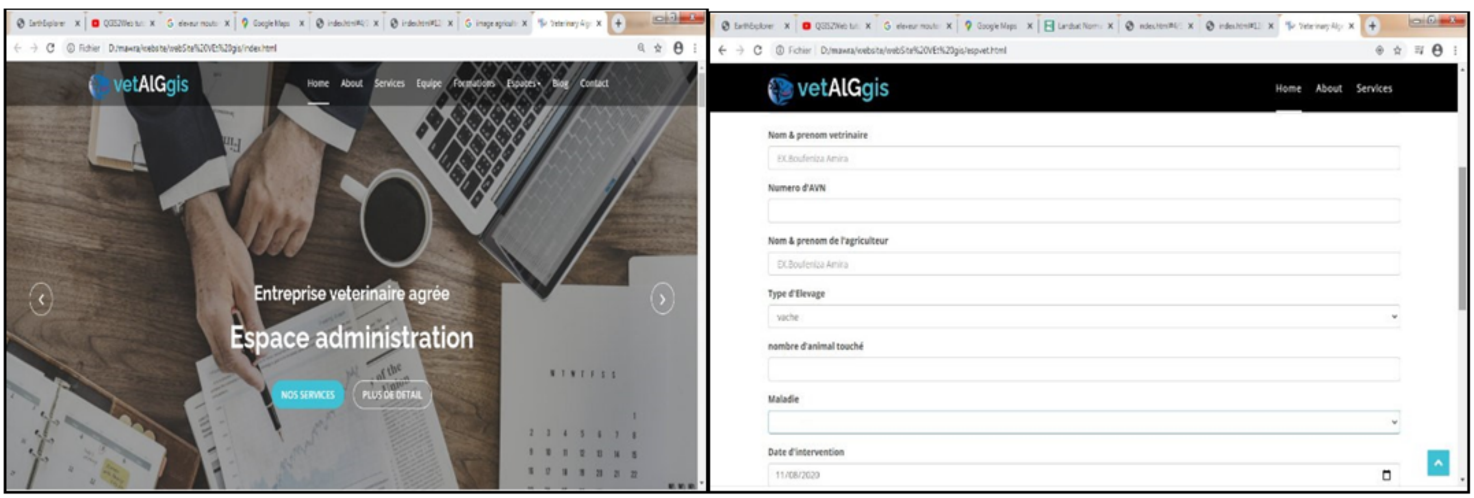

Figure 3

Administration area in VETALGIS Web application

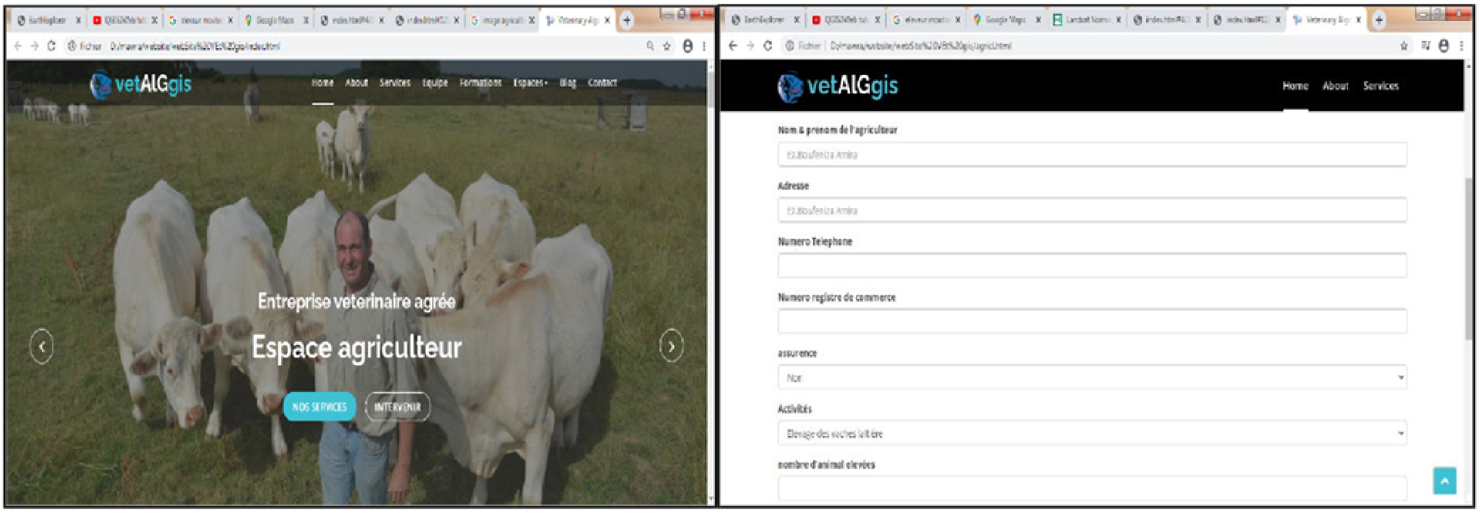

Figure 4

Agricultural area in VETALGIS Web application

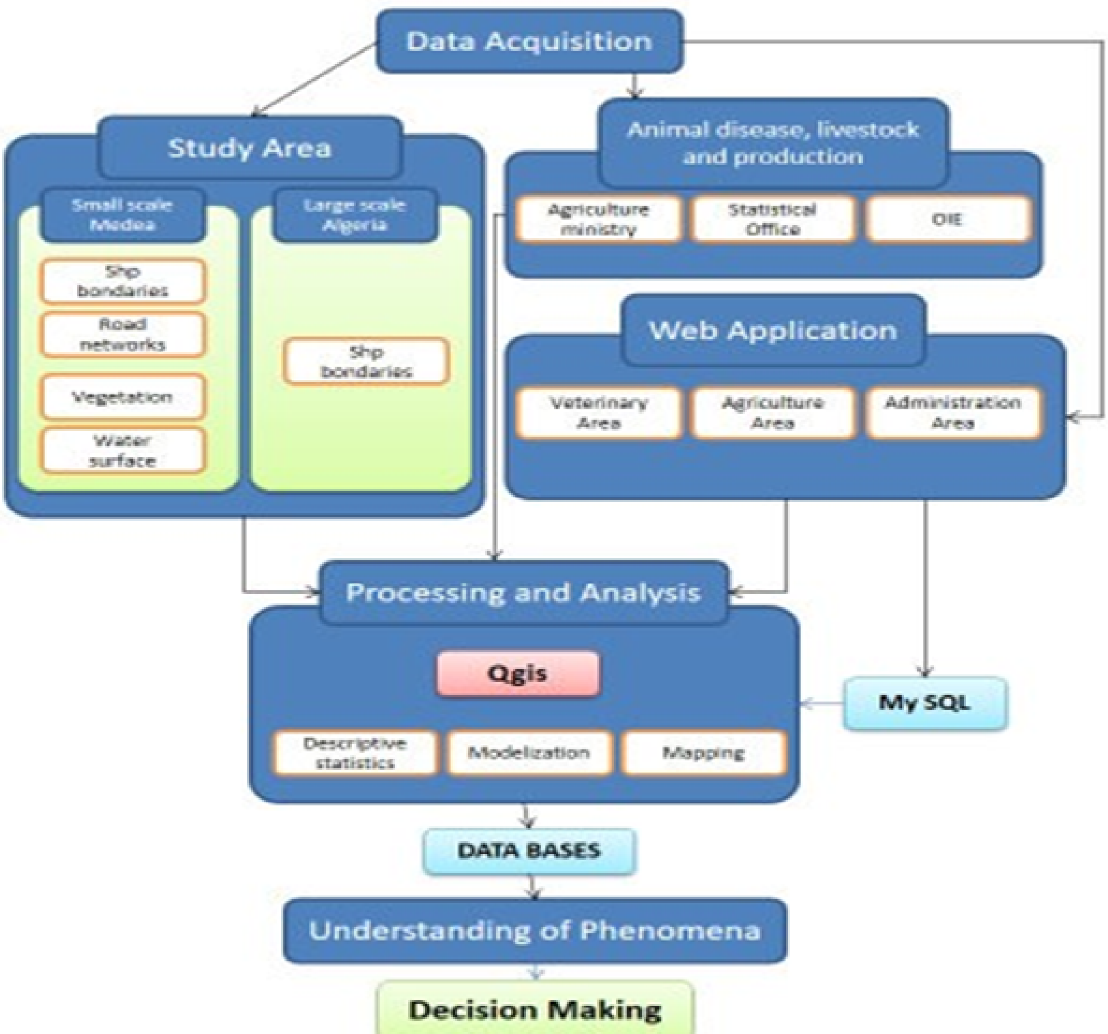

Figure 5

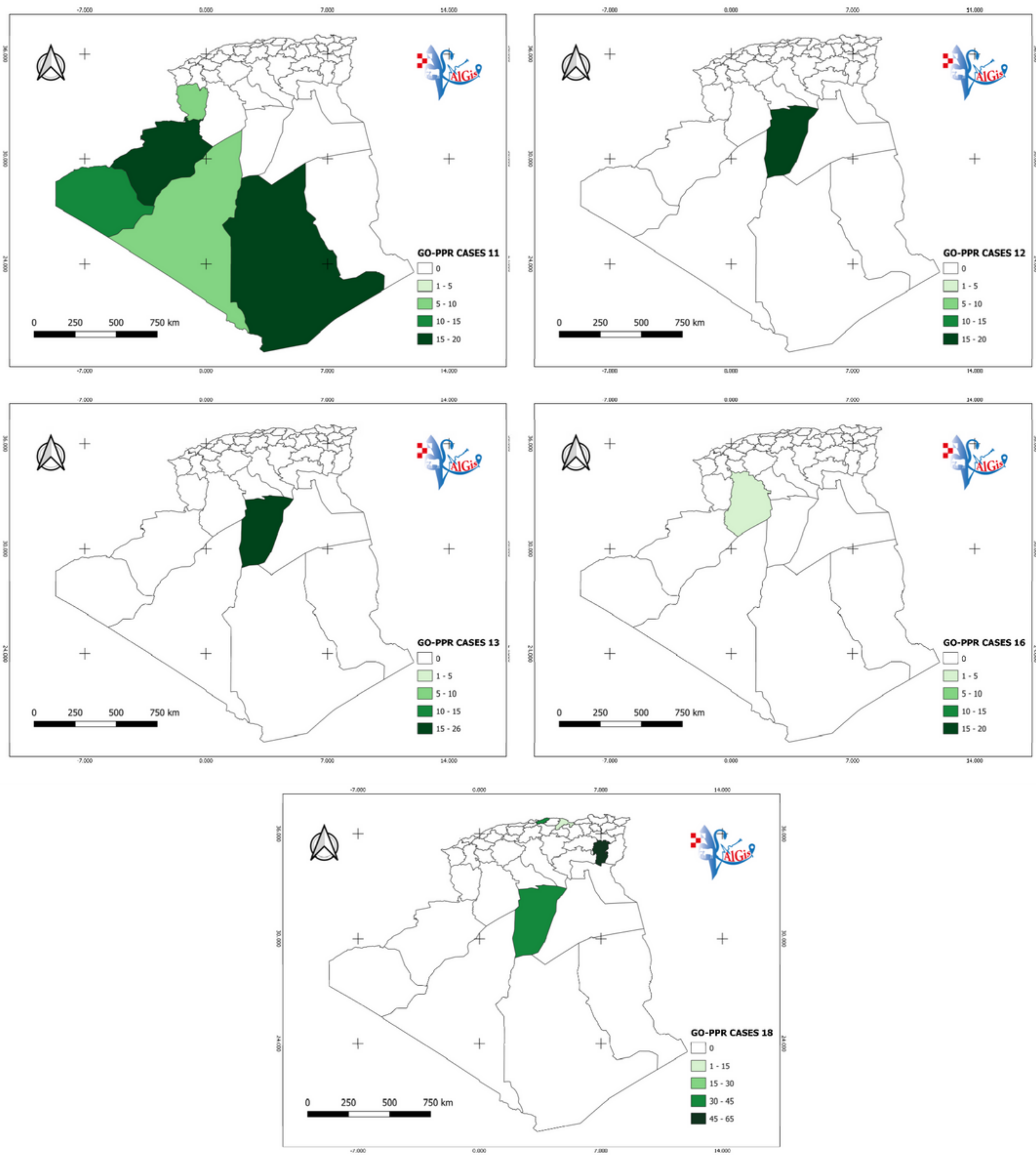

Figure 6

PPR in goats in Algeria

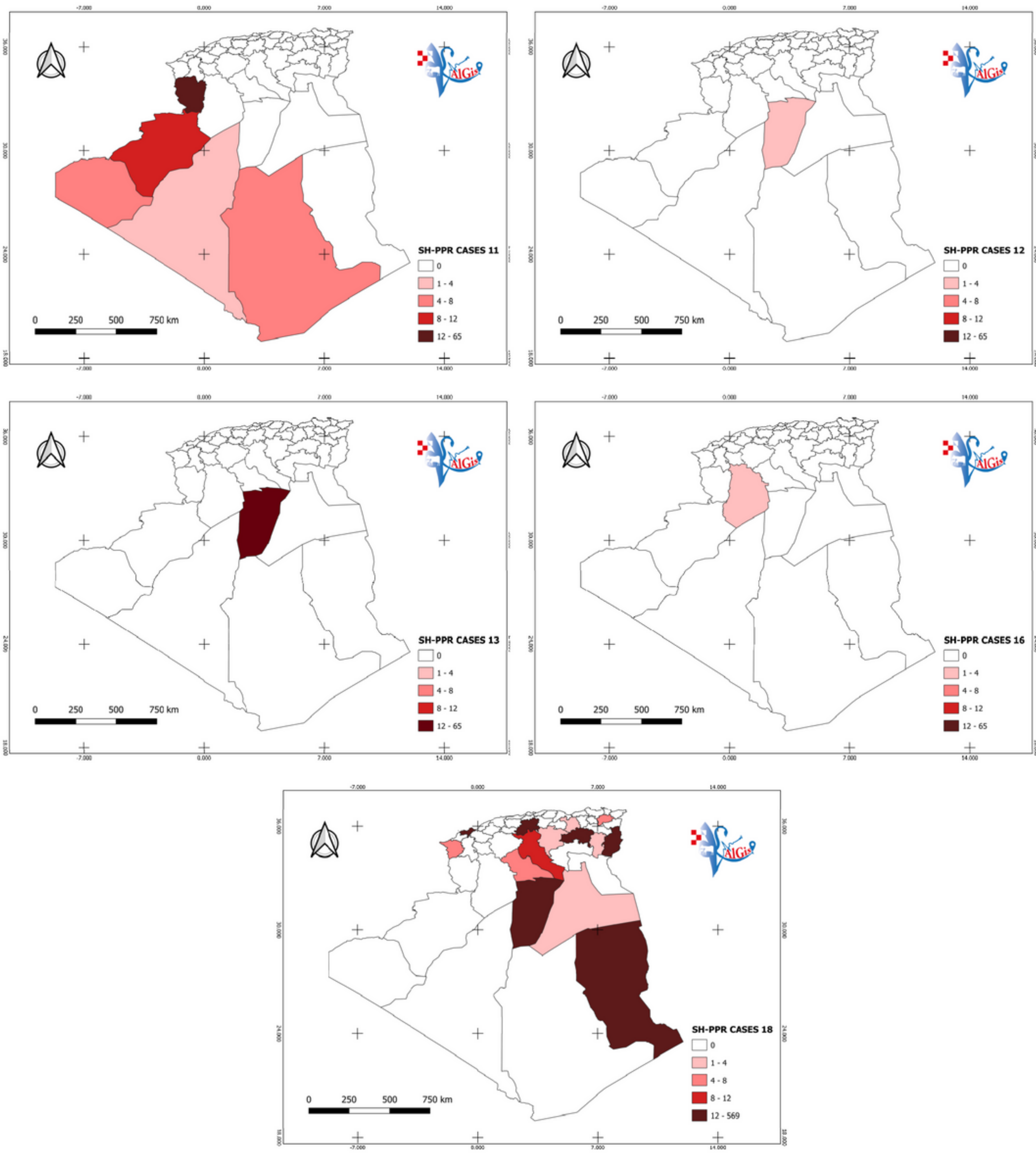

Figure 7

Distribution of PPR cases in sheep in Algeria

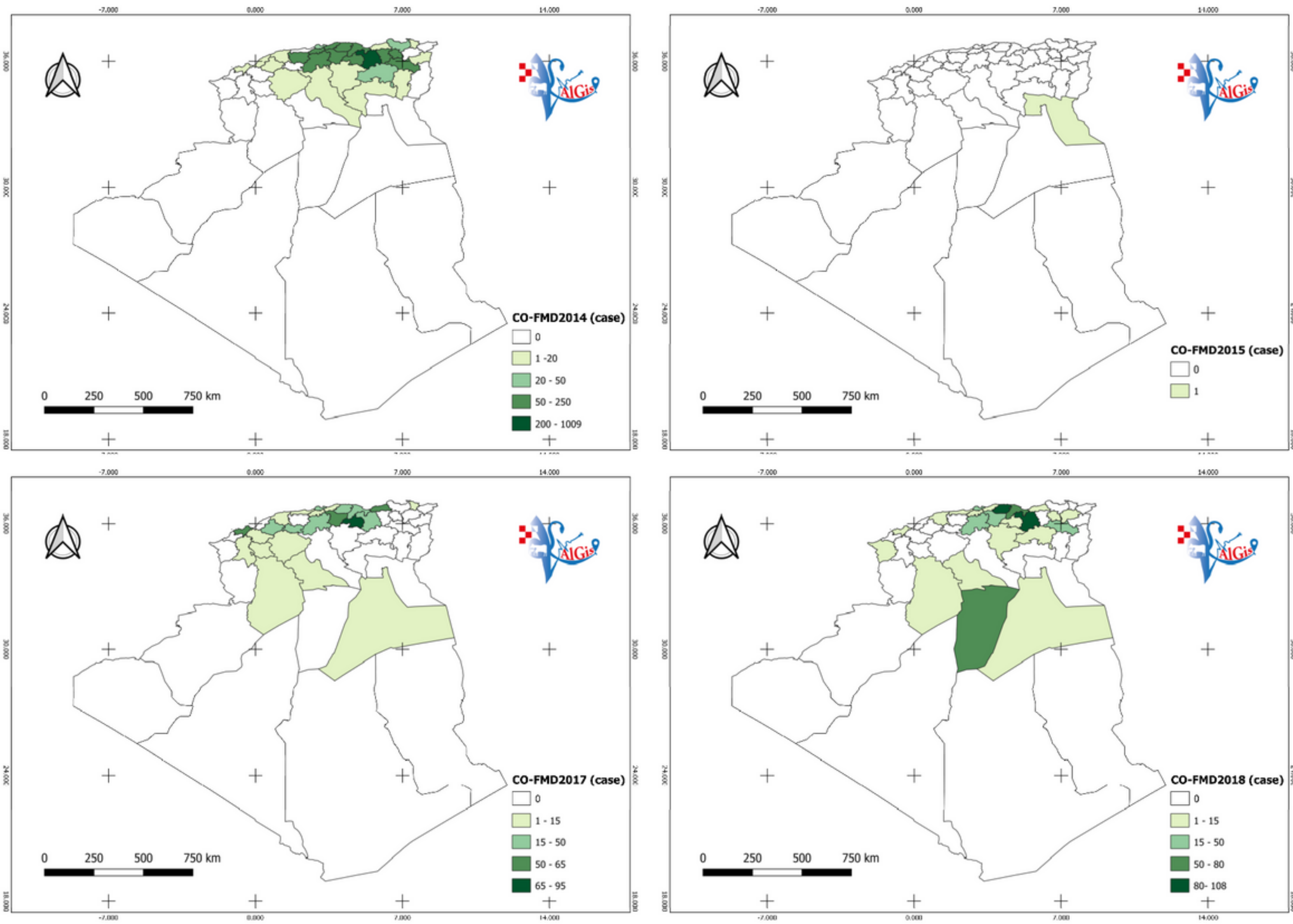

Figure 8

Distribution of FMD cases in cattle in Algeria

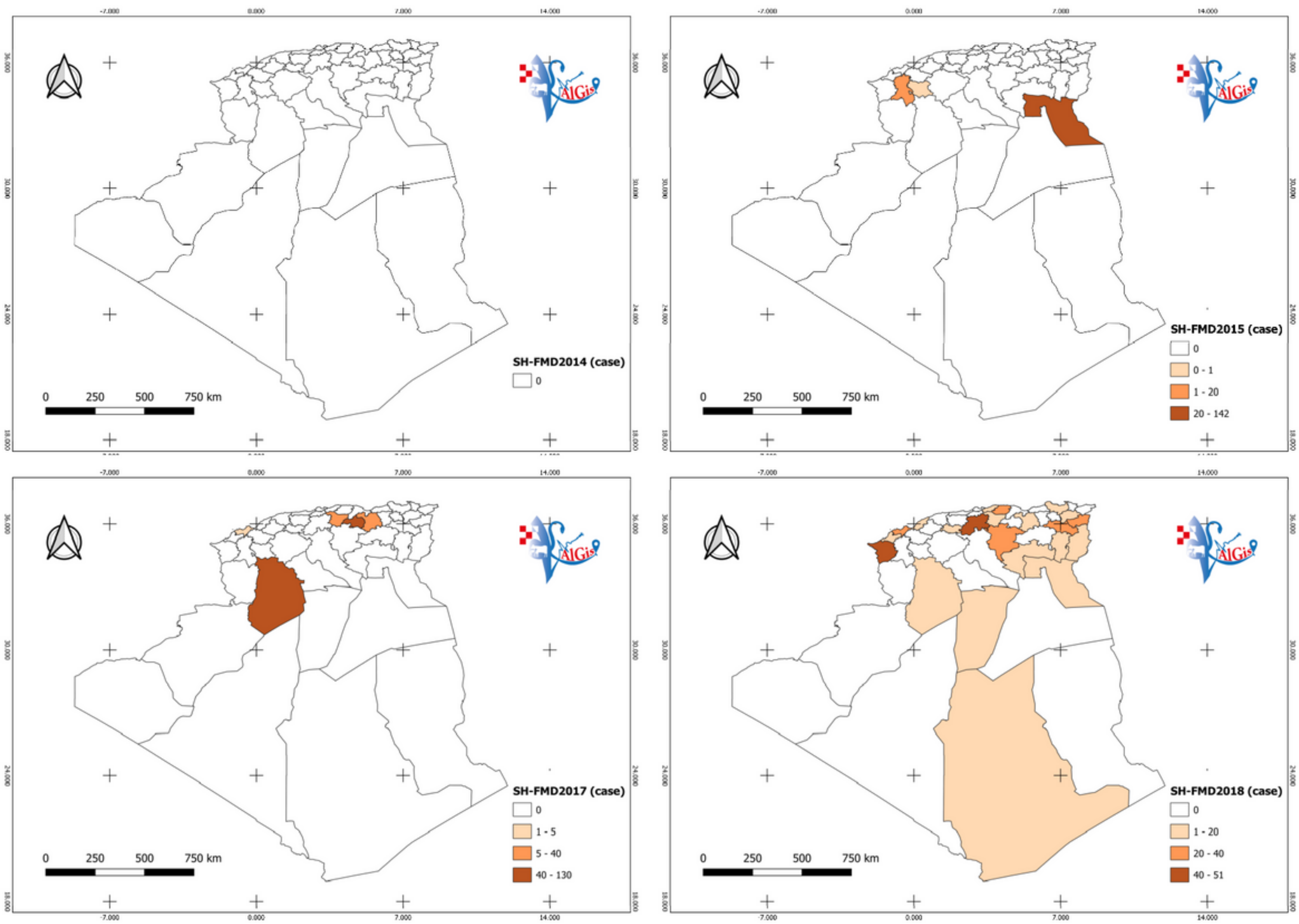

Figure 9

Distribution of sheep FMD from 2014, 2015, 2017, 2018 respectively.

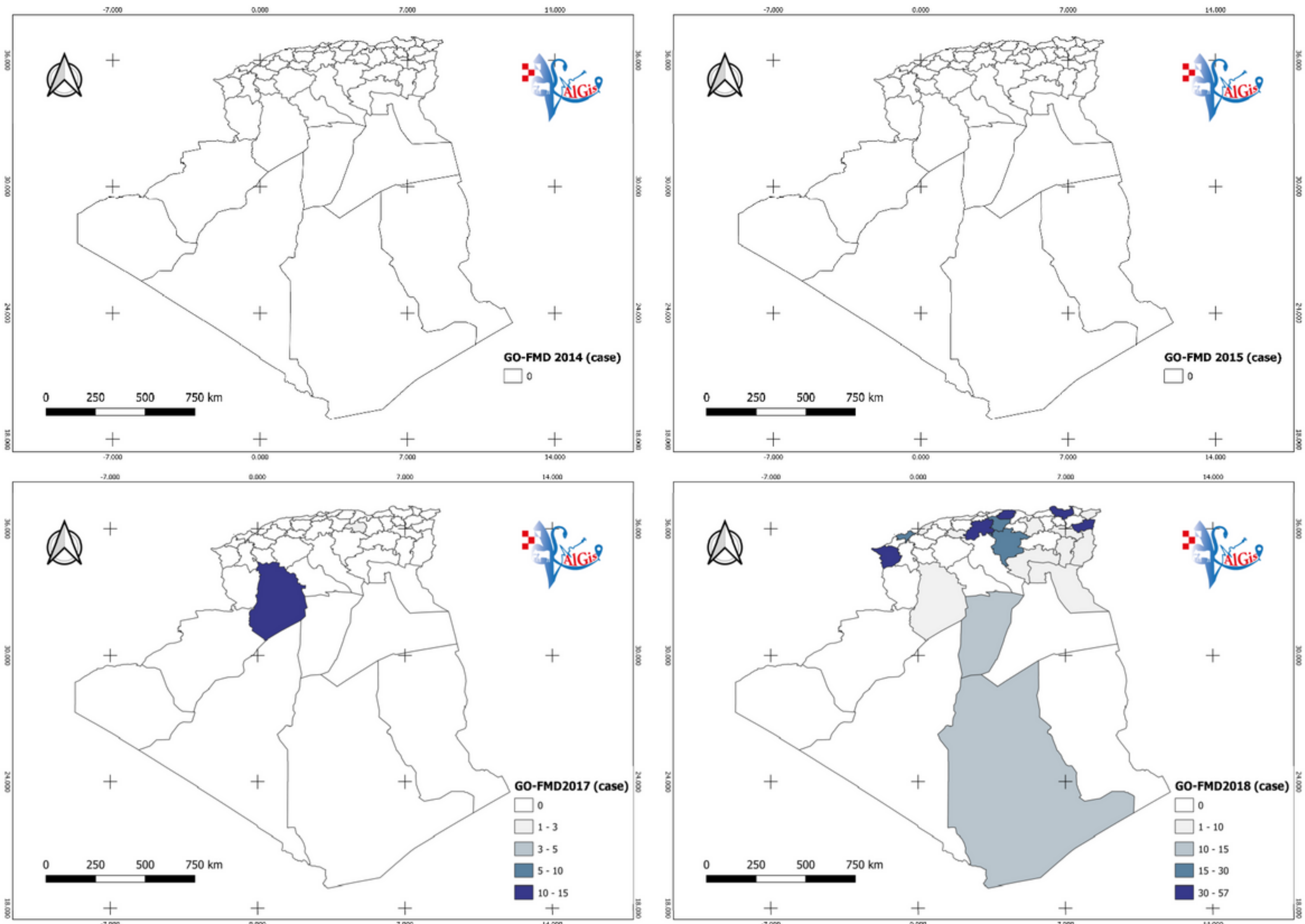

Figure 10

Distribution of goat FMD from 2014, 2015, 2017 and 2018 respectively.

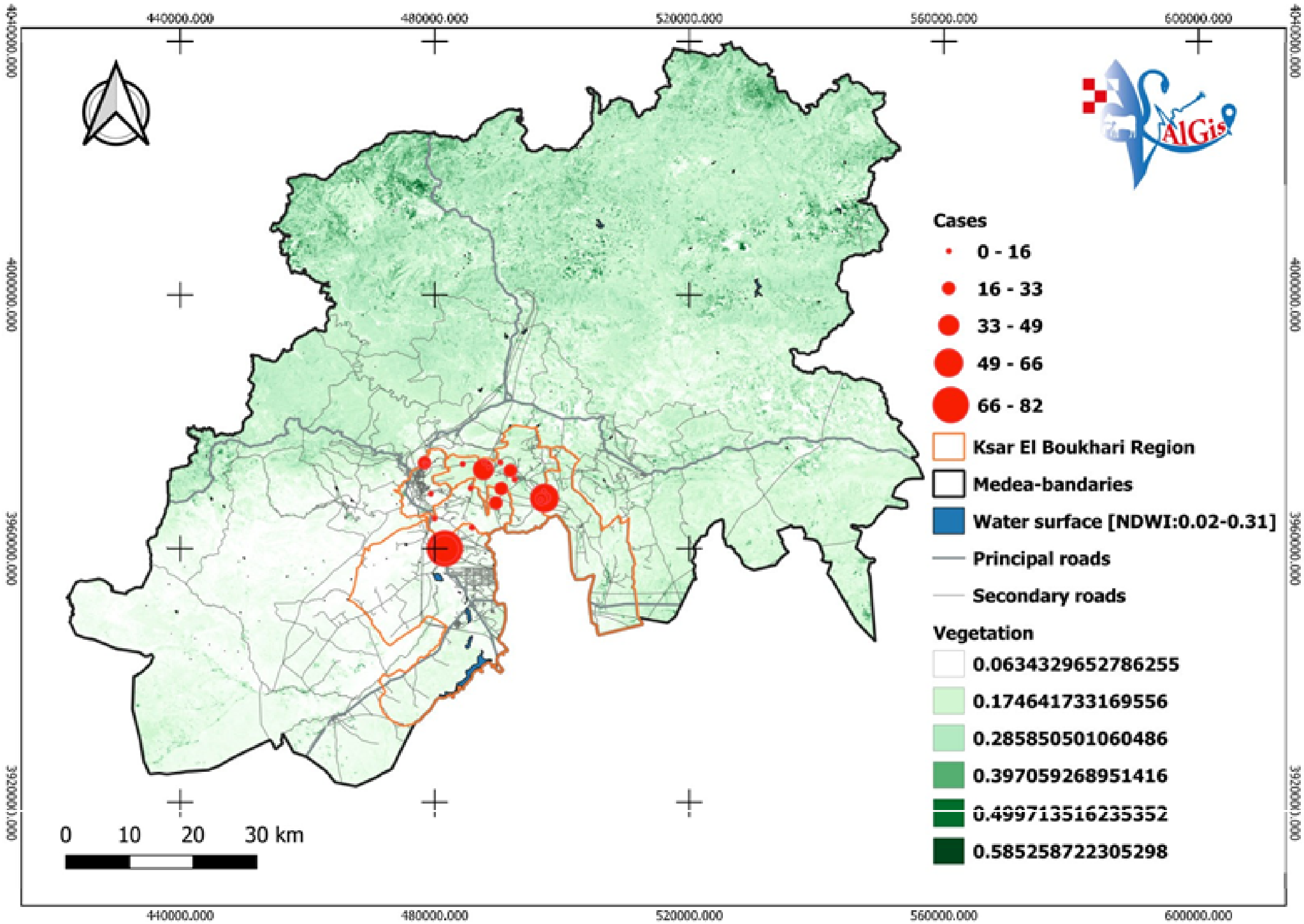

Figure 11

Medea's map showing FMD outbreaks which were declared in January and February 2019.

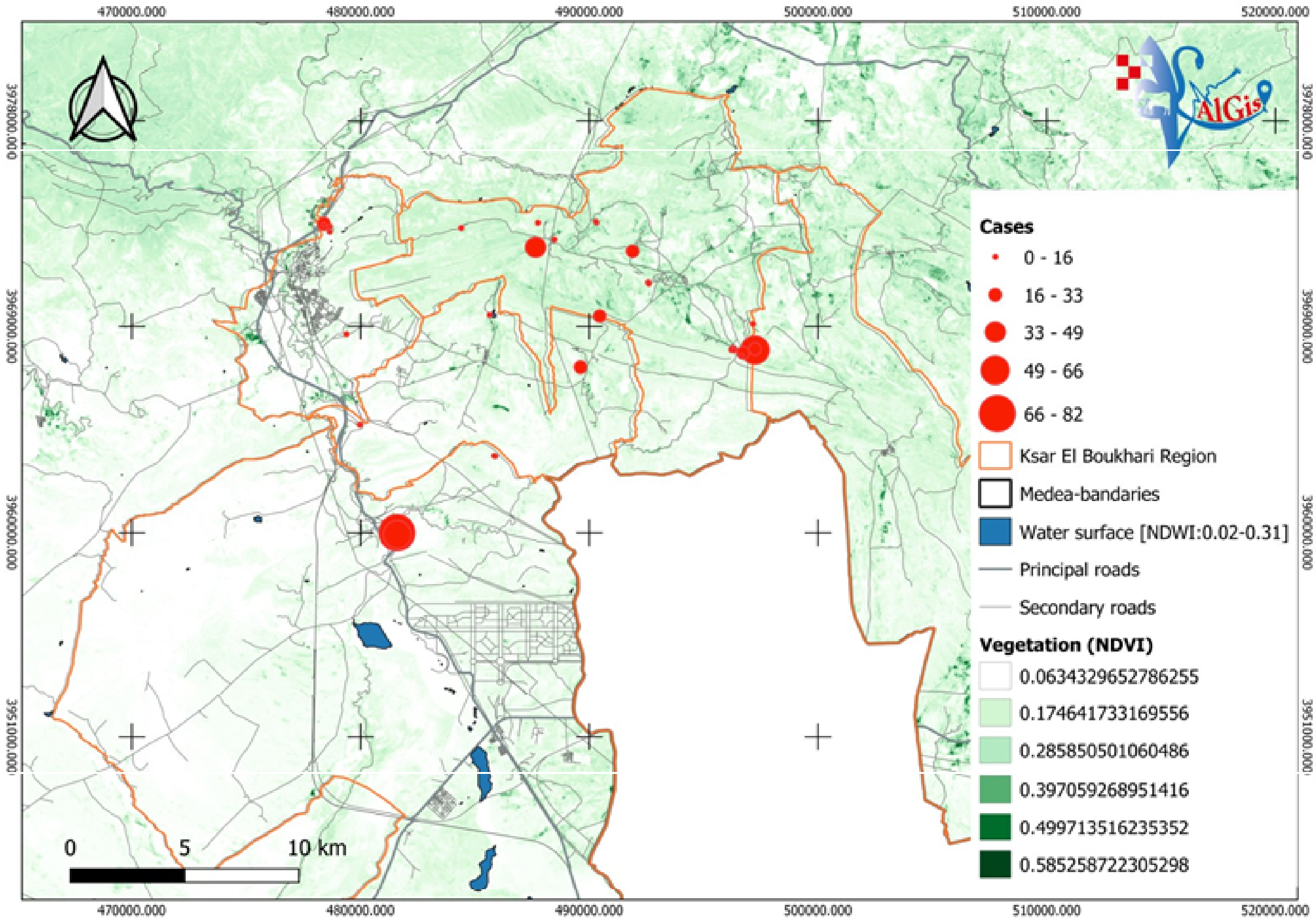

Figure 12

FMD outbreaks in Kser El Boukhari region declared in January and February 2019.

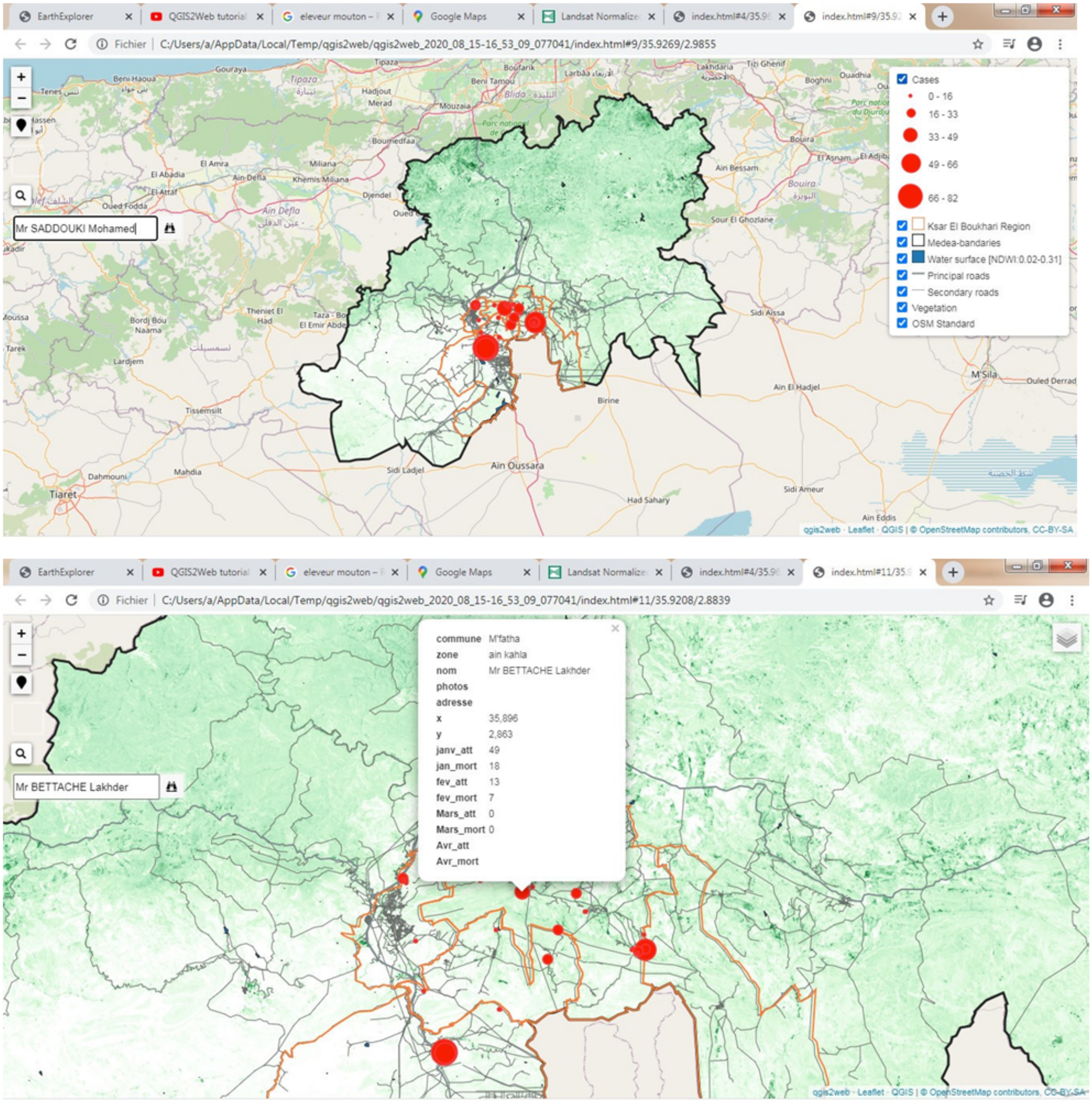

Figure 13

Medea’s web map exported by the plugin QSGis2Web.