Chapter 7

A WebGIS based toolbox to provide an actual database for poultry production in Europe

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Abstract

The use of livestock data offers a variety of application possibilities. Next to regional development planning for rural areas, regional patterns of livestock production can be identified. With regard to animal diseases, these data are of special interest, e.g. to investigate the risk of epidemics in regions of high livestock density farming. Within the project, the data were collected for different purposes. One of them was to define risk areas for the introduction and spread of avian influenza. Therefore the most actual data with a high spatial resolution were required. Since the European data server Eurostat does not provide poultry data in the quality and detail needed, all national statistical offices of the 27 European member states where approached to provide the data.
For the visualisation of the poultry data, two different variables were selected. On the one hand, the distribution of the poultry stocks on regional level was depicted by graduated symbols. On the other hand, maps showing the regional poultry density were generated. The geodata were transformed into mapfiles and implemented in an internet compatible client-server-model, in which all components are open source products. The core part of the system is a development environment for building spatially-enabled internet applications called MapServer. The final toolbox provides all information available in a web-based mapserver database, where the scientific user can conduct several semantic queries in the field of European poultry production.

1. Introduction

The use of livestock data offers a variety of application possibilities. Next to regional development planning for intensively farmed agricultural regions and comparative spatial analysis, regional patterns of livestock production can be identified. With regard to animal diseases, these data are of special interest, e.g. to investigate the risk of epidemics in regions of high livestock density farming. A good example is the zoonotic poultry disease avian influenza (AI). Apart from its capability to infect humans, the outbreaks of this disease have already evoked severe economic losses for the global poultry industry. As experiences have shown, densely populated poultry areas are of high risk for an introduction of the AI virus. Therefore it is of special interest and importance to provide the most actual poultry data on regional level. With this knowledge the centres of poultry production can be identified, which is essential for a variety of fields. On the one hand it is important from the veterinary point of view to ensure animal health and to develop vaccination strategies for these regions. On the other hand, poultry stock information is valuable for the poultry product boards from an economic point of view. Like the Dutch system "Productschappen Vee, Vlees en Eieren (PVE)", the poultry branches need this information to install quality assurance programs or to develop further registration and identification systems. Additionally, the regional poultry data are of great use for the work of decision makers. In terms of disease prevention and control, information on poultry production clusters can be applied to implement monitoring systems or to adapt emergency plans. Furthermore, for long-term regional development planning such as

the reorganisation of poultry production areas to prevent an easy transmission in a high risk period (as already conducted within the density reduction strategy for turkey farms in Italy, Ferre et al. 2006), regional livestock data are of great value.

The main objectives of this chapter are:
- to inform about the possibilities and difficulties of data collection in the EU-27;
- to describe the method to classify regions according to their degree of poultry density;
- to describe the system and the technical steps to implement the data;
- to present the toolbox and its functionalities; and
- to show the needs of maintaining the toolbox updated and working.

2. Material and Methods

2.1. Data collection and harmonisation

At the beginning of the data collection, three quality criteria were defined for the data collection:
- regional poultry data with the highest spatial resolution possible;
- data by poultry species; and
- most actual year available.

To visualise and differentiate regional patterns of poultry production as well as sparsely and densely poultry production areas, data on regional level were required. As the data were needed to define risk areas for the introduction of avian influenza and spread, a high spatial resolution of the data was essential. In addition, the different poultry species seem to show a different susceptibility to the AI virus and therefore a differentiation of the data by poultry species was needed. To provide a useful up-to-date database for the further work packages, the most actual data available had to be used.

The first data research was carried out at EUROSTAT (http://epp.eurostat.ec.europa.eu/). Eurostat publishes statistics in the fields of economy and finance, industry and (external) trade, population and social conditions, agriculture, transport as well as environment and energy. With regard to data on poultry stocks by regions, Eurostat does not offer the degree of detail which was needed within the project. Eurostat only provides data on "poultry total", which sums up all poultry species for every year, as well as the number of laying hens and the number of broilers on regional level. But since there is not a regular agricultural census in the single countries every year (the frequency of a census varies between one and ten years) and the detail of the survey level additionally varies by country, a lot of inconsistency can be found in this database. Furthermore, for new member states, such as Latvia, Lithuania, Malta, Romania or Bulgaria, no or only very few data on national level can be found at the Eurostat website.

Therefore it was decided to search for the desired data at the single statistical departments of the 27 European member states. In a first step, the website of the statistical office of every country was checked for data availability. In most of the cases, no poultry data were available on the websites. Consequently, the statistical offices were contacted by email and the poultry figures were requested.

The requested parameters are listed below:
- Number of birds and number of holdings by regions for the following species:
  - o layers (of laying age);
  - o pullets (not of laying age) ;
  - o broilers;
  - o ducks;
  - o geese;

- o turkeys; and
- o others (ostriches, quails, etc.);
- agricultural area (in hectare); and
- area in km²

As stated before, it was asked for the most actual year and the best detailed spatial resolution available. To use a comparable spatial level, the European NUTS levels were used. "NUTS" stands for the nomenclature of territorial units for statistics (NUTS). The system was established by Eurostat in order to provide a single uniform breakdown of territorial units for the production of regional statistics for the European Union. As can be seen from figure 1, NUTS 0 describes the national level of a country, whereas NUTS 3 stands for the district level and NUTS 5 for the municipality level of a country. Due to changes in the European statistical regulations in 2006, the NUTS levels 4 and 5 were renamed in "Local Administrative Units" (LAU). As most of the statistical divisions of the single European member states do not use these terms, this paper sticks to the original terms from NUTS 0 to NUTS 5.

As a matter of regional or local government reforms, not every NUTS level can be found in all European member states. An actual list of the different NUTS level by countries can be obtained from the internet address: http://ec.europa.eu/eurostat/ramon/nuts/introannex_regions_en.html. To provide detailed results, NUTS 5 would be the best level to use, but due to reasons of privacy, this level is often not available from the countries. In case of availability, the data may be quite old as detailed surveys are often only conducted in a ten-year-period (e.g. Austria, Slovenia, Hungary).
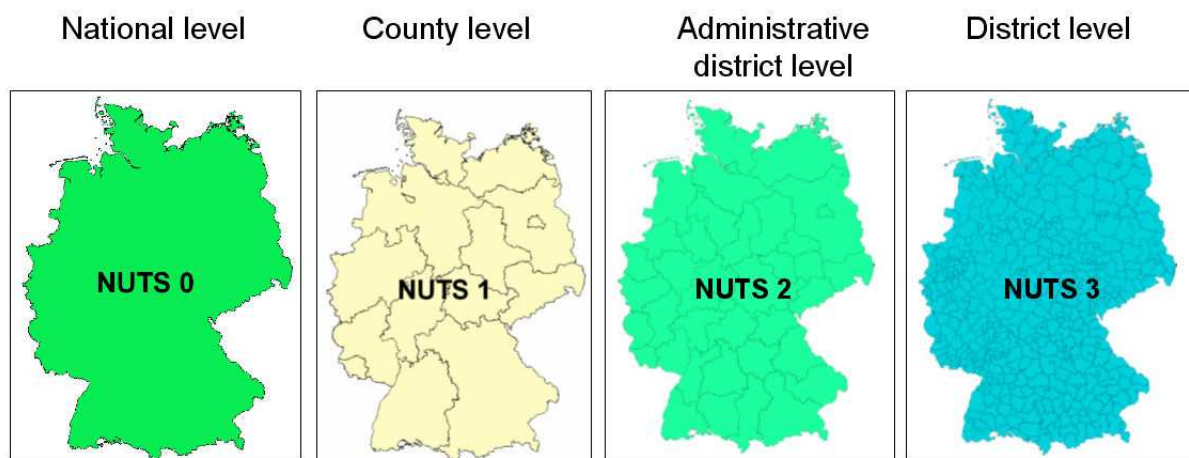

Figure 1. NUTS level 0 to 3 in Germany.

Next to the different degree of cooperativeness in the statistical offices to answer or to provide data, the frequency of the regional poultry censuses varies between one and ten years. In countries like Austria, Sloveni or Hungary, a detailed agricultural survey only takes place every ten years, whereas the statistical offices of Germany, Latvia or France provide a census every two years. In addition, the period to the publication of the data is different, too. For some countries (e.g. The Netherlands, Belgium), the statistical data are published within one year, whereas it takes about three to four years for the offices to prepare and publish the data in Greece, Poland or Portugal.

Besides, the censuses are often not comparable by poultry species. Since the regional information on poultry stocks seem to be quite sensitive data, the number of birds by species are often summed up and published as "poultry total". Consequently, a differentiation

between the single poultry species is not possible. Additionally, the definition of single poultry species or the size of holdings varies between the countries, and clear definitions are often not available. While Portugal, Slovenia, and Greece just publish the number of layers in total, other countries like Luxembourg, The Netherlands, or the United Kingdom do distinguish between layers of different ages (e.g. laying age, not of laying age) or parent stocks. To deal with these problems in the toolbox, the following solutions were found. Maps visualising a subcategory of a poultry species (e.g. layers of laying age) were only produced for the single countries, where these data are available. Maps comparing the poultry stocks of all European member states only display data for a poultry species category (e.g. layers, turkeys). In case of different subcategories present in a country, the sum was calculated and used for this issue. An overview about the current definitions and frequencies by countries can be obtained from the authors.

Another problem occurred in the fact that some of the countries used national administrational units which are not congruent with the NUTS-levels (e.g. Wales, Belgium). In these cases, the data had to be transformed and reclassified with the help of a geographical information system (GIS). Furthermore, some of the data were delivered in the national language of the country (e.g. Greek, Spanish, and Portuguese) so that a translation was needed. During the start of the project in 2005, the data were delivered in different file formats (.txt, .xls, .pdf, .html, .xml, .igy), which had to be identified and recoded. The last data update was done end of 2007, when most of the countries were able to provide the data in a compatible format, such as MS Office Excel.

The aim of the data collection was to develop a database with the most actual year and a detailed geographical breakdown – and both of the requirements should be similar in every country. Due to the problems described above, this aim was impossible to achieve. Therefore, the following two different alternatives were used within the toolbox and for further data analyses.
- Option 1: Similar and most actual year (disadvantage: different NUTS levels),
- Option 2: Similar geographical breakdown and most actual data (disadvantage: different years).

To compare the results on a regional level, option 2 was adopted and used to visualise the data and to produce risk maps (Grabkowsky et al., this report). To gain the most actual year of the data in the proceeding project, a second data request to each European statistical office was done in 2006 and a final one was conducted end of 2007.

The incoming data of various origins and sources were harmonized and integrated step by step in a MS-Excel database. End of 2006, the flexible and standardized database was filled with all poultry data available from the 25 European member states. In 2007, Romania and Bulgaria became new member states of the European Union. To complete the database for all member states, these countries' statistical offices were also approached for poultry data. The final database implemented contains data for the years 1999-2008 on NUTS levels 0-5. An overview by countries, years and poultry species available can be obtained from the authors.

2.2. Visualisation of the data

All data available were joined with geographical information (with the national IDs and codes of the NUTS levels) in order to implement the data in the GIS. To visualise the data, the GIS system ArcView 3.3 was used. After release in September 2006 the ArcView version 9.2 was adopted. For the toolbox it was decided to display the data of the two most detailed NUTS levels available for each country. Due to the different statistical framework described above, these levels differ between the countries. For the project partner countries Germany, Italy,

Hungary, and The Netherlands, data for the NUTS levels 3 and 5 could be implemented. For most of the other countries, the best geographical breakdown available was NUTS 3.

For the visualisation of the poultry data in the toolbox, two different variables were implemented. On the one hand, the distribution of the poultry stocks on regional level was depicted by graduated symbols. On the other hand, the regional poultry density was considered to be another parameter to display.

Based on the livestock information from the national offices for statistics, the poultry density was calculated from the number of birds and the area of the single NUTS regions (number of birds per km²). According to the degree of density all regions were assigned to three classes:

- Densely Populated Poultry Area (DPPA);
- Medium Populated Poultry Area (MPPA); and
- Sparsely Populated Poultry Area (SPPA).

In addition to these classes, every administrative area with no poultry registered by the statistical offices was attributed with a zero value. Taking into account that small backyard holdings with less than 200 birds do not have the obligation to report their stock within the agricultural surveys, in these areas may still occur some poultry stocks and a related poultry density, which is not computable. Roaming usually freely as they scavenge for food, mingling with wild birds or sharing water sources with them, small backyard flocks pose a certain risk for introduction of the AI virus (WHO 2006). In addition, the introduction of AI in backyard flocks would be associated with a heightened risk of human exposure and infection. Due to this explanation, these regions with no poultry officially registered were integrated and assigned to a fourth class, the

- unknown Populated Poultry Areas (UPPA).

In these areas, the hypothetical amount of all unknown small poultry flocks is considered (Grabkowsky 2007).

Since the density values vary on the different NUTS levels (the more detailed the geographical breakdown, the higher the density), a NUTS level related density classification was developed. As can be seen from table 1, the classification system was based on a logarithmic scale. These ranges were used for all poultry species. To give an overview about the entire poultry production in Europe, all poultry species were added to "poultry total". Since this value summarizes different poultry production branches with different spatial patterns, the regional poultry density reveals higher values. Therefore, the logarithmic classification was manually modified to redefine the class of the DPPA. As discussed with experts on European poultry production, a threshold of 3,000 birds per km² was adopted to identify the European centres of poultry production (table 1).

Table 1. Density classifications for the different NUTS levels (in birds/km²).

Density classifications	Poultry density intervals for different NUTS levels			Density intervals for "poultry total"
	NUTS 2	NUTS 3	NUTS 5	"Poultry total"
Densely populated poultry area (DPPA)	> 100	> 1,000	> 10,000	> 3,000
Medium populated poultry area (MPPA)	10 - 99	100 - 999	1,000 - 9,999	1,000 - 2,999
Sparsely populated poultry area (SPPA)	0,01 - 9	10 - 99	100 - 999	100 - 999
Unknown populated poultry area (UPPA)	0 - 0,01	0 - 9	0 - 99	0 - 99

The data were imported to the GIS, joined with the administrational data of each country and visualised the way described above. For every theme (poultry species by country on a specific NUTS level and for the most actual year), a shapefile was produced. In total 432 shapefiles were generated to display both, the poultry distribution and the poultry density.

2.3. System

The basic idea was to provide the most actual poultry data in an internet-based server, where the user can conduct several semantic queries in the field of European poultry production. Next to the essential need to be internet compatible, the system for the toolbox had to fulfill a variety of requirements as specified below:
− Free and fast information access and retrieval;
− Dynamic, platform independent data exchange and availability;
− Data documentation by standardized metadata;
− Low costs for software and hardware;
− Data access controlled by a user management; and
− No special knowledge or software needed at the client site to provide a user-friendly system.

The system chosen is a client-server-model, which consists of different open source components. The core part is a web-based information system called MapServer. MapServer was originally developed by the University of Minnesota (UMN) ForNet project in cooperation with NASA, and the Minnesota Department of Natural Resources (MNDNR). The system is an open source development environment for building spatially-enabled internet applications. Although it is not a full-featured GIS system, MapServer excels at rendering spatial data (maps, images, and vector data) for the web (http://mapserver.gis.umn.edu/). The range of possible applications reaches from the fields of biodiversity, heavy metals in mosses to volcanology. A list of applications and references can be found at http://mapserver.gis.umn. edu/gallery. Similar to all of these examples, the system is designed for efficient data retrieval and the visualisation of various (meta-) data, for publishing, and for the illustration of research results. As the dataset includes also sensitive data, data dissemination at different levels of data access can be ensured. With its user-friendliness, the system additionally supports the aim to prepare the data for decision- and policy-makers in an efficient and comprehensible way.

To prepare the server for a data implementation, the following components had to be installed:
- Linux (Operating system), Apache (WebServer);
- Open source libraries (Geospatial data abstraction library (GDAL) and Simple feature library (OGR));
- UMN Mapserver (development environment);
- PostgreSQL and PostGIS (data management system); and
- Mapbender (Graphical user interface (GUI) to visualise the geodata).

The software components and the system architecture of the web GIS are illustrated in figure 2. As it can be seen, the MapServer is the main part of the client-server-model, which includes components to store and manage (geo-) data, to generate maps, to conduct GIS operations, and to communicate with the client. The communication is achieved by the HTTP (hypertext transfer protocol) server Apache. The clients (Browser) requests (e.g. map inquiry) are handled by the Apache server which returns a response (e.g. map).
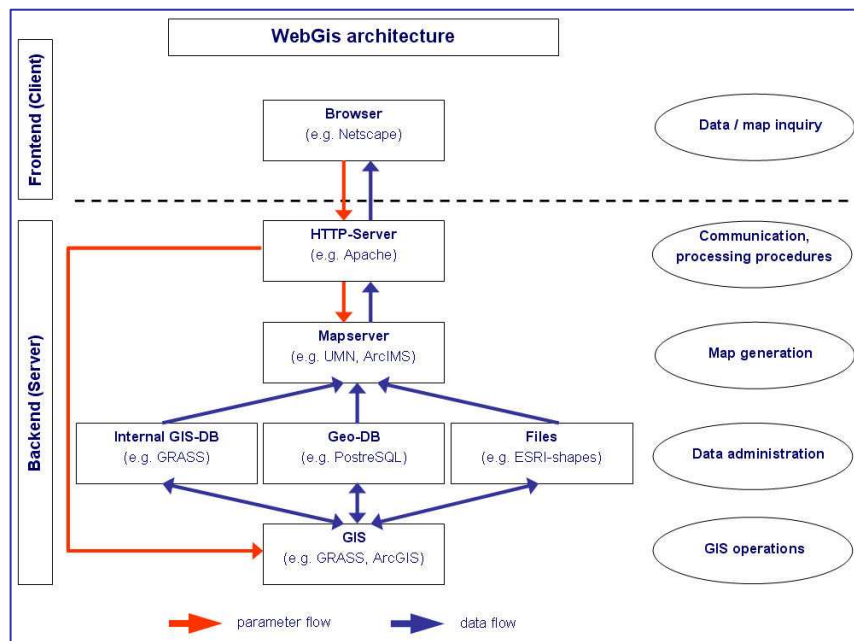
Figure 2. System architecture and software components.

2.4. Data implementation

In the following text passage, the technical steps to implement the data are shortly described. For further information, a selection of papers and websites with detailed information are cited at the end of this paper. The geodata to implement consists of the 432 shapefiles, which visualise the poultry stocks and the poultry density on regional level. To enrich the system, additional information on traffic routes, waterways, lakes, cities, city areas, railways, and airports were added for each country. The data used were gained from the European map set 2008 of the GfK Macon institute.
Subsequent to the installation of the server components, the following four steps had to be done to implement the data.

1. Import of the vector geodata in PostgreSQL (spatially enabled databases).
All shapefiles produced in the GIS are vector data, which include features made up of points, lines, and polygons. The MapServer supports ESRI shapefiles by default, but all 432 shapes generated were additionally compiled to receive the support of the spatially enabled database PostgreSQL. PostgreSQL is an object-relational database management system (ORDBMS), where the data are temporarily exported and stored in case of a client request. It is also open source software and is used to assist the server in handling and converting spatial queries and analyses.
2. Configuration of the mapfiles.
In the following step the single shapefiles were transformed into mapfiles and added to the mapserver. A map file is a structured text configuration file for the MapServer application. It defines the area of the map, the data source and the storage location for the output images. It also stores the information about the map layers, including their data source, projections, and symbology.
3. Programming of the analysis routines.
In the third step, a query capability to conduct attribute and spatial queries was programmed. The query routines enable the user to select for example features based on a click on the map

or to draw a user-defined selection box to zoom in to a predefined point. The defined request is passed through a URL to the mapserver, which returns images, maps or additional information.

4. Programming of html pages.

The last step to perform was to configure and to program the html pages, which build the interface between the user (client) and the mapserver. These html pages are responsible for the output of the additional information and the maps.

3. Results

The data administration and access is realised on a server at the ISPA of the University of Vechta. The internet address is: www.ispa-gis.uni-vechta.de

To protect the database and system, a password system was installed. The password can be requested by email (bgrabkowsky@ispa.uni-vechta.de).

The starting page of the website (figure 3) welcomes the visitor and gives some hints how to proceed to the poultry data and maps (1). Links to further information about the project, avian influenza, and the NUTS levels are implemented under the point "More information" (2).
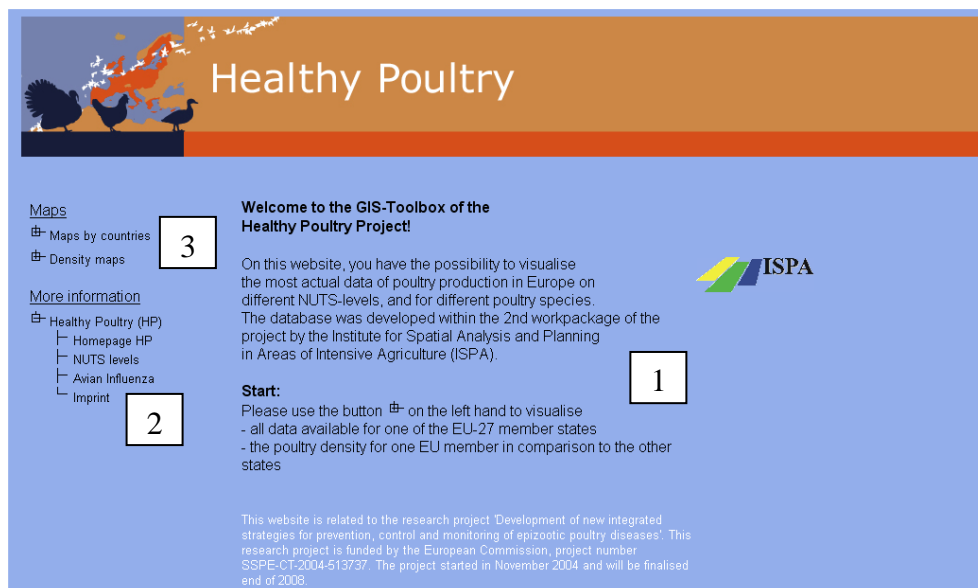

Figure 3. Welcome page of the GIS-toolbox.

The topic "maps" provides the possibility to access the section "poultry stock maps" or the section "poultry density maps". By clicking on one of these two alternatives, the user has to enter a password. Afterwards, the user is forwarded to the desired section.

3.1. Section "Poultry stock maps"

By clicking on "poultry stocks", a list of the 27 EU countries is expanded (figure 4). Now the user can choose between the single countries and select one by clicking on the name. In the example shown in figure 5, Germany was selected. As can be seen, a new html page occurs, which contains five different elements.
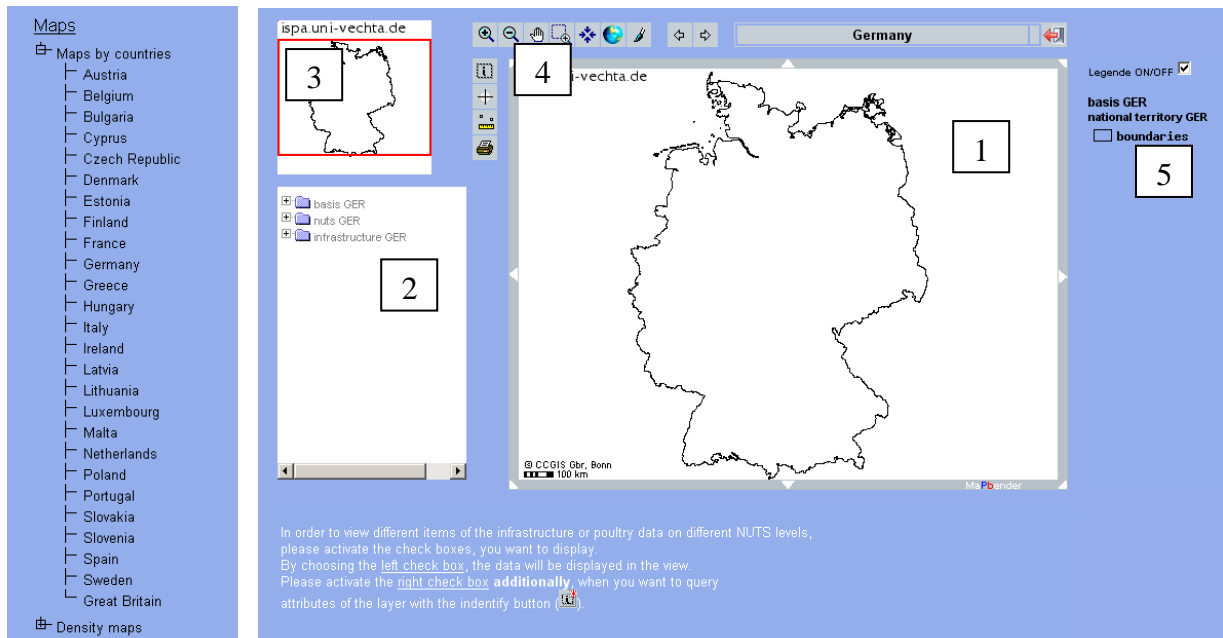

Figure 4 (left). List of EU-27 countries;
Figure 5 (right). New html page, when Germany is selected from the list.

The main part is a map display, where the border of Germany is shown (1). On the left side, a small window contains three folders, where the single mapfiles are stored (2). In the upper left corner of the page, the current selection shown in the map display is marked in the total extend with a red box (3). Above and left to the map display, 13 icons indicate the functionalities of the toolbox (4). And on the right hand, the legend of the map is visualised (5). To expand the folders on the left hand, the user just has to click on one of them. In order to view different items of the infrastructure or poultry data on different NUTS levels, the check boxes have to be activated (left click on mouse). By choosing the left check box, the data will be displayed in the view. By additionally activating the right check box, the identify button ( ) can be used to query attributes of the single mapfiles, which are stored in the database.

As can be seen in figure 6, the infrastructure folder is expanded and the map layers of the city areas, the lakes, the rivers, and the location of the important bird areas (IBA) are displayed on the map. The symbology is explained in the legend on the right side.
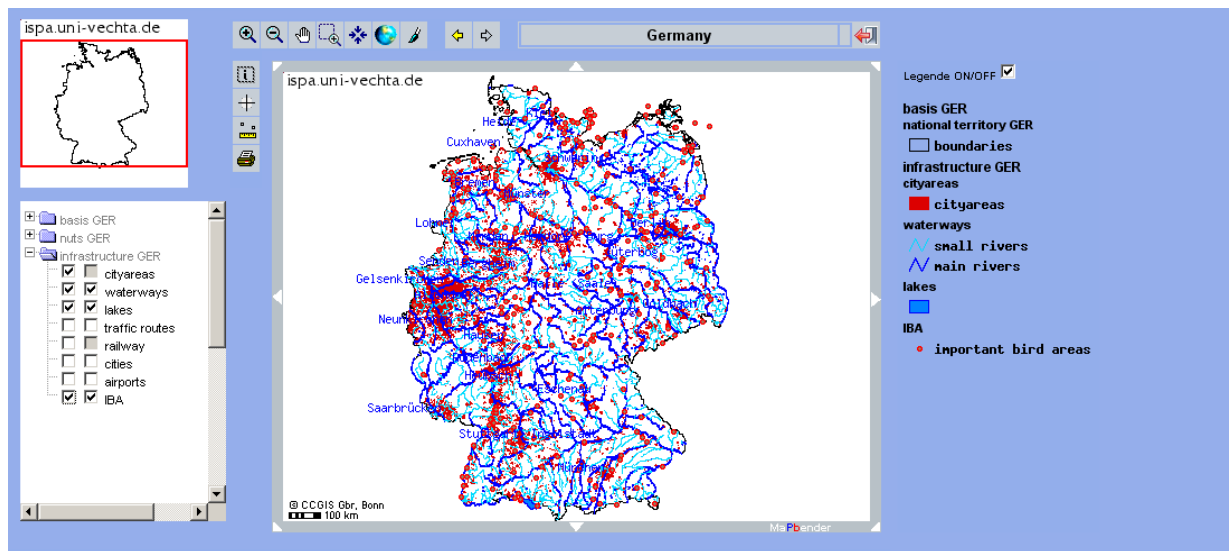
Figure 6. City areas, wetlands and IBA in Germany.

Furthermore, there is a tool bar to navigate within the maps (figure 7). The explanation of the single tools is given below.

Figure 7. Toolbar to navigate within the map display.

1   Zoom in
2   Zoom out
3   Pan
4   Draw zoom box
5   Select position and center it
6   Zoom to the full extend
7   Redraw map
8   Back
9   Forward

To use one of the navigation tools (except tool 3 and 4), the user just has to click on the tool itself. To pan (3) or to draw a zoom box (4), the user has to click on the tool and then use the mouse pointer in the map display. The more the user zooms in the map the more details are revealed as displayed in figure 8, where the lakesand rivers of the county of Brandenburg can be seen.
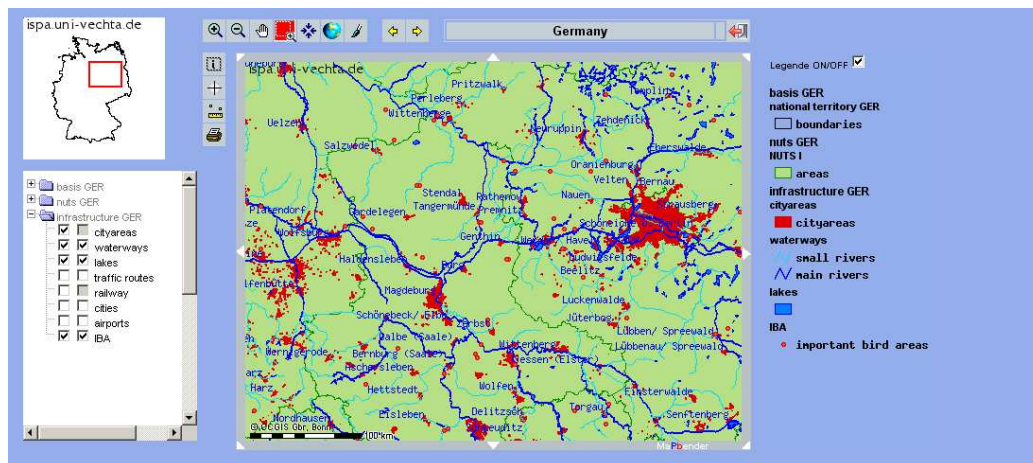
Figure 8. Wetlands and IBA in the county of Brandenburg.

The second folder contains the data of poultry stocks by different regions and poultry species. In the German folder, the user can choose between the NUTS levels 1 to 5 and between six different poultry species. To visualise for example the distribution of ducks on NUTS 5 (municipality level), the user has to activate the check boxes of the related NUTS level to view the administrational borders. To add the graduated symbols showing the distribution of ducks, the related check boxes have to be activated, too (figure 9).
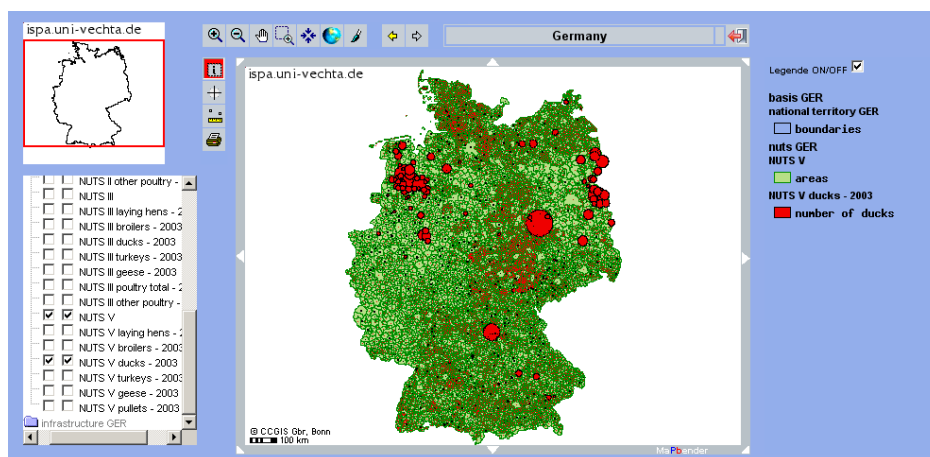

Figure 9. Spatial distribution of ducks in Germany 2003, NUTS 5.

The information button ![info] enables the user to receive additional data of a selected feature. By clicking with the mouse pointer on the information icon and afterwards on the feature to gain information from, a new window opens, where the information is supplied. As can be seen from figure 8, the map display shows the distribution of ducks in Germany. To gain the information how many ducks are present in one of the municipalities, the user has to click on one of the graduated symbols. In response, a new window opens, where the name of the municipality as well as the number of registered ducks are displayed (figure 10).

Figure 10. Information about the number of ducks in the municipality of Visbek.

By using the three tools below the information button, the user can print the map display, grap coordinates of a defined selection or measure a distance or area.

To go back to the list of countries, the adjoining icon has to be used.

3.2. Section "Poultry densities"

To enter the section of "poultry densities", the user has to start from the welcome page and log in with the same password as received for the other section "poultry stocks". Afterwards, a new window with the map display opens.
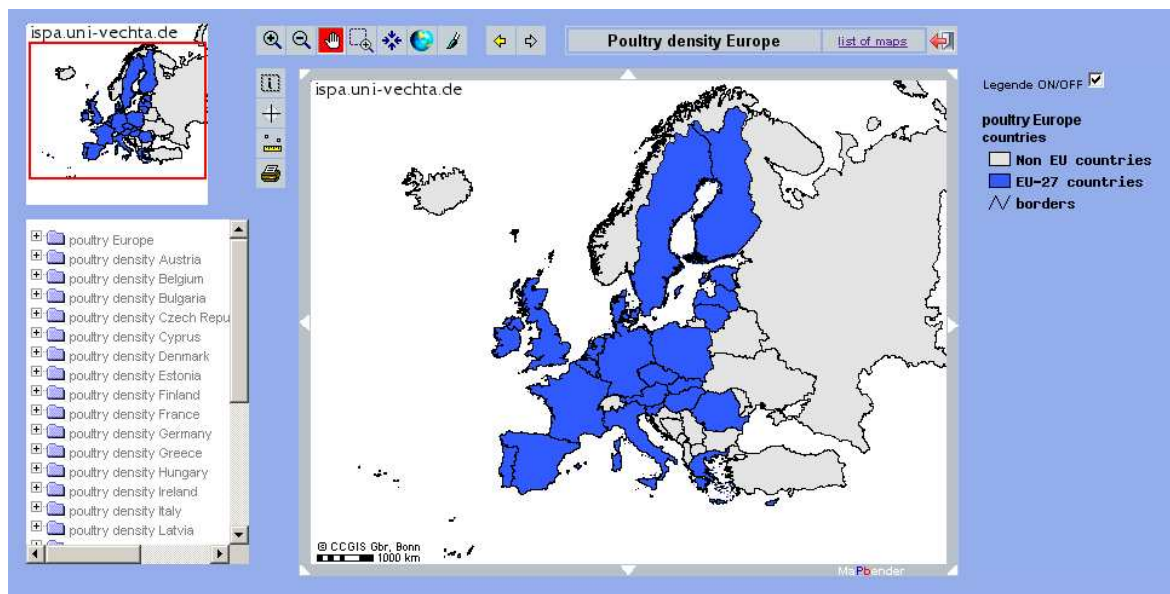

Figure 11. Introduction page to visualise the poultry densities by countries and species.

As can be seen from figure 11, a list of folders with all countries available as well as a folder for European maps is stored on the left part of the window. The navigation tools offers the same possibilities as described above. To visualise the poultry density of a country, the user has to click on one of the folders and choose the desired poultry species. In the example shown in figure 12, the broiler density on NUTS 3 is visualised for the year of 2003. To identify the value expressed by the density colours, the user can use the identify button. In case no data are available for a single region, no colour is attributed to the region.
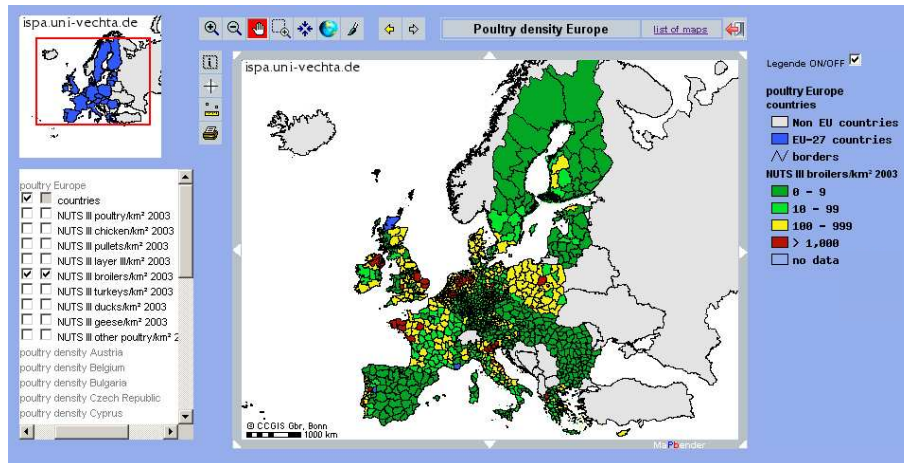

Figure 12. European broiler density on NUTS 3 for the year of 2003.

4. Discussion

As could be shown in this paper, the collection of poultry data from all of the 27 European member states was accompanied with a variety of problems. Especially in regard to the national survey frequencies and data collection standards, a long-term harmonisation is appreciated but a solution in the near future will not be provided. Therefore, Eurostat represents an important connection between the national statistical offices and the user of European data. But to date, Eurostat does not offer appropriate data on the field of poultry production. Although this system has the capability to provide useful information, which is representative for all of the European members, there is still the need to develop and improve the system in regard of standardisation, harmonisation, and documentation.
Therefore, the statistical offices were approached and a new, standardized poultry database was developed. Implemented in the toolbox, the data supply essential information for various research fields. To keep it up-to-date, every statistical office of the EU-27 needs to be approached regularly and a continuous implementation of the new releases is required.
The toolbox presented is a powerful tool to visualise and analyse poultry production in Europe. Its user-friendliness provides an easy and comprehensible access to a statistical database, which is especially of use for decision makers and other important stakeholders. To enrich the system, further information such as the location and type of poultry farms, feed mills, and rendering plants as well as additional analysis tools could be easily implemented. However, to maintain the functionalities of the toolbox or to add new features, further financial support would be necessary.

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