

Study Beekeeping potential data and development of a decision support system involving a web mapping platform

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ABSTRACT

The role of a decision support system is to gather, synthesize and present information in order to make informed decisions. In this project, a mapping platform and a decision support system are proposed to present beekeeping data in Quebec. A complete review of the data and factors influencing honey production must first be carried out. The decision support system will be designed according to the nature of the data and access to available technologies. Continuous and real-time data management must be configured to make data interoperable. Multi-dimensional data loading tools will need to be configured to display data and analyses in a dashboard. Beekeepers will be able to optimize or move their hives according to their interpretation of the results displayed in the decision support system.

Index Terms—Dashboard, data warehouse, beekeeping, pollination, floral resource, environmental factor

1. INTRODUCTION

The development of beekeeping is closely linked to the suitability of the land for beekeeping and, above all, to the availability of beekeeping plants. What's more, land use is not stable over time as humans modify it. [1]. The concept of land suitability refers to the performance of a certain type of land in its current state for a defined use [2]. Agricultural measures and policies are needed to ensure the conservation, utilization, and multiplication of animal and plant resources while maintaining a balance with the ecosystems and social climate of countries [3]. In this regard, honey bees play a vital and irreplaceable role as pollinators in agricultural production and terrestrial ecosystems. Moreover, the exclusive use of honeybees is debated in the scientific community. A diversity of pollinator species in an ecosystem increases the pollination efficiency of floral systems tenfold and optimizes the pollination service for increased agricultural yield. On the other hand, the honeybee is the only pollinator species that can produce honey [1].

In this context, the Centre de recherche en sciences animales de Deschambault (CRSAD) has developed a beekeeping data visualization platform for beekeepers in Quebec. The APISolution platform brings together geographic and qualitative hive data. CRSAD wants to enhance the platform to include additional data and optimize honey production for Quebec beekeepers. The project will be designed in partnership with the organization's developers, focusing on data characterizing the area under study and the region's beekeeping potential. Data has already been collected in the field, but further data collection is planned over the two years of research. The project is being carried out in partnership with the beekeeping potentiality project research group, which includes several partner professors from the Université de Montréal and the Université de Sherbrooke, as well as doctoral and master's students.

Bee pollination is recognized as a vulnerable ecological service. Both wild bee and honey bee populations are in serious decline in Europe and North America [1]. The project's problem is to find, under current environmental conditions, the beekeeping potential to meet the need for production optimization among beekeepers in Quebec. The second part of the problem is that decision-makers need a means of receiving and interpreting data and potentiality analyses. The product already in use at CRSAD is called APISolution. With synthesized, user-friendly access to analyses, beekeepers can optimize their hives by moving them to areas with the most productive conditions, or by modifying some of their production methods.

Literature reviews propose different methods for studying beekeeping potential and optimizing beekeeping production. Using GIS, the state of the bee environment can be analyzed [5]. With their help, a beekeeping potential calculation approach can be applied using spatial data layers. These layers are referred to as criteria or factors, some of which are vegetation cover (specimen, attractiveness, and flowering period), climate (temperature and precipitation) and so on [5]. The data layers are recorded in a database, organized, and interpreted by a multifunctional server-side algorithm (back end) and sent by various processes to the display part (front end) of the Decision Support System (DSS). This approach

enables decision makers to make informed decisions on the potential of a site for the establishment of beehives, or for the conservation management and optimization of existing hives. A platform for managing and disseminating information of use to beekeepers is to be developed using GIS and a web mapping platform.

2. METHODOLOGY

2.1 The DSS

The methodological approach is based on the project objectives to establish the main techniques, methods, and analyses. The foundation of the project is the development of a DSS. A DSS is defined as a subject-oriented grouping of data intended to support managers in their decision-making processes [6]. There is no universally accepted standard architecture for a DSS in the literature, but a typical architecture is proposed by most authors [6]. DSS, unlike GIS, enables the management of more than two dimensions. In addition to traditional GIS dimensions such as spatial and descriptive, a DSS enables the management of additional dimensions such as time.

2.2 Data acquisition and transformation

The project's DSS is developed by setting up an infrastructure that presents the data the beekeepers need to make the best decisions. Project data is distributed through various sources and is varied and often heterogeneous. The data may come from within the organization, but most of it is external.

A key objective for the team is to research the factors influencing beekeeping potential, as well as the associated spatial data. Since some data sources have been acquired by members of the beekeeping potential team, part of the data acquisition comes directly from the members. Data are deposited on a server by the PhD student (Guy Armel Fotso Kamga) and then downloaded to the local machine and server locations determined to exploit the data. For web-accessible data, it can be directly downloaded and sent to configured structures and databases. Some data is retrieved from the web using automated Python processes. This makes it possible to retrieve a larger volume of data, and the most up-to-date ones at that.

When data is received, some sources have a format that does not conform to the system's implementation. To standardize the data, a limitation of one or more formats is established to develop an interoperable and easily manipulated data warehouse. Once the data has been acquired, its initial format can be checked. If the format is suitable, the data can be tested in the platform or in cartographic software such as QGIS. For example, the beehive location data layer had to be modified because the geographic coordinates were not in the right format and the layer was not in the right projection. ETL processes are used to normalize data prior to production of

the data warehouse. Format-change tools are also integrated into python code, such as those in the GDAL/OGR libraries, and transform data format and attributes through automated processes.

Meteorological data are used to assess a hive's environment in order to analyze its beekeeping potential. The data used comes from Canada's high-resolution deterministic forecasting system [7], which represents a prediction of atmospheric elements for the day and the next 48 hours. Atmospheric elements include temperature, precipitation, cloud cover, wind speed and direction, humidity and others [7]. This spatiotemporal data is extracted from the Government of Canada website as GRIB2 data and transformed into a geotiff raster layer using a script. A clip operation must be applied to cut the layer over the study area. Automated code is currently being produced to automate layer extraction and transformation, as new layers are produced several times a week. In the mapping platform, these data layers can be displayed and adjusted according to the desired time of year. Stored geotiffs are grouped by month of the year, and a drop-down list lets you choose which layer to select according to the desired day of the month.

To estimate beekeeping resources, the project requires the use of the InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) family of tools [8]. This tool uses geospatial data, biophysical and economic models to estimate ecosystem service flows. It then converts the data into values and files in order to visualize the data on a map [8]. In this project, a beekeeping potential model is created by a PhD student. This model includes a soil classification with attributes that can characterize floral resources and soil use by bees. Next, a weighting is assigned according to the literature for pollen and nectar resources, in order to produce a beekeeping resource index using the previous two. The soil classification used to produce the data using the InVEST tool comes from the most up to date and detailed data available from Service Canada. An automated process will be produced by the end of the master's degree to calculate relative resources and implement the most up-to-date data on the platform.

To visualize data on the cartographic platform and keep loading times to a minimum, an effective option is to create web map services (WMS) with the cartographic data layers. The first step is to obtain a server capable of hosting the services, following by creating dedicated locations for the web map services. Services are created using MapServer. The service begins with the creation of a main configuration file (mapfile), which describes the relationships between objects, indicates the location of data and defines how they are to be structured. Each data layer to be produced must have its own secondary mapfile. Secondary mapfiles contain information such as layer name, layer location, projection and web service name. For example, for the project's hive position layer, a beehive image replaces the point features normally represented by points. To check the functionality of the services, it is advisable to set up a connection to the services on a cartographic software such as QGIS.

2.3 Front end and back end

The multifunctional algorithm can be described as the tool that takes all the queries and analyses from the back-end environment and brings them to the front-end environment, which represents what the user can visualize to make decisions. The algorithm owns the automated BI tools that manipulate the data warehouse as a data cube and transfers them to the DAS interface. Most of the programming code is in Python, and the front-end templates are in web languages: HTML, JavaScript and CSS. The back end manages user registration and navigation between web pages. This navigation is made possible by the flask web framework in Python. It enables back-end programming including several pages such as the cartographic dashboard, specific cartographic pages, the home page and user registration and personal pages.

To produce the dashboard, a series of steps is required. Production begins with the inclusion and parameterization of a basic web map. Display tools are integrated one at a time, establishing links and procedures with the dataset. OLAP data visualization tools are activated to fetch portions of the data as data views from the data warehouse. It is necessary to add one tool at a time to ensure that a new tool does not create problems with the others. The visual design of the dashboard is based on the colours and styles requested by CRSAD.

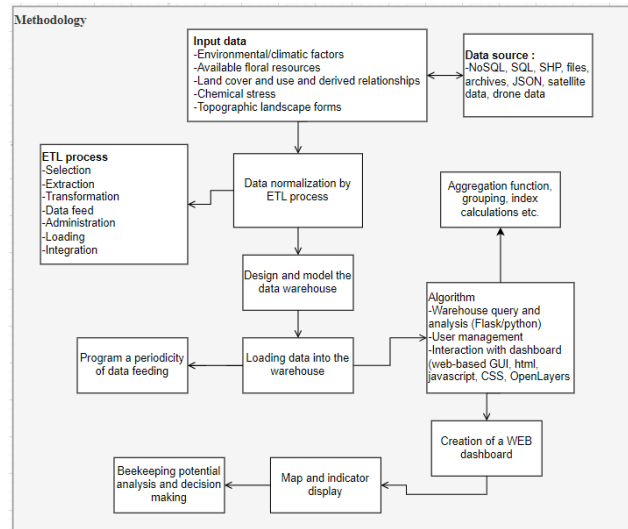


Figure 1. Methodological diagram

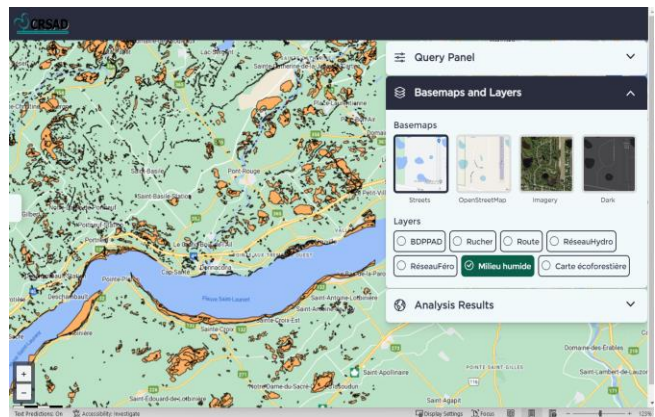


Figure 2. Map interface example

3. EXPERIMENTAL RESULTS

The web mapping platform is fully functional, allowing the use of home, registration, users, dashboard and specific mapping pages. A data warehouse stores vector and raster data. The multifunctional algorithm enables the extraction, transformation and loading of multidimensional information from the data warehouse to the platform, the automated extraction and normalization of multiple data groups, and the production of analyses on the data in the cartographic interface.

The web mapping platform provides a display of precise, interactive geospatial layers, making it easier for Quebec beekeepers to consult beekeeping potential data and make decisions. The platform provides features on the geographic distribution of floral resources and bee-friendly habitats in Quebec, as well as on land use, nectar and pollen resources, facilitating the identification of areas rich in beekeeping resources. The platform integrates data on the bee's

Fig. 1. Methodological diagram

environment, including meteorological data such as precipitation, temperature, cloud cover, etc., to assess the influence of a region's climatic conditions on honey production potential.

4. CONCLUSION

The results of this research can enhance understanding of the ecosystems that revolve around a beehive through data analysis and can affect apiary owners financially. The research will enable decision-makers who are beekeepers to analyze the potential of beehives in the study area according to a high number of factors. With the aid of a user-friendly platform, even for people unfamiliar with computers can make informed decisions about the potential of a site for the establishment of new hives, or for the management and optimization of existing hives. Additional elements will be incorporated into the project over the summer, and it will be completed in the autumn.

5. REFERENCES

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