Original article

Development of an Innovative Application for Nosemosis and Varroosis Rates in Bolu Beekeeping Locations by using Google Earth Engine

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Abstract

Beekeeping is one of Turkiye's important sources. Our country's rich geography and various climatic conditions are quite suitable for beekeeping, which is directly related to geography, climate and topography. There has been an increasing interest in beekeeping, which provides higher income with less maintenance and cost compared to other agricultural activities. This increase has also brought to the agenda the need to take various measures to increase the efficiency obtained from beekeeping activities. The first issue to be considered is bee diseases. Nosema spp. and Varroa spp. are two important disease factors frequently encountered in beekeeping. Both cause serious health problems in bee colonies and threaten the health of bees. In this study, it is aimed to implement a map application consisting of bee disease rates in beekeeping locations in Bolu province in order to perform early detection of bee diseases and to take the necessary measures. In this direction, field studies were carried out and coordinate information of beekeeping locations in Bolu province was obtained. At the same time, bee samples were collected from these locations and examined in a laboratory. After field and laboratory studies, a data set was created with coordinate, district name, nosemosis and varroosis disease rate information. The created data set was transferred to the Google Earth Engine (GEE) platform and visualized. An application was developed with the codes written on the GEE platform and the coordinate, district name, nosemosis and varroosis disease rate information of the clicked district beekeeping locations were shown on the panel. This study provided a preliminary view for the first time on the nosemosis and varroosis disease rates in the same locations for the future periods and created a database for the future periods.

Keywords: Google Earth Engine, Beekeeping, Nosemosis, Varroosis, Bolu.

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INTRODUCTION

Beekeeping, one of the important areas of modern agriculture, provides significant contributions to the country's economy with products such as royal jelly, honey, pollen, and beeswax obtained from bees. These products provide benefits not only financially, but also in many areas such as health, cosmetics, paint, agriculture, and food. In addition, the role and importance of bees in pollination processes that support the sustainability of nature is quite significant.

In addition to all the benefits provided by bees and beekeeping, the interest in beekeeping, which has the potential to generate higher income with less maintenance and cost compared to agricultural activities such as corn, wheat, and hazelnuts, has increased significantly recently. However, when the "2024 Product Report - Beekeeping" published by the General Directorate of Agriculture and Forestry is examined, it is seen that although the number of hives increases every year in Turkiye, there has been a decrease in honey production until 2021, and although an increase is achieved in 2022, there is a decrease again in 2023 (Figure 1. and Figure 2.). This situation is an indication that beekeeping activities cannot be continued consciously.
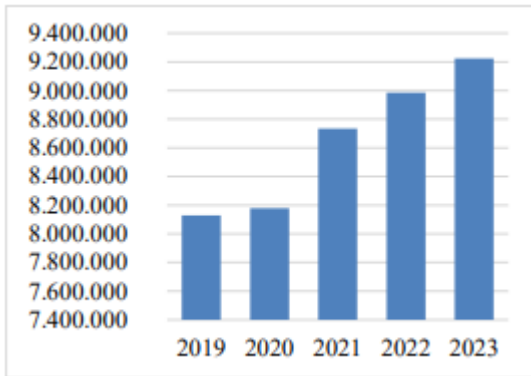

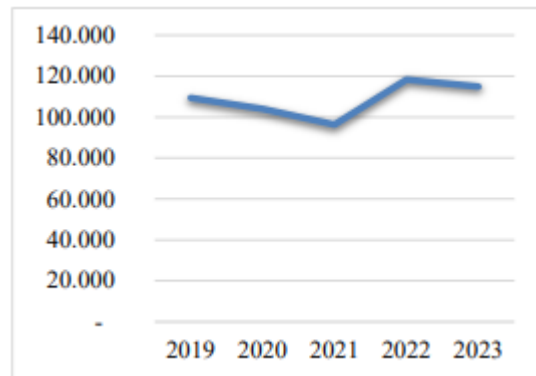**Figure 1.** Number of hives (total) in Turkiye (TÜİK, 2024)

Figure 2. Honey production (tons) in Turkiye

One of the most important factors that slow down the progress of beekeeping in Turkiye and reduce production efficiency is honey bee diseases and parasites. Pathogens and parasites frequently encountered in bee colonies have been identified as bacterial, viral, fungal, protist and mite origin. Two of these pathogens, *Nosema* spp. and *Varroa* spp., cause a significant decrease in honey production (Yaman and Sağlam Güvendik, 2023).

Infection by the common parasite *Nosema* spp. can affect the physiological state, behavior, and survival abilities of honey bees. *Nosema* infection disrupts the midgut structure and changes the energy needs of bees (Olgun et al., 2020). Another important factor affecting honey bee health worldwide is the parasitic mite *Varroa destructor*. A study has shown that *Varroa* parasite does not consume the hemolymph of the honey bee, but rather damages the fatty tissue, which plays a critical role in the hormonal system, especially in pesticide detoxification (Arrese and Soulages, 2010; Ramsey et al., 2019;

Olgun et al., 2020; Yaman et al., 2023). Both of these diseases, which cause serious health problems in bee colonies, threaten the health of bees. Therefore, necessary precautions should be taken to increase the efficiency of beekeeping activities and to sustain conscious beekeeping approaches.

When the studies and literature were examined, it was seen that pesticides were used to manage nosema and varroa diseases (Özmen Özbakır et al., 2016), colonies were burned (Gülpınar, 2005), and biological control methods (Uygur and Girişgin, 2008; Ütük et al., 2010; Bartlett 2022) were used.

Recently, it has been observed that Geographic Information Systems (GIS) and remote sensing (RS) techniques and technologies, which have been widely used in pest control, disease detection, mapping, analysis and interpretation, are not used both in Turkiye and around the world. Therefore, within the scope of this study, it is aimed to develop a map application showing bee disease rates in beekeeping regions in Bolu province in order to make early detection of bee diseases and to take necessary precautions.

To achieve this goal, the cloud-based Google Earth Engine (GEE) platform, a remote sensing technology, was used.

MATERIALS and METHODS

Study Area

Bolu is a province located in the Western Black Sea Region of Turkiye and is famous for its natural beauty. It offers a very suitable environment for beekeeping activities thanks to its rich vegetation, lakes, streams and climate. Bolu's diverse flora provides abundant nectar and pollen resources necessary for bees' nutrition. In addition, the climatic conditions in the region are ideal for bees to grow healthily and work efficiently. These features make Bolu attractive for beekeeping. For this reason, Bolu province and its districts were selected as the study area (Figure 3).
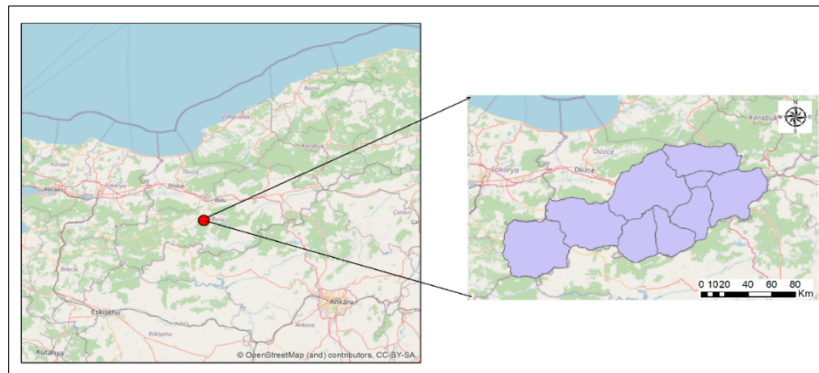

Figure 3. Study area (Yaman ve Yaman, 2023)

Creating the Database

Field studies were conducted in each district of Bolu province, which consists of 9 districts. During the field studies, location information was recorded and bee samples were collected from the colonies. Nosemosis and varroosis rates in the collected samples were taken from the study of Yaman and Sağlam Güvendik (2023). The database in Table 1 was created to carry out the application.

Table 1. Database

District	Latitude	Longitude	Nosemosis (%)	Varroosis (%)
Merkez	40.728913	31.749567	11.7	2.5
Yenicaga	40.758942	31.99765	8.1	5.9
Dortdivan	40.657067	31.990509	3.03	0
Gerede	40.806466	32.323554	5.28	0
Seben	40.335444	31.6398535	5.71	0
Kibriscik	40.410592	31.85085	0.5	0.6
Mengen	40.938325	32.076856	6.9	19.3
Goynuk	40.426389	30.853528	0.7	1.7
Mudurnu	40.477578	31.344025	3.3	8.2

The created database was converted to be suitable for working on the GEE platform and uploaded to the platform with the steps "Assets-> New-> CSV file (.csv)". After the upload process, the database was visualized by coding suitable for the work. Thanks to this visualization and coding, location information was marked on the map (Figure 4).
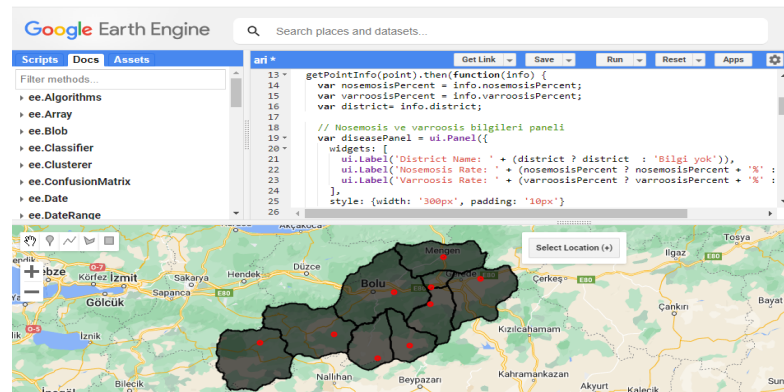

Figure 4. Visualized location information

Development of the Application

The aim of the study was to display the results on a panel by coding in accordance with the purpose. In this direction, a software was created to click on the locations marked with the "onClick" function using the loaded database and to obtain information on the locations with the "getPointInfo()" command. Then, the coding process was completed by using the necessary functions to display the results in written form on the panel.

RESULTS and DISCUSSION

Bee samples were collected from locations where beekeeping activities were carried out in Bolu province and the collected samples were analyzed in a laboratory environment. According to the analysis results, nosemosis and varroosis diseases were found in bees. Disease rates were evaluated based on the district where the samples were collected, based on the study of Yaman and Sağlam Güvendik (2023). The results obtained were converted into an application on the GEE platform and visualized (Figure 5).
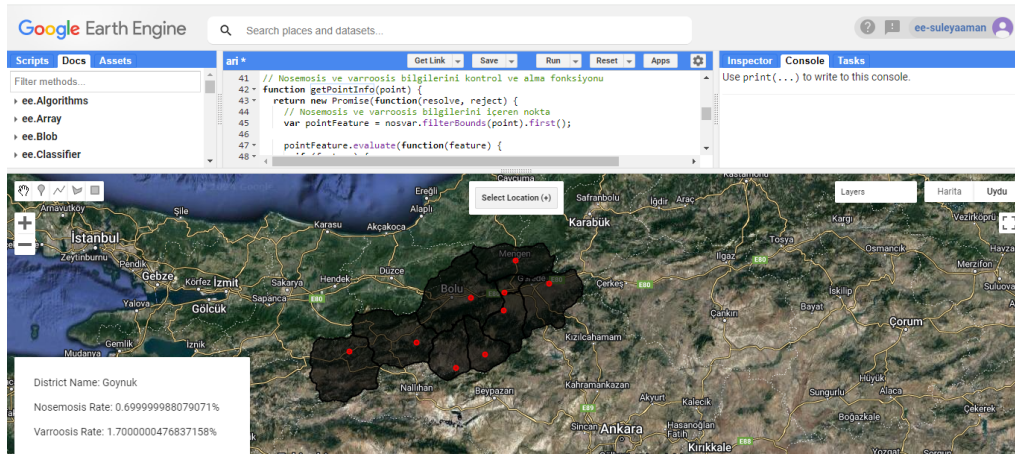

Figure 5. Application developed on Google Earth Engine platform

In the application, the points marked in red in Bolu province are district locations and the nosemosis and varroosis rates of that district are entered for each location. The district and disease rate information of the selected locations is presented to the user via a panel. The panel information changes for each location clicked and shows information about that district. Some sample results of the application are given in Figure 6.
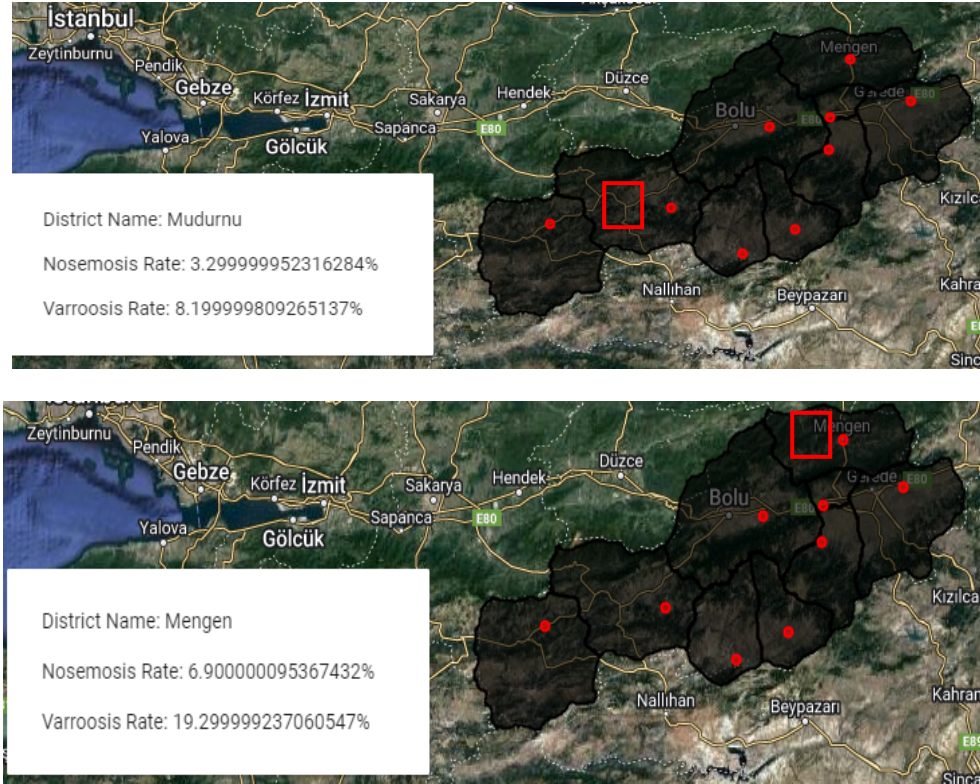
Figure 6. Some sample demonstrations of application results

As a result of the study, the application that works perfectly has been successfully implemented. When the nosemosis and varroosis results are examined, nosemosis was found in samples taken from all districts, while varroosis was also found in other districts except Gerede and Seben districts. The results show that the disease rates in bees in Bolu province are high. In this context, it is necessary to raise awareness of beekeepers, change the methods of struggle, and use current technologies more widely.

When we look at the studies on bee diseases, although we come across studies examining *Nosema* spp. and *Varroa* spp. diseases on honey bees, no example of any study on visualizing the results by developing an application through a cloud-based software such as GEE has been found in either the world or Turkish literature. The increased use of remote sensing and GIS technologies in this field will add a different dimension to the fight against pests. It will increase early detection and provide great benefits by providing future-oriented materials with the databases created.

The study stands out with its originality, providing the first preliminary view of nosemosis and varroosis disease rates for future studies to be conducted in the same locations, and creating a database for researchers.

Conclusion

The number of locations can be increased to increase the efficiency of the study and to create a more powerful database. This study can be carried out for each province of our country and a Turkiye-

wide nosemosis and varroosis disease rate application can be developed. This application can be kept up to date by developing an area where researchers can process the results they obtain.

Thanks to this study, bee disease rates can be monitored and necessary precautions can be taken early.

Acknowledgement

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