Pertanika J. Sci. & Technol. 27 (2): 685 - 702 (2019)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Development of Information System for Efficient Use of Nectar Resources and Increase Honey Yield per Colony

Ahmet Albayrak[1]* and Raif Bayır[2]

[1]*Department of Computer Engineering, Faculty of Technology, Karadeniz Technical University, Trabzon, Turkey*
[2]*Department of Mechatronics Engineering, Faculty of Technology, Karabuk University, Karabük, Turkey*

ABSTRACT

In this study, for 5.1 million bee colonies and nearly 42 thousand migratory beekeepers in Turkey, an information system is recommended that determines the areas where the honey season will pass taking into account the flowering periods of plants. Migratory beekeepers produce honey by following the flowering periods of nectar sources. Bee colonies should be placed in the optimum number in areas with nectar sources. Less colony settlement has a negative impact on agricultural production. Colony condensation also adversely affects the honey yield of bee colonies per hive. In this study focuses on the optimal number of colonies in the nectar region. In the first stage, 81 provinces in Turkey were analyzed in terms of nectar resources and meteorological conditions which are the major sources of honey production. This evaluation used fuzzy cognitive maps. As a result of the evaluation, 33 provinces were identified as the most suitable provinces in terms of nectar sources and meteorological conditions. In the second phase of the study, a new approach has been proposed for migratory beekeepers to pass the nectar flow season at maximum efficiency and to use nectar resources at maximum level. This approach is based on the placement of bee colonies, considering the potential of the bee farming of the regions and the number of bee colonies subjected to migratory beekeeping.

ARTICLE INFO

Article history:
Received:8 June 2018
Accepted:7 December 2018
Published: 25 April 2019

E-mail addresses:
ahmetalbayrak@ktu.edu.tr (Ahmet Albayrak)
rbayir@karabuk.edu.tr (Raif Bayır)
* Corresponding author

ISSN: 0128-7680
e-ISSN: 2231-8526

One of the advantages of this approach is that it will maximize honey yield per colony for migratory beekeepers. Another advantage of this system is that the distribution of bee colonies according to the number of plants in the region will be positive in terms of quality and quantity of agricultural production.

Keywords: Fuzzy cognitive maps, information system, migratory beekeeping, nectar flow

INTRODUCTION

Beekeeping is carried out as an important agricultural activity in Turkey as well as all over the world. The number of beekeepers in Turkey is around 57, 897 according to official records. These beekeepers have a total of 6.8 million bee colonies (Kekeçoğlu et al., 2007). Approximately 75% (42 000) of beekeepers in our country are migratory beekeepers. Approximately 75% of the bee colonies are subjected to nigratory apiculture, which corresponds to about 5.1 million colonies. (Fıratlı et al., 2010). According to the Food and Agriculture Organization of the United Nations (FAO) in 2012, a total of 37,863,019 bee colonies and 1,636,398,98 tons of honey are produced in the world (Albayrak et al., 2018). The yield per colony is 43.21 kg. Turkey ranks second in terms of total number of colonies in the world (6.8 million bee colonies). Honey yield per colony is approximately 15 kg in Turkey. Referring to Turkey's average yield per colony was 32% lower than the world average (Kekeçoğlu et al., 2007). Beekeepers in Turkey, according to the colonies of bees, carry nectar sources flowering period. Following this flowering period, this kind of beekeeper is called migratory beekeeper. Beekeeper can produce more honey by migratory beekeeping (Şahinler & Cengiz, 2010).

Beekeeping is the lifestyle of honey bees and it is one of the animal dependent activities most dependent on nature because of the natural gathering of the raw materials of their products. This dependence makes the beekeeping more sensitive to the environment. As a matter of fact, the result of environmental changes can change the yield of honey per hive. It is known that 85% of the differences between the colonies in terms of honey yield are due to environmental conditions and 15% is due to genotype difference (Kekeçoğlu et al., 2007; Fıratlı et al., 2010).

Honey production is a main goal of beekeeping. For honey production, a variety of conditions must be appropriate, both inside and outside the hive. Another parameter of success in honey production is the beekeeper itself. It positively contributes to the maintenance and management of colonies, where the beekeeper has sufficient knowledge and experience. Inside elements affecting honey production include: bee numbers and health status in the colonies, the age and fertility of the queen bee in the colonies, race and morphological conformity of the bees in the colon. The non-hive elements can be given as the number of agricultural crops near the area where the colonies are located, and if so, the density of pesticides, the number and density of nectar plants in the area where the colonies are located and the suitability of meteorological conditions (Semerci, 2007; Sudarsan et al., 2012).

In beekeeping, literature on information systems (IS) or decision support systems (DSS), researchers have focused more on the genetic makeup of bees in colonies and on the improvement of these genetic constructs. Thus, beekeepers that yield higher yields could be obtained. One of the most important factors affecting the yield of honey is the disease, harmful and parasites that occur in the colon. These are bacterial and viral diseases. BeeAWARE is an expert system developed for the diagnosis and treatment of honey bee diseases, pests, parasites and bee colon which require on-site inspection and analysis. Many studies like this expert system have been reported in the literature (Zacepins et al., 2015). These studies are mostly the monitoring of colonies and the early diagnosis and treatment of developing diseases, monitoring of the spawning capacity of the queen bee, management of the swarming and control of the deaths in the colonies. IS/DSS in beekeeping is a system that can process different information such as video, weight, temperature and sound measurements of the column (Zacepins et al., 2015). New methods for determining the status of bee colonies can be developed by creating intuitive approaches through the interdisciplinary collaboration of bee specialists and engineers, physicists, mathematicians and information technology experts. IS/DSS operations are likely to remain limited soon, as only a small part of bee farming operations can be automated (Zacepins et al., 2015).

Fuzzy cognitive map (FCM) is a method used for modelling complex systems using existing knowledge and human experience. FCM is used to predict the behavior of a system, to test the influence of parameters and to analysis and simulate the system. FCM performs modelling using a connection matrix in the light of experience (Albayrak et al., 2018). In this study, FCM is used to digitize expert beekeeper knowledge and model the problem.

There is not much work in the literature on the efficient use of nectar resources and the placement of honey bee colonies. The works done is limited to a certain extent. Some studies focus only on mathematical modeling, while others are limited to certain regions. This study focuses on colony settlements for the whole country, considering the external factors affecting beekeeping. It focuses on maximizing efficiency and maximum pooling per colony. How many bee colonies a region can take can be due to the fulfillment of these two criteria.

"The efficient use of the nectar resources in the area where the colonies will be placed." The area in which the colonies are to be placed should not have more or less bee populations. In the case of a bee colony, nectar resources in the region may not be available. As a result, less honey will be produced. At the same time, the pollen of the flowers in the region will not be able to be pollinated enough, so the crop will be less and less productive. If more bees are placed in the area, all the nectar resources can be collected, but the bee colonies placed will compete. This means that the bees in the region at that time will not reach the expected amount of honey. Especially for migratory beekeepers this is extremely difficult.

"In the region, a sufficient number of bee colonies." As in the first criterion, it is known that the number of colonies to be placed in a region is related to the nectar resources of that region. For sustainable agriculture, bee colonies should be placed in an appropriate number of bees as both beekeepers and when considering the fruits and vegetables that the bees pollute.

In beekeeping, IS/DSS studies where nectar resources are assessed are limited in the literature. In a study conducted by Nuru Adgaba in Saudi Arabia from these studies, pictures were taken by remote measurement method. These pictures were classified by the Hopfield neural network and the number of trees was obtained in hectare. Trees and shrubs are a great source of nectar in the region. Thus, practical information has been obtained for beekeepers. An information system has been proposed to show where beekeeping can be done with the highest efficiency in terms of time and space (Agbaba et al., 2017).

In the study conducted by Zoccali et al. (2017) to determine suitability of bee farming in southern Italy, the data were classified by the Analytic Hierarchy Process (AHP) and fuzzy logic. As a result, Calabria region in southern Italy was found to be the best region (47.76%) in terms of its suitability for bee farming. Olive trees were found in this area as 38,12%, oak forests as 15,16% and annual plants with high and medium honey yield as 16,22% (Zoccali et al., 2017).

In Egypt, according to the study of beekeeping analysis, Egypt map is divided into three categories. These categories are classified as inappropriate, appropriate and more appropriate. While most areas are classified as eligible or more appropriate, areas with very severe climatic conditions are classified as inadequate (Abou-Shaara, 2015). In Iran, Amiri and her colleagues selected criteria under three headings in their study of beekeeping planning. These are environmental factors, nutrients and water resources. As environmental factors, proximity to traffic and road areas, temperature values, altitude and soil type were chosen. The number of nectar plants in the region selected as food sources has been considered (Amiri et al., 2011). In Turkey, the whereabouts of nectar sources and intensity information is available. Considering the nectar resources, nomadic bee growers can be directed. In this study, as a result of the evaluation of nectar and pollen sources and meteorological conditions, a system has been developed to provide the most efficient use of flower sources of migrant beekeepers in our country.

The aim of this study is to develop an information system that will ensure maximum use of nectar resources and at the same time ensure maximum efficiency per hive. The aim of this study is to develop an information system that will ensure maximum use of nectar and resources and at the same time ensure maximum efficiency. This study consists of problem description, determination of nectar source potential of provinces with fuzzy cognitive maps, determination of nectar flow periods and result sections.

MATERIALS AND METHODS

Recommended System

In this study, bee farming potential (BFP) was first calculated for each province by FCM. Then, with Equation 3, nectar flow time (NFT) periods were calculated for each province. The coefficient (BFP) obtained by FCM and the nectar flow seasons (NFT) were multiplied when the number of colonies (NC) that each province could receive. The values obtained from this process are collected. Total value of the results obtained, gives the total nectar source for bees in Turkey. This represents the total amount of seasonal food for the bees. This value is distributed among the migratory bee colonies in Turkey. The block diagram of the proposed system is given in Figure 1.

As shown in Figure 1, in the last step migratory bee colonies are distributed according to the nectar densities of the illusions. Non- migratory bee colonies were not considered in this study. The Beekeeping Association and Agricultural Credit Cooperatives, which are of interest to this study topic, were selected as stakeholders. The Beekeeping Association (TBA) is an association where all beekeepers are members. The Agricultural Credit Cooperatives (ACC) is also working with migratory beekeeper. The city where ACC is located calculates and supervises how many bee colonies should come. Migratory beekeepers are required to obtain permission from ACC when they plant their colonies. The city in which ACC is located uses very non-scientific methods to determine how many bee colonies to place. The calculations made while determining the number of bee colonies the city can take do not satisfy most migratory beekeepers.

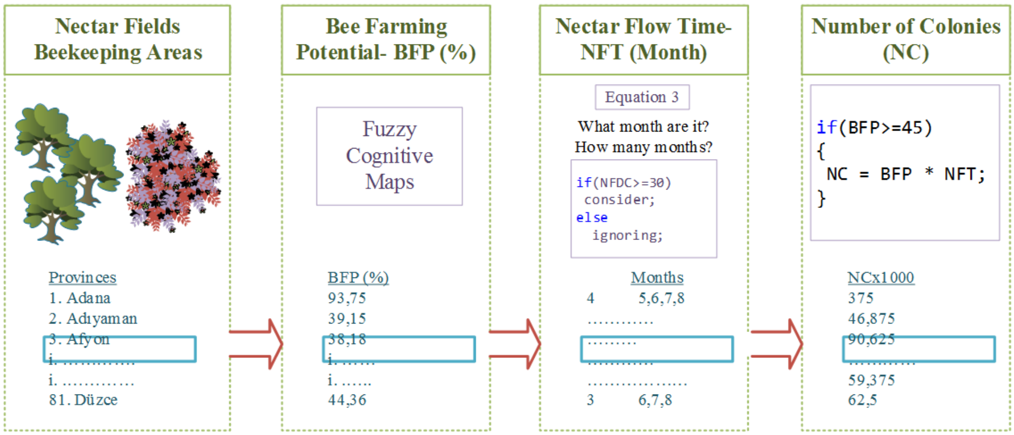

Figure 1. Recommended block diagram of information system.

Bee Farming Potential Assessment with FCM

FCM is a tool used for modeling complex systems with existing knowledge and human experiences. It is used to estimate the behavior of the FCM system, to test the effect of the parameters, to analyze and simulate the system (Papageorgiou et al., 2013). FCM developed a decision support system in 2014 with a user interface for renewable energy projects in Greece. The system was used locally in planning energy investments and determining profitability levels (Kyriakarakos et al., 2014). FCM has been successfully used in the prediction of apple harvest. Six concepts and prediction models were designed (Papageorgiou et al., 2013).

FCM is a combination of fuzzy logic and cognitive mapping. FCM includes concept/node factors. The causal relationships between the factors and the connections are given. Direct links are labeled with [0,1] or [-1,1] with fuzzy values, which represent the power of influence between concepts. The fuzzy part allows us to define the degree of causality of the connections between these diagrams and concepts (Papageorgiou et al., 2013).

Fuzzy cognitive maps can model the relationship between concepts defined in problem space with the help of weight matrix. Factors affecting honey production were considered when selecting concepts for FCM. While these factors were chosen, expert beekeeper knowledge was utilized. The concepts used in this study are given in Table 1 respectively.

Table 1

Concepts of the fuzzy cognitive map

Concepts	Number of Membership Function	Unit
C1: Nectar producing plants	Three membership functions	%
C2: Pollen producing plants	Three membership functions	%
C3: Average temperature	Three membership functions	◦C
C4: Sunshine duration	Three membership functions	Hour
C5: Number of rainy days	Three membership functions	Day
C6: Bee farming potential	Five membership functions	%

Concepts are expressed as state vectors within the FCM (Ai). The state vector provides information on the behavior of the system (Papageorgiou et al., 2013). Since the concepts C3, C4, C5 are meteorological data, this data is taken from the state meteorology department. This is the last fifty years (1968-2018). The concept of C6 (Bee Farming Potential) constitutes the honey production potential that they possess. These membership functions, which are defined as Very Low, Low, Medium, High and Very High, determine how much honey can be produced (Bee Farming Potential). Questionnaires were conducted with experts in the field of beekeeping to determine the relationship of the concepts created with each other. Survey questions “C1 concept, how much influence the C3 concept” is formed. The answer to each question consists of 11 selective answers. Each of these answers is defined by a different type (triangle, trapezoidal) membership function. Thus, expert opinion is added to the system as a numerical value. The weight matrix obtained from the questionnaire is given in Table 2.

Table 2
Survey result weight matrix (Aij)

	C1	C2	C3	C4	C5	C6
C1	0		0.135	0.475	0.16	0.012
C2		0	0.475	0.52	0.11	0.045
C3			0			
C4				0		
C5					0	
C6	0.3	1	0.215	0.475	-0.2	0

The result of this questionnaire is the weight matrix to hold the causal connections between concepts (Wij). There is no data in the empty spaces in Table 2. These gaps also mean that there is no interaction between the concepts in the column and the line. The values obtained for each concept connection are refined with the sum of the centers of gravity according to Equation 1.

$$W_{ji} = \frac{\int y^{y} \mu(y)^{dy}}{\int y^{\mu(y)dy}} \quad (1)$$

In Equation 1, Wij [-1,1] is the weight matrix, y is the membership function, and μ(y) is the membership function. The FCM state vector is updated with the connection value between the concepts. The update operation is the product of the Wij values in the weight matrix, which is associated with the state vector Ai. In addition, the state vector is added to the previous state. This equation is given in Equation 2.

$$A^{(k)} = f(A^{(k-1)} + \sum A^{(k-1)}.W) \quad (2)$$

In Equation 2, A (k-1) represents the old state of the state vector and W is the weight matrix. The obtained values must be passed through the threshold function while being transferred to the new state vector A (k) (Kannappan et al., 2011). Since the state vector contains positive values [0,1], the sigmoid threshold function is preferred in this study. After stakeholders have identified the concepts, which membership functions and concepts should be represented and the limit values of the concepts to be used in membership functions have been determined (Papageorgiou & Laspidou, 2015). The limit values of the concepts are given in Table 3.

Table 3

Limit values of concepts

	Nectar producing plants (%)	Pollen producing plants (%)	Average temperature (°C)	Sunshine duration (hour)	Number of rainy days (day)
Low	0-30	0-30	0-10	0-3	0-15
Medium	30-60	25-50	10-20	3-6	15-25
High	60-100	50-100	>20	>6	>25
	Bee Farming Potential (%)				
Very Low	0-20				
Low	20-40				
Medium	40-60				
High	60-80				
Very High	80-100				

With experts from stakeholders, it has been decided that the type and location of the membership function will be used to represent the concepts. In Figure 2, the membership functions and settlements representing the concepts are given.

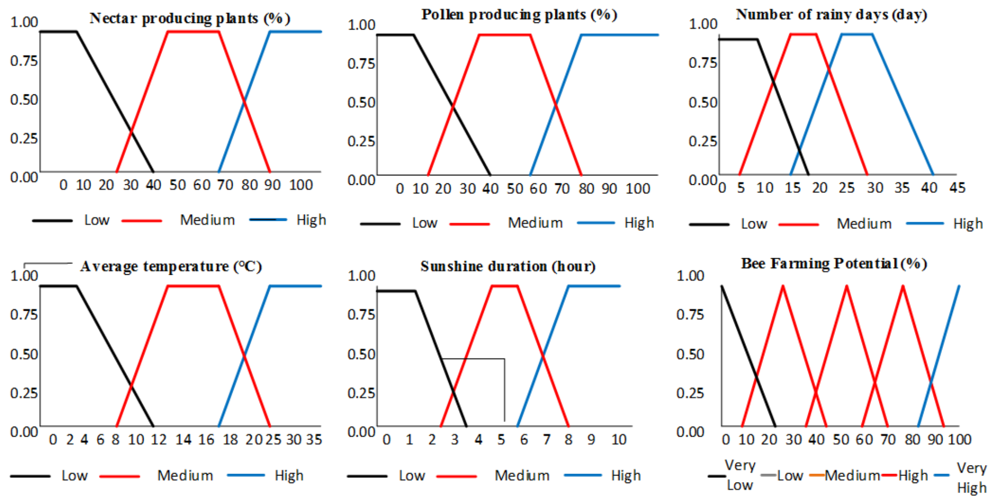

Figure 2. Membership functions of concepts

The fuzzy cognitive map developed in Figure 3 is given. As can be seen from Figure 3, meteorological conditions affect both nectar-pollen bearing plants and honey production. It emphasizes the importance of meteorological conditions for the area where these bee colonies will be placed.

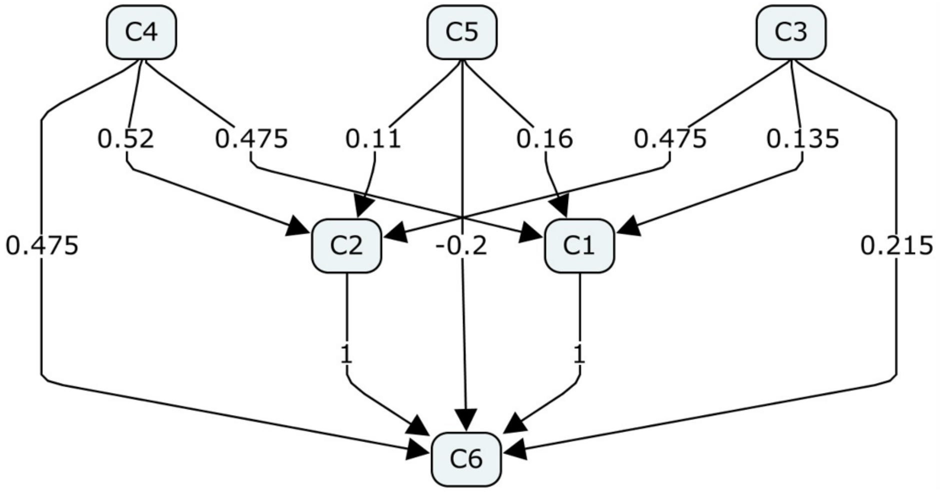

Figure 3. Fuzzy cognitive map

It is necessary to train the weight matrix which holds the relations between concepts that the fuzzy cognitive map has. To stop the simulation, it must be Ak = Ak-1 or Ak-Ak-1. Here e represents the acceptable error rate (e = 0.001). Training is terminated when the acceptable error rate is reached. Immediately after updating the state vector, the weight matrix is updated with the Non-Linear Hebbian learning algorithm. The training algorithm of the weight matrix of FCM is as follows:

Step 1: Read the state vector A0 and the weight matrix Wij
Step 2: Repeat for each iteration step
2.1: Calculate the state vector according to Equation 2.
2.2: Calculate the weight matrix according to the Hebbian algorithm.
2.3: Calculate the stopping criterion
Step 3: Repeat step 2 until you reach the stopping criterion.
Step 4: Show the latest weight matrix and state vector to the user.

When the above algorithm is run for 81 provinces, it can be said that 33 provinces are more efficient in honey production. These provinces are given in Table 4.

Determination of Nectar Flow Periods of Provinces

To be successful in beekeeping; it depends on the richness of the nectar resources and the use of honey bees with ecotheped genotypes adhered to the region. The plants with the most effect in honey production are nectar-harvested plants. In a study conducted by the General Directorate of Forestry in Turkey, pollen and nectar in the amount of 100 grams of honey has been removed. Nectar production and pollen production classification according to the quantities measured (General Directorate of Forestry, 2012; Sorkun, 2007; Davis, 1988). This classification is given in Table 4.

Table 4
Classification within 100 g honey

Classification name	Quantity (gr)
DOMINANT	>=45
Secondary	=16-45
Minor	=3-15
Trace	<3

As the number of plants carrying nectar-pollen increases, the resources that bees can visit also increase. To be able to produce honey at the desired level, elevation and flowering periods of the plants which are dominant nectar-pollen potential should be considered. In this study, periods in which each nectar flow is calculated by Equation 3. In Equation 3 Ni *i.* Nectar is the ratio of nectar that nectar has, and Nic is the coefficient expressing the effect of nectar on honey formation. Pi *i.* how much pollen is possessed by the plant having the pollen potency, and Pic gives the constant value-coefficient expressing the effect of the pollen on honey formation. These coefficients were determined because of questionnaires conducted with selected experts from the stakeholders of the study. The effect of nectar on honey formation was found to be 0.8, and the effect of pollen on honey formation was found to be 0.2 (Bayır & Albayrak, 2016; Albayrak et al., 2018). Because of operating the equation for cities, the nectar flow density coefficient (*NFDC*) is obtained for each province.

$$NFDC = \sum_{i=0}^{i=n} Ni * Nic + Pi * Pic \qquad (3)$$

Here n is the number of plants carrying pollen each nectar has. In this study, the NFDC coefficient is primarily scaled and then limited as migratory beekeepers are considered. At the end of the scaling, the NFDC coefficient is defined between zero and one hundred. As migratory beekeepers were considered, the numbers below the NFDC coefficient value of thirty were not considered (Bayır & Albayrak, 2016). At the same time as Table 4, the nectar flow periods of the provinces recommended for the traveler bee growers are given. The value of bee farming potential (BFP) obtained because of FCM can vary for each province. In this study, provinces with BFP value less than 45% were not included in the evaluation because migratory beekeepers were considered.

RESULTS AND DISCUSSION

After the determination of beekeeping breeding potential (Table 5), ArcGIS from GIS software was used for visualization. In the literature, the use of GIS in the field of beekeeping is recommended to be used as a technology to allow new discoveries (Rogers & Staub, 2013). Turkey on a thematic map in ArcGIS environment, independent of spatial information, the data is processed. With the processing of the data, a total of 12 maps were produced, giving nectar flow periods for the whole country. One of these maps is given in Figure 4.

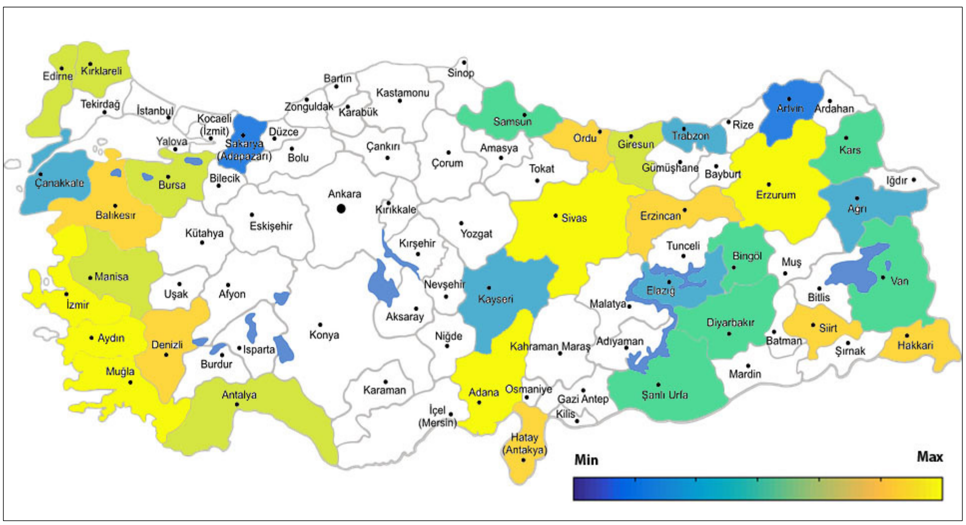

Figure 4. Potential map of beekeeping.

Table 5

Assessment of the provinces selected for FCM (bee farming potential) and nectar periods

	Province	Bee Farming Potential (FCM) (%)	Nectar Flow Time (Month) (Equation 3)	Nectar Flow Time (Month) (Equation 3)	Total Area (km^2)	Areas where bee farming can be done! (km^2)	Areas where bee farming can be done! (%)	Number of Colonies (x1000)
1	Adana	93.75	4	5,6,7,8	14,03	8,2777	59%	375
2	Artvin	46.875	1	7	7,436	3,04876	41%	46.875
3	Aydın	90.625	5	4,5,6,7,8,9	7,943	2,85948	36%	453.125
4	Ağrı	53.125	2	7,8	14,927	6,56788	44%	106.25
5	Antalya	78.125	4	5,6,7,8	20,909	6,2727	30%	312.5
6	Balıkesir	84.375	3	6,7,8	14,299	6,43455	45%	253.125
7	Bursa	71.875	4	5,6,7,8	10,882	0,76174	7%	287.5
8	Bingöl	65.625	2	7,8	8,253	4,984812	60,40%	131.25
9	Çanakkale	53.125	4	5,6,7,8	9,933	4,37052	44%	212.5
10	Denizli	87.5	4	5,6,7,8	12,134	5,21762	43%	350
11	Diyarbakır	62.5	3	6,7,8	15,272	4,88704	32%	187.5
12	Edirne	78.125	4	5,6,7,8	6,098	4,2686	70%	312.5
13	Elâzığ	53.125	3	6,7,8	9,383	3,28405	35%	159.375
14	Erzurum	95	3	7,8,9	25,355	5,5781	22%	300
15	Erzincan	81.25	3	7,8,9	11,903	3,5709	30%	243.75
16	Giresun	78.125	3	7,8,9	6,934	2,107936	30,40%	234.375
17	Hatay	81.25	5	5,6,7,8,9	5,524	2,37532	43%	406.25
18	Hakkâri	81.25	2	8,9	9,521	7,42638	78%	162.5
19	İçel	87.5	4	6,7,8,9	15,62	6,8728	44%	350

Table 5 *(Continue)*

	Province	Bee Farming Potential (FCM) (%)	Nectar Flow Time (Month) (Equation 3)	Nectar Flow Time (Month) (Equation 3)	Total Area (km^2)	Areas where bee farming can be done! (km^2)	Areas where bee farming can be done! (%)	Number of Colonies (x1000)
20	İzmir	90.625	4	5,6,7,8	12,007	5,88343	49%	362.5
21	Kars	62.5	3	7,8,9	2,347	1,50208	64%	187.5
22	Kayseri	50	3	7,8	17,17	5,151	30%	150
23	Kırklareli	75	3	6,7,8	6,55	3,7335	57%	225
24	Manisa	75	3	6,7,8	13,269	4,737033	35.70%	225
25	Muğla	98	7	4,5,6,7,8,9,10	12,974	6,22752	48%	700
26	Ordu	84.375	3	6,7,8	5,952	1,01184	17%	253.125
27	Sakarya	46.875	3	6,7,8	4,878	1,65852	34%	140.625
28	Samsun	65.625	4	6,7,8	9,352	3,92784	42%	262.5
29	Sivas	90.625	3	7,8,9	28,488	5,12784	18%	271.875
30	Siirt	81.25	2	8,9	6,182	0,9273	15%	162.5
31	Şanlıurfa	68.75	4	5,6,7,8	19,451	5,44628	28%	275
32	Trabzon	59.375	1	7	4,662	0,55944	12%	59.375
33	Van	62.5	3	7,8,9	21,334	3,41344	16%	187.5
						Total Colony:		8,346.875

The potential value of beekeeping for Adana province is 93.75. This means that. The honey yield per colony in Adana province is 93.75%. Of course, this yield will be achieved if the meteorological conditions are appropriate, the colony health is good, the hives are modern hives, the bees are suitable for the region and the beekeepers are sufficiently experienced in beekeeping. It is seen that the nectar flow period for Adana province is 4 months. It does not mean that there is no nectar flow season for the remaining 8 months of the year. It only means that there is a flow of nectar at maximum level in the 4-month period. This four-month period is 5 (May), 6 (June), 7 (July) and 8 (August) for Adana province are months. Migratory beekeepers are predominantly coming to the city of Adana during these periods.

Figure 4 gives a map for the month of June. How many hives can be placed in Adana province can be determined by subtracting settlements, industrial zones, bare mountains, steppes, agricultural land and pesticides from the total surface area of the province. The total area of Adana is 14,030 km^2. The area where beekeeping can be done covers 59% of this area. This area is 8,277 km^2. The number of colonies subjected to migratory beekeeping was equal to the number of beekeeping potentials multiplied by the nectar flow periods. In this way, bee colonies subjected to migratory beekeeping during the nectar flow season can be distributed to the zones depending on the nectar flow density.

With this study, while the pollination of the plants is achieved at the maximum level, the maximum efficiency is obtained from the bee colonies on the other hand. More colonies are accepted during periods of intense nectar flow and pollination is not missed. Due to the density of nectar flow, the number of bee colonies accepted by each province varies dynamically. As such, this study can be considered as sustainable agricultural practice. Figure 5 shows the software screen used by stakeholders. The software used by the stakeholders was developed using the C # programming language on the Microsoft .NET platform.

Stakeholders are logged into the system with username and password. Meteorological data are automatically updated by the system. This information is obtained through web services following the publication of the State Meteorology Department. ACC administrators instantly enter into the system the number of hives that come into their province. Thus, migratory beekeepers can determine their route by following the number of colony the provinces they will go to simultaneously. The maps give the potential for bee farming up to date and at the same time contain the knowledge of how many bee colonies it can take. The introduction of a new bee feed into the system and the updating or deletion of the existing plant in terms of nectar and pollen have been left to the ACC administrators.

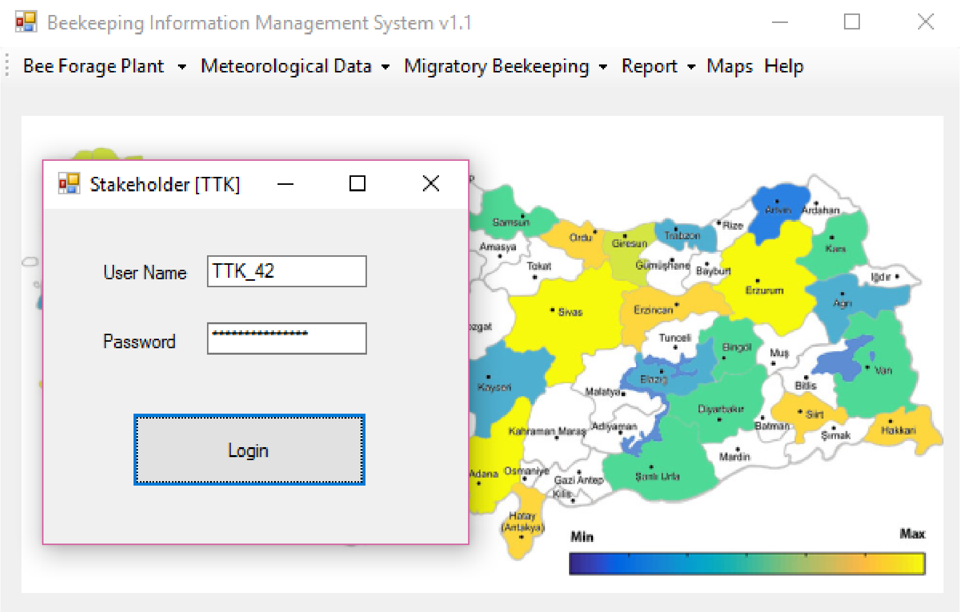

Figure 5. Software screen

Testing the System with Migratory Beekeeper Information

We tested the proposed information system with information from the migratory beekeeper. The head of the Beekeepers Association of Ordu Province, who is a migratory beekeeper, has 300 bee colonies. This person spent the year 2017 hosting three bee colonies in three different places. He was in Mersin / Tarsus from 15 January 2017 until 15 May 2017. Then from 15 May 2017 until 15 September 2017, the bee colonies were hosted in Erzurum / Hınıs. This period is the period of nectar flow for that region. The bee colonies produced the actual honey production during this period. It is a high plateau near the Van district of Hınıs district of Erzurum. Table 6 gives the amount of honey produced per colony in these three periods.

Table 6

Migratory beekeeper yield per colony

Accommodation Periods	Accommodations		
	Mersin Tarsus	Erzurum Hınıs	Samsun Çarşamba
15 Jan - 15 May	~7.1 kg	-	-
15 May- 15 Sep	-	~47 kg	-
15 Sep – 15 Jan	-	-	~6.4 kg

The migratory beekeeper finally housed bee colonies from September 15, 2017 until the end of the year on Samsun / Çarşamba. In this period, bee colonies were able to produce only winter honey. As shown in Table 5, the migratory beekeeper produced the actual honey production in Erzurum / Hınıs and between 15 May and 15 September. In this section, the migratory beekeeper information (for 2017) and the proposed system were compared.

The apiculture potential of Erzurum province was determined as 95% (Table 5). The migratory beekeeper was able to produce 47 kg of honey per colony in this region. This value is significantly high as honey yield per colony obtained in Turkey. The highest yield was measured to be about 51 kg per colony in Turkey (Kekeçoğlu et al., 2007). When compared with this value, it is seen that the system gives correct results with 92%. Similarly, the period of nectar flow for Erzurum province was determined as 3 months. The migratory beekeeper remained in the region for 4 months. Migratory beekeepers can stay longer in the regions where they go to avoid the period, especially during nectar flow periods.

CONCLUSION

In this study, the number of colonies that can be taken by the nectar flow density is calculated. These numbers are for migratory beekeepers. Migratory beekeepers can enter the system, choose the appropriate ones for themselves and make annual migration plans. In determining the number of colonies based on the density of nectar flow, it is possible for the nectar flow seasons not to be missed (all nectar can be collected) and the bees can reach the maximum honey yield per colony without entering the stratum without being in the race.

In Turkey, TBA coordination and cooperation between the ACC is not sufficient. Due to the inadequacy of cooperation, there can be major problems from time to time. This study is important because it is a transparent application that will minimize the problems among the relevant stakeholders. While our country is in a very favorable position for beekeeping as plant diversity, the world average of honey per colony has not yet been caught. Developing an application that agricultural farming bees for Turkey within the country must be sustainable. GIS-supported remote sensing methods can be used for more stable and real-time operation of the system.

REFERENCES

Abou-Shaara, F., H. (2015). Suitability of Current and Future Conditions to Apiculture in Egypt using Geographical Information System. *Journal of Agricultural Informatics, 6*(2), 12-22.

Agbaba, N., Alghamdi, A., Sammoud, R., Senkte, A., Tadesse, Y., Ansari, J. M., ... & Hepburn, C. (2017). Determining spatio-temporal distribution of bee forage species of Al-Baha region based on ground inventorying supported with GIS applications and Remote Sensed Satellite Image analysis. *Saudi Journal of Biological Sciences, 24*(5), 1038-1044.

Amiri, F., Rashid, A., Shariff, M., & Arekhi, S. (2011). An approach for Rangeland Suitability Analysis to Apiculture Planning in Gharah Aglach Region, Isfahan-İran. *World Applied Sciences, 12*(7), 962-972.

Albayrak, A., Duran, F., & Bayır, R. (2018). Development of Intelligent Decision Support System using Fuzzy Cognitive Maps for Mobile Beekeepers. *Turkish Journal of Electrical Engineering and Computer Sciences, 26*, 2476-2488.

Bayır, R., & Albayrak, A. (2016). The monitoring of nectar flow period of honey bees using wireless sensor networks. *International Journal of Distributed Sensor Networks, 12*(11), 2-8. doi: https://doi.org/10.1177/1550147716678003

Davis, P. H. (1988). *Flora of Turkey and East Aegean Islands*. Edinburg: Edinburg University Press.

Fıratlı, Ç., Karacaoğlu, M., Gençer, H., V., Gürel, F., & Koç, A. U. (2010, January 11-15). Structural analysis of beekeeping Turkey. In *Proceedigs of Turkey Agricultural Engineering VII. Technical Congress* (pp. 707-717). Ankara, Turkey.

General Directorate of Forestry. (2012). *Provinces in which Honey Plants with Pollen and Nectar Capacity of the Important Honey Plants in Our Country*. OGM Report. Ankara, Turkey.

Kannappan, A., Tamilarasi, A., & Papageorgiou, E. I. (2011). Analyzing the performance of fuzzy cognitive maps with non-linear hebbian learning algorithm in predicting autistic disorder. *Expert System with Applications, 38*, 1282-1292.

Kekeçoğlu, M., Gürcan, E. K., & Soysal, M., İ. (2007). The status of beekeeping for honey production in Turkey. *Journal of Tekirdag Agricultural Faculty, 4*(2), 227-236.

Kyriakarakos, G., Patlitzianas, K., Damasiotis, M., & Papestefanakis, D. (2014). A Fuzzy Cognitive Maps Decision Support System for Renewables Local Planning. *Renewable and Sustainable Energy Reviews, 39*, 209-222.

Papageorgiou, E. I., Aggelopoluo, K. D., Gemtos, T. A., & Nanos, G. D. (2013). Yield prediction in apples using Fuzzy Cognitive Map learning approach. *Computers and Electronics in Agriculture, 91*, 19-29.

Papageorgiou, E. I., & Laspidou, C. S. (2015). Application of Fuzzy Cognitive Maps to Water Demand. In *FUZZ-IEEE International Conference* (pp. 1523-1530). Istanbul, Turkey.

Rogers, S. R., & Staub, B. (2013). Standard use of Geographic Information System (GIS) techniques in honey bee research. *Journal of Apicultural Research, 52*(4), 1-48.

Semerci, A. (2017). Turkey Beekeeping General Situation and Future Expectations towards. *Journal of Agricultural Faculty of Mustafa Kemal University, 22*(2), 107-118.

Sorkun, K. (2007). *Turkey's nectar plants, Pollen and Honey*. Ankara: Palme Press.

Sudarsan, R., Thompson, C., Kevan, G. P., & Eberl, J., H. (2012). Flow currents and ventilation in Langstroth beehives due to brood thermo re-gulation efforts of honeybees. *Journal of Theo-retival Biology, 295*, 168-193.

Şahinler, N., & Cengiz, M. (2010). European Union countries and Turkey with a view to beekeeping. In *2nd International Muğla Beekeeping and Pine Honey Congress* (pp. 11-17). Muğla, Turkey.

Zacepins, A., Brusbardis, V., & Meitalovs, J. (2015). Challenges in the development of Precision Beekeeping. *Biosystem Engineering, 30*, 60-71.

Zoccali, P., Malacrino, A., Campolo, O., Laudani, F., Algeri, G., Giunti, G., ... & Palmeri, V. (2017). A novel GIS-based approach to assess beekeeping suitability of Mediterranean lands. *Saudi Journal of Biological Sciences, 24*, 1045-1050.