Citation/Atıf: Sarı, F., Sarı, FK. 2020. Land Use Change Assesment for Beekeeping in Southeast Anatolia (Arıcılık için Arazi Kullanım Değişikliklerinin Güneydoğu Anadolu İllerinde İncelenmesi). U.Arı.D.-U.Bee.J. 20(1): 51-61, DOI: 10.31467/uluaricilik.684608

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

LAND USE CHANGE ASSESMENT FOR BEEKEEPING IN SOUTHEAST ANATOLIA

Arıcılık için Arazi Kullanım Değişikliklerinin Güneydoğu Anadolu İllerinde İncelenmesi

Fatih SARI[1], Fadimana KOYUNCU SARI[2]

Selçuk University, Cumra Applied Sciences, Department of Geomatic Information Systems, Konya, TURKEY, ORCID NO: 0000-0001-8674-9028, Yazışma yazarı/Corresponding author: E-mail: fatihsari@selcuk.edu.tr

Selcuk University, Faculty of Agriculture, Department of Landscape Architecture, Konya, TURKEY ORCID NO: 0000-0001-5829-0061, E-mail: fdmnkync90@gmail.com

Geliş Tarihi / Received: 04.02.2020 Kabul Tarihi / Accepted: 08.04.2020 DOI: 10.31467/uluaricilik.684608

ABSTRACT

In this study, land use changes in Mersin, Adana, Osmaniye and Hatay provinces were determined. The study area has vital importance on honey production (citrus, cotton, etc.) for the Turkish beekeeping sector and it is very vulnerable to land use changes due to urbanization and climate change. The land use changes were determined by using 2000, 2006, 2012 and 2018 land cover maps in the Geographical Information Systems (GIS) platform. Moreover, 2000, 2006, 2012 and 2018 beekeeping statistics were retrieved to compare the land use changes and honey production. The results indicate that the fruit trees land use class has increased 1210 km^2 from 2000 to 2018 because of these suitable lands for citrus production. In total, 3170 km^2 natural plant areas have been destroyed within 18 years which threaten natural beekeeping activities. The study area includes 42 districts and when evaluating the beekeeping statistics, total honey production has increased from 6500 tons to 15000 tons from 2000 to 2018. For the purpose of evaluating land use change and its effects, transitions were determined for the 2000-2018 period to understand the change in land-use trends. The transitions revealed that fruit tree and agricultural lands are being enlarge by destroying the natural plant areas and other complex patterns which are important for beekeeping activities.

Keywords: Land Use Change, Beekeeping, Geographical Information Systems

ÖZ

Bu çalışmada Mersin, Adana, Osmaniye ve Hatay illerindeki arazi değişimleri incelenmiştir. Çalışma alanı Türkiye bal üretimi (narenciye, pamuk vb.) için oldukça büyük öneme sahip olup şehirleşme ve iklim değişikliği kaynaklı arazi kullanım değişikliğine oldukça yatkındır. Arazi değişimleri, 2000, 2006, 2012 ve 2018 arazi kullanım haritaları kullanılarak Coğrafi Bilgi Sistemleri (CBS) platformunda değerlendirilmiştir. Ayrıca 2000, 2006, 2012 ve 2018 arıcılık istatistikleri kullanılarak arazi değişimleri karşılaştırılmıştır. Sonuçlara göre meyve ağaçları arazi örtüsü, 2000 yılından 2018 yılına kadar bölgenin narenciye üretim uygunluğundan dolayı 1210 km^2 genişlemiştir. Toplamda 18 yıl içinde arıcılık için önemli olan 3170 km^2 doğal bitki alanlarının yok olduğu gözlemlenmiştir. Çalışma alanı 42 ilçeyi barındırmakta olup bal üretimi 6500 tondan 15000 tona yükselmiştir. Arazi kullanım değişikliği ve etkilerini anlamak için arazi geçişleri 2000 yılından 2018 yılına kadar hesaplanmıştır. Arazi kullanım dönüşümleri, meyve ağaçları ve tarımsal alanların doğal bitki alanlarını yok ederek genişlediği sonucunu ortaya çıkartmıştır.

Anahtar kelimeler: **Arazi Kullanım Değişikliği, Arıcılık, Coğrafi Bilgi Sistemleri**

GENİŞLETİLMİŞ ÖZET

Amaç: Arazi kullanım değişiklikleri, tüm dünya genelinde doğal alanların yok olmasına neden olan bir oluşumdur. Arazi kullanımları, artan nüfus, endüstrileşme, artan gıda ve barınma ihtiyacı, tarımsal alanların artırılması ihtiyacı ve doğal afetler gibi nedenlerle hızlı bir şekilde değişmektedir. Özellikle yerleşim alanları hızlı bir şekilde büyümekte ve doğal alanlar üzerinde baskı yaparak büyüme eğilimine girmektedir. Ayrıca ekonomik kaygılar nedeniyle doğal alanların büyük bir kısmı tarımsal alanlar ve meyve bahçelerine dönüştürülmektedir. Arıcılık faaliyetleri doğrudan arazi kullanımına bağlı olduğundan, arazi değişiklikleri aynı zamanda arıcılık faaliyetlerini de doğrudan tehdit etmektedir. Bu amaçla sürdürülebilir arıcılık faaliyetleri ve doğal kaynakları korumak için arazi kullanım değişiklikleri ve trendleri önemle izlenmeli ve arazi kullanım planları oluşturulmalıdır. Böylece yakın gelecekte bölgeyi ve diğer tüm arıcılık faaliyetlerini tehdit eden arazi değişimleri öngörülebilecek ve şimdiden gerek arazi kullanım planları gerekse yasal sınırlamalar ile arıcılık için önemli bölgelerin korunması sağlanabilecektir.

Yöntem: Arazi kullanım değişikliklerinin incelenmesi amacıyla 2000, 2006, 2012 ve 2018 arazi kullanım haritaları kullanılarak 18 yıllık arazi kullanım değişiklikleri hesaplanmıştır. Toplamda 45 adet arazi sınıfı barındıran CORINE arazi kullanım verisi, 13 sınıfta (Yerleşim, Tarım, Meyve Bahçeleri, Meralar, Sklerofil, Seyrek Bitki Alanları, Su Kaynakları, Karışık Bitki Alanları, Ormanlar, Zeytinlikler, Yarı Tarım-Orman Alanları, Çıplak Alanlar ve Orman Geçiş Alanları) gruplandırılarak her bir arazi sınıfının belirtilen periyotlardaki kapsadığı alanlar hesaplanmıştır. Buna ek olarak, arazi kullanımlarının değişmesinde birbirlerine dönüşen arazi türleri hesaplanarak değişimin en çok hangi sınıflarda gerçekleştiği ve artan-azalan arazi sınıfları belirlenmiştir. Tüm analizlerin yapılabilmesi, periyotlar arasındaki arazi değişimlerinin hesaplanabilmesi için Coğrafi Bilgi Sistemi yazılımlarından olan ArcGIS 10.5 kullanılmıştır. Her bir sınıfa ait kapsama alanları ve arazi türlerinin birbirleri arasındaki geçişler "Zonal Statistics" aracı ile hesaplanmıştır. Arıcılık istatistikleri de kullanılarak bal üretimi artan ilçelerdeki arazi değişimleri incelenmiş ve sonuçlar paylaşılmıştır.

Sonuç: Arazi kullanım değişiklikleri incelendiğinde, en büyük artışın meyve ağaçları arazi kullanım sınıfında olduğu görülmektedir. Çalışma bölgesinin narenciye üretiminde en büyük paya sahip olduğu düşünüldüğünde daha fazla narenciye üretim sahası oluşturmak için çeşitli arazi sınıflarının meyve bahçesine dönüştürüldüğü görülmektedir. Her ne kadar bu durum narenciye balı üretimine olumlu etkisi olsa da arazi değişimlerinin sadece doğal bitki alanlarından meyve bahçelerine dönüştüğü göz önüne alındığında doğal alanlarda yapılan arıcılık faaliyetlerini tehdit ettiği görülmektedir. Ayrıca meraların ve doğal bitki alanların büyük kısmının da tarımsal arazilere dönüştüğü ve toplamda 3170 km^2 doğal bitki alanının tarımsal arazilere ve meyve bahçelerine dönüştüğü ortaya çıkmıştır. Dolayısıyla 18 yıllık arazi değişimleri göz önüne alındığında, arazi kullanım değişikliği trendi bu şekilde devam ederse bölgenin büyük çoğunluğunun narenciye bahçesine dönüşeceği ve 10 yıllık zaman diliminde doğal bitki alanlarının da büyük ölçüde yok olacağı ön görülmektedir.

INTRODUCTION

Honey bees are the main pollinators of agricultural crops (Klein et al. 2007; Brown and Paxton 2009) and this role results in beekeeping activities to be a rural development indicator which can be derived from assessing bee products (honey, pollen, propolis, royal jelly, and bee venom) (Estoque and Murayama 2010; 2011; Damián 2016).

The current transformation of natural areas to agricultural lands is mainly caused by land fragmentation (DeFries et al. 2004; Murray et al. 2009) and land use change which can affect the quantity and quality of pollen and nectar sources (Requier et al. 2019). Land use change is the main reason of habitat loss which results in declines of natural resources (Pimm et al. 2001; Guan et al. 2011). Land cover change rate usually increases from human causes such as need for new agricultural lands, urbanization and industrialization (Halmy et al. 2015). Although agricultural lands can provide a high amount of pollen, pesticide usage can also have damaging effects (Johansen, 1977; Murray et al., 2009).

In recent studies, there are a large number of studies about land use change detection in the field of urban, agricultural, natural resources, water surfaces and moors (Muller 1994; Lambin 1997; Thomas and Laurence 2006; Huang et al. 2008; Ye and Bai 2008; Guan et al. 2011; Subedi et al. 2013; Halmy et al. 2015). However, currently there is no study that

focuses on land use change detection for beekeeping activities. Because beekeeping activities have a close relationship with water surfaces, floral resources, urban and agricultural lands, all the land use classes must be considered in this context from other studies. Thus, this study proposes a more comprehensive approach for detecting land use changes as it relates to beekeeping activities.

For the purpose of deciding what land use changes are beneficial or not for beekeeping, each land use transition must be evaluated. The land use transition reveals the reasons for the land use change and what might be its future projection. Generally, urban areas tend to be enlarged at the expense of forests, pastures, and agricultural lands. However, agricultural lands and fruit tree areas are also increasing and covering up natural plant areas and pastures. While enlarging agricultural lands and fruit tree areas provide high amount of pollen and nectar sources, destroyed natural plant areas are also valuable pollen sources which are decreasing at the same time. To balance the land use changes, land use plans must be established to sustain productivity of beekeeping activities by determining the impact of the land use changes. In this study, land use changes and transitions were examined for Adana, Mersin, Hatay and Osmaniye provinces, which are central to the citrus and citrus honey production.

MATERIALS and METHODS

Study Area

The study areas were Adana, Mersin, Osmaniye and Hatay provinces located in the South of Turkey and border the north east coasts of the Mediterranean Sea basin. In total, these provinces have 42 districts with an area of 39662 km^2. The study area is one of the main centers of the citrus and cotton production, are valuable lands, and have suitable climate for citrus and cotton production. There is a high potential of increased industrial activity due to the urbanization of the Mersin Port. Especially, the Adana province has the highest urbanization potential because of intensive agricultural and industrial activities that are already ongoing in this region. According to the 2018 beekeeping statistics, 14997 tons of honey have been produced in the study area and have an increasing trend in honey production. The study area boundaries are given in Figure 1.

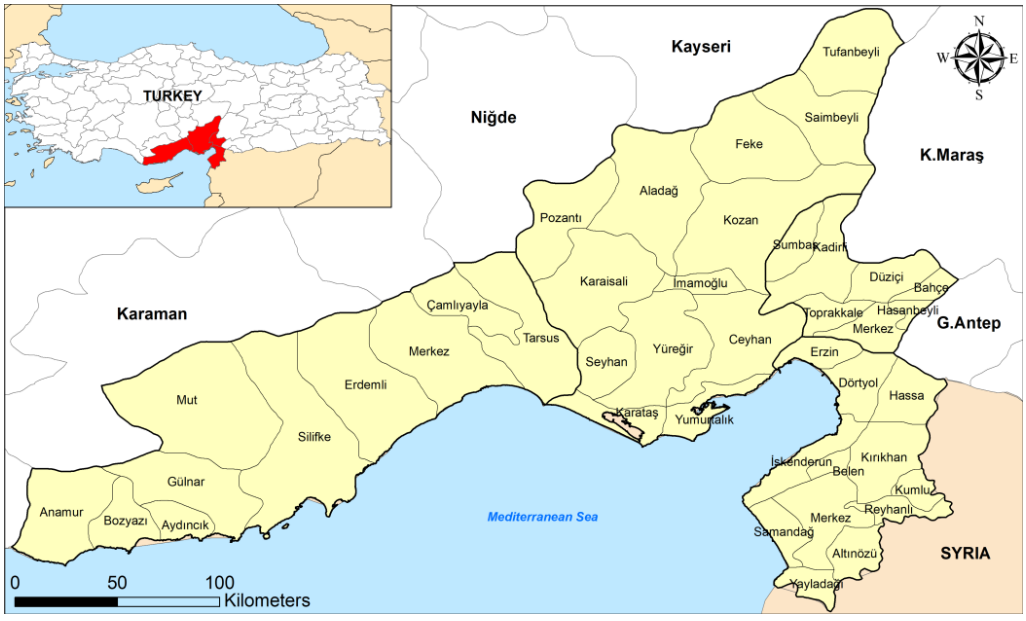


Figure 1. The study area boundaries

Spatial Dataset

The land use changes were determined by using CORINE 2000, 2006, 2012 and 2018 Land Cover raster data at 100 x 100 meters resolution. CORINE maps have 45 land use classes and for this study, the classes were clustered into 13 classes. The beekeeping statistics were retrieved from Turkish Statistical Institute web site for 2000, 2006, 2012 and 2018 years. ArcGIS 10.5 software was used to generate spatial analyses and land use changes determination.

Methodology

The land use changes and transition probabilities are the main decisive data when detecting the trends of land use changes (Huang et al. 2008; Halmy et al. 2015). For the purpose of determining land use changes, transition probabilities were specified via the IDRISI software. The land use change calculation was based on a comparison of CORINE map pixels from 2000 to 2018. The result of this comparison provides both land use area and transitions between land use classes. Cross Table in the IDRISI software and the Tabulate Area analyses in the ArcGIS software were combined to detect land use changes and transitions for the study area.

DETERMINATION OF LAND USE CHANGES

Land use changes

For the purpose of determining land use changes, four land use cover map were classified into 13 main classes and area of each class were determined using the km^2 unit. The land use changes revealed that urban, fruit trees, sclerophyll and shrubs are increasing rapidly on average. Agriculture, pastures, agro-natural and complex patterns tend to decrease. These classes were found to have both negative and positive associations with beekeeping activities and honey production. The land use maps in 2000, 2006, 2012 and 2018 are given in Figure 2.

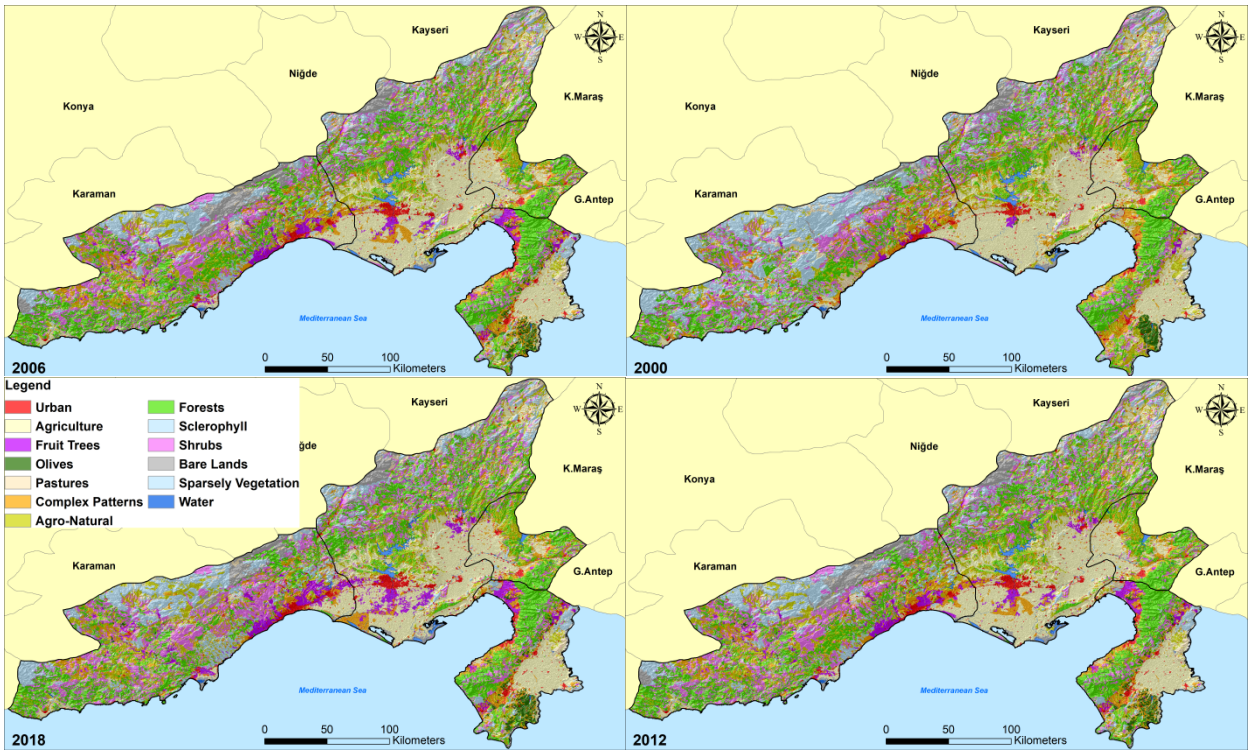


Figure 2. 2000, 2006, 2012 and 2018 land use cover maps

When evaluating the land use changes, fruit tree area has enlarged approximately 1200 km^2 from 2000 to 2018, which is very important for citrus honey production. The study area is the main center of citrus production and this production appears to be increasing over time. Similarly, as the rest of Turkey, urban areas have been increasing rapidly and include residential and industrial areas which have negative effects on beekeeping activities. Urban areas have been enlarged 341 km^2 and this enlargement has mostly occurred in the Mersin and Adana provinces. There is also a valuable decrease in complex patterns and pastures within the study area, which means that the natural plant areas have been transformed to the other land use classes. In the study area, complex patterns and pastures are the main source of natural plant areas in which beekeepers tend to be intensively located. The pastures have decreased 852 km^2 and complex patterns have decreased 285 km^2 from 2000 to 2018 and this translates to approximately 1100 km^2 of natural plant areas that have been destroyed from the transformation of this land for other uses. While agricultural lands are decreasing (by 375 km^2), the annual change rate is quite low in comparison to other land use classes. Agricultural lands are an indicator of cotton honey production in the study area. Agricultural lands tend to decrease over time.

The percent of change in the rate of the land use change for each class is given in Table 1 (%1 = 400 km^2).

Table 1. Percent coverage of land use classes according to the 2000, 2006, 2012 and 2018 years

Land Use Class	2000	2006	2012	2018
Urban	1,9	2,2	2,3	2.7
Agriculture	18,5	17,8	17,7	17,6
Fruit Trees	0,8	2,7	2,8	3,8
Olives	0,6	0,9	0,9	1,0
Pastures	5,0	3,4	3,3	2,9
Complex Patterns	7,6	7,6	7,7	6,8
Agro-Natural	11,9	12,5	12,4	11,7
Forests	21,1	22,5	22,0	21,2
Sclerophyll	1,0	2,0	2,0	2,9
Shrubs	14,8	15,5	15,9	16,9
Bare Lands	2,4	4,0	4,0	3,0
Sparsely Vegetation	13,6	8,0	8,0	8,5
Water	0,9	0,9	0,9	1,0

The gain and loss is given in Figure 3 which summarizes the land use changes. The high losses have occurred in sparsely vegetated areas, pastures, and complex patterns. The largest gain occurred in the fruit tree land use class.

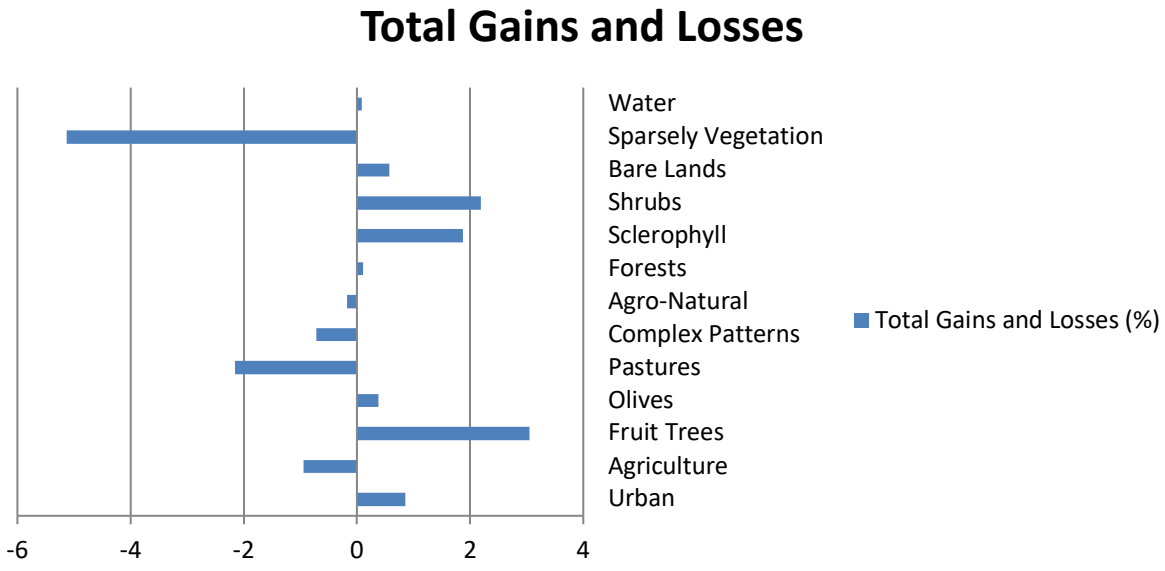


Figure 3. Gains and losses of land use area from 2000 to 2018

When evaluating the changes year by year, shrubs, fruit trees, urban areas and sclerophyll land use classes are increasing and agriculture, complex patterns and pastures are decreasing continuously. These continuous changes suggest that there is a systematic effect of land use changes. For instance, the economic income of the citrus production have been effecting other land use classes to transform areas into ones suitable for fruit tree production for the purpose of establishing new citrus areas. Similarly urban areas have been enlarging due to the increasing population and industrial activities in the study area. Although continuous land use changes are affecting land use regimes, they also affect the beekeeping activities. A discontinuous increase and decrease of land use generally occurred for different reasons such as natural disasters, changing climatic conditions and land use plans (Figure 4).

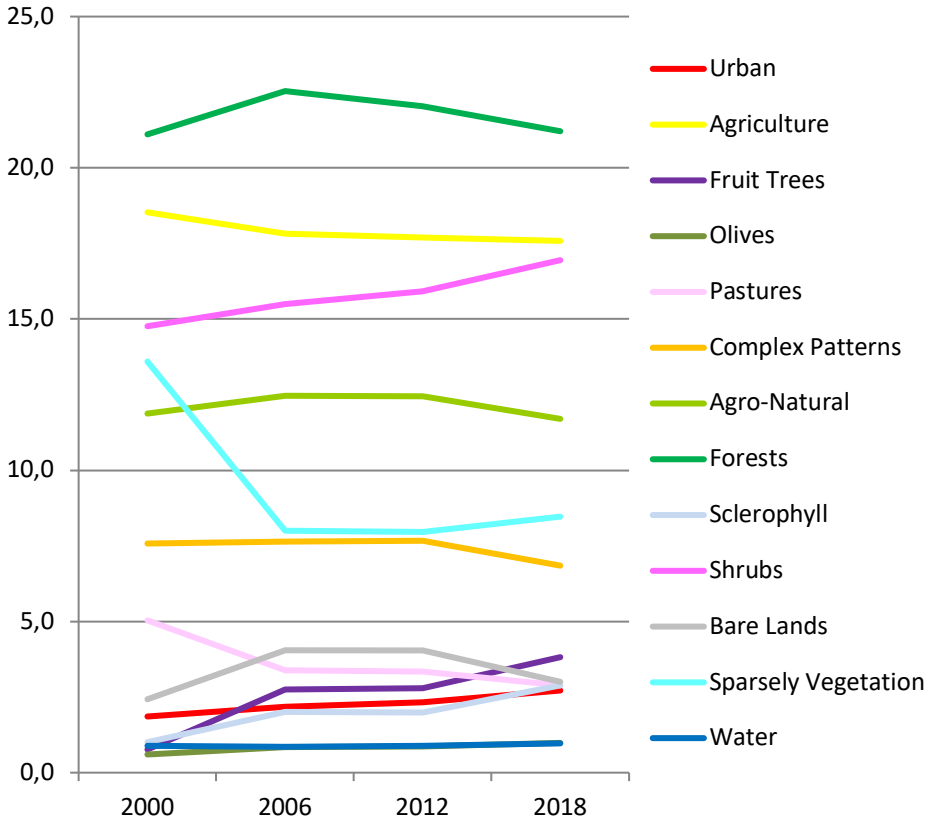


Figure 4. Changes of land use classes from 2000 to 2018

Transitions of land use classes

Understanding the reasons and effects of land use changes requires evaluating the land use transitions. For example, if bare lands transformed into urban areas, this status change will not affect beekeeping activities and other land use classes because bare lands in the first place have no economic and environmental impact on beekeeping activities. However, if pastures, agricultural lands and fruit trees are transforming into urban areas, this can be evaluated as a threat for beekeeping activities. Thus, the transitions from 2000 to 2018 have been generated to evaluate if the transitions will have a large impact or not. The transitions are given in Figure 5.

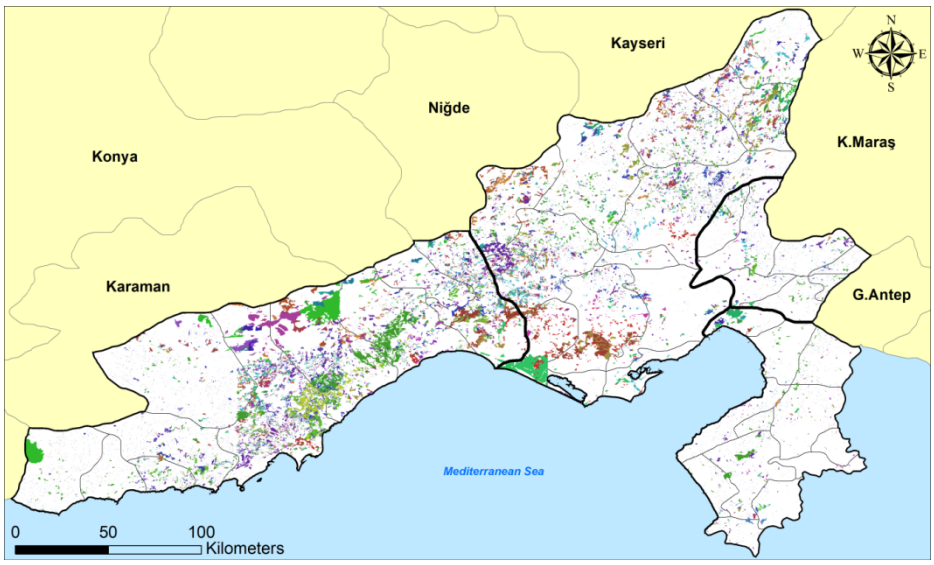


Figure 5. Transitions of land use classes from 2000 to 2018

Because 13 land use classes have been used in this study, 169 transitions were calculated (13 x 13) and due to this high number of transitions, the legend was not provided for Figure 5. However, important transitions for beekeeping activities are given in Table 2 instead. As can be seen in Table 2, the gains in agricultural lands are mostly from the conversion of pastures, complex patterns and agro-natural land, which means that natural areas are generally getting transformed into agricultural lands. Moreover, complex patterns, agriculture and agro-natural land use classes are also being transformed into fruit tree land use. At this point, two disadvantages can be underlined for fruit trees. The high amount of transitions from agriculture to fruit trees implies that fruit trees and agricultural lands are located in adjacent lands to one another. Thus, pesticide use in agricultural lands could affect the fruit trees and impact the honey bees responsible for the citrus honey production.

Table 2. Transitions of some land use classes

Land Use Class		Change
Transitions from	**To**	**(km^2)**
Agriculture	Urban	**59,8**
Complex Patterns	Urban	**79,4**
Pastures	Agriculture	**5,6**
Complex Patterns	Agriculture	**210,9**
Agro-Natural	Agriculture	**218,1**
Agriculture	Fruit Trees	**148,3**
Complex Patterns	Fruit Trees	**246,6**
Agro-Natural	Fruit Trees	**85,1**

Beekeeping statistics

The beekeeping statistics revealed that the honey production in the study area have been increasing from 6496 tons to 14998 tons within 18 years. Seyhan, Yüreğir, İmamoğlu, Karaisalı, Kozan, Mersin (center), Çamlıyayla, Silifke, Tarsus and Osmaniye Merkez districts have the highest contribution to the total honey production in the study area, with 11833 tons in 2018. Moreover, the Kozan district has the 33% of the total production in the study area. The honey production statistics are given in Figure 6.

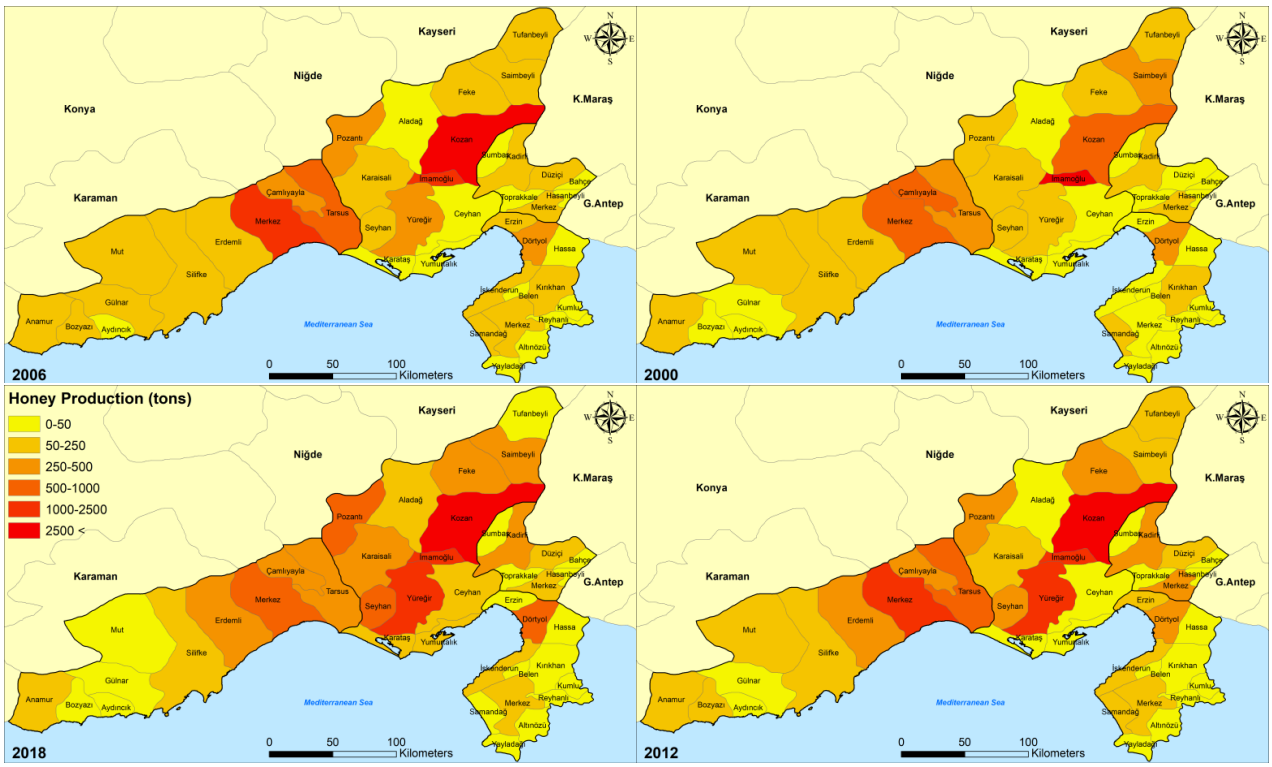
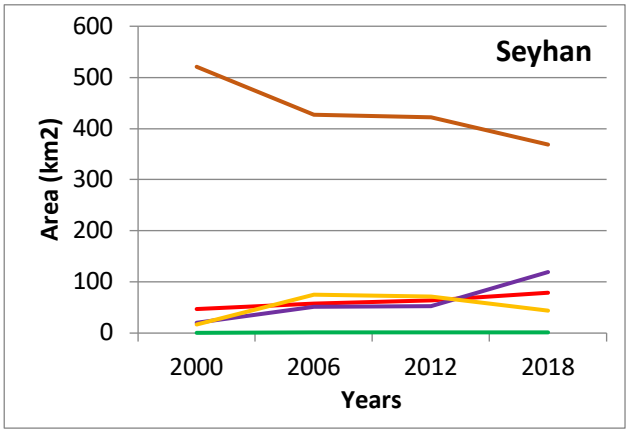
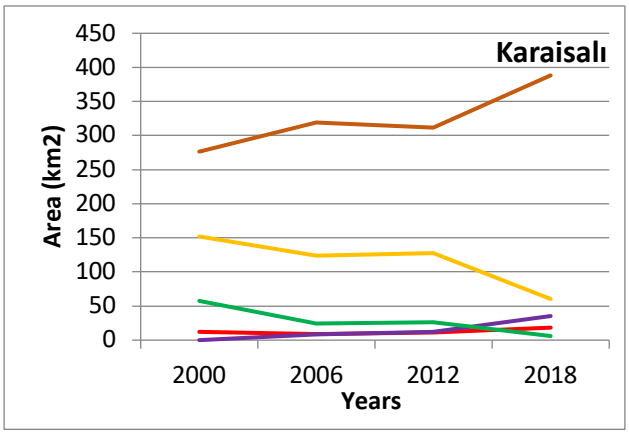


Figure 6. 2000, 2006, 2012 and 2018 beekeeping statistics (total honey production)

When evaluating the land use changes in these districts, as can be seen in Figure 7, the fruit trees land use class has been increasing along with the honey production. While fruit trees are increasing in all districts, pastures and complex patterns are decreasing. Thus, the honey production increasing can most likely be attributed to the fruit tree lands in these districts. However, we would like to point out that the decreasing pastures and complex patterns will reduce the natural plant areas so the urban and residential enlargement patterns must be monitored carefully.





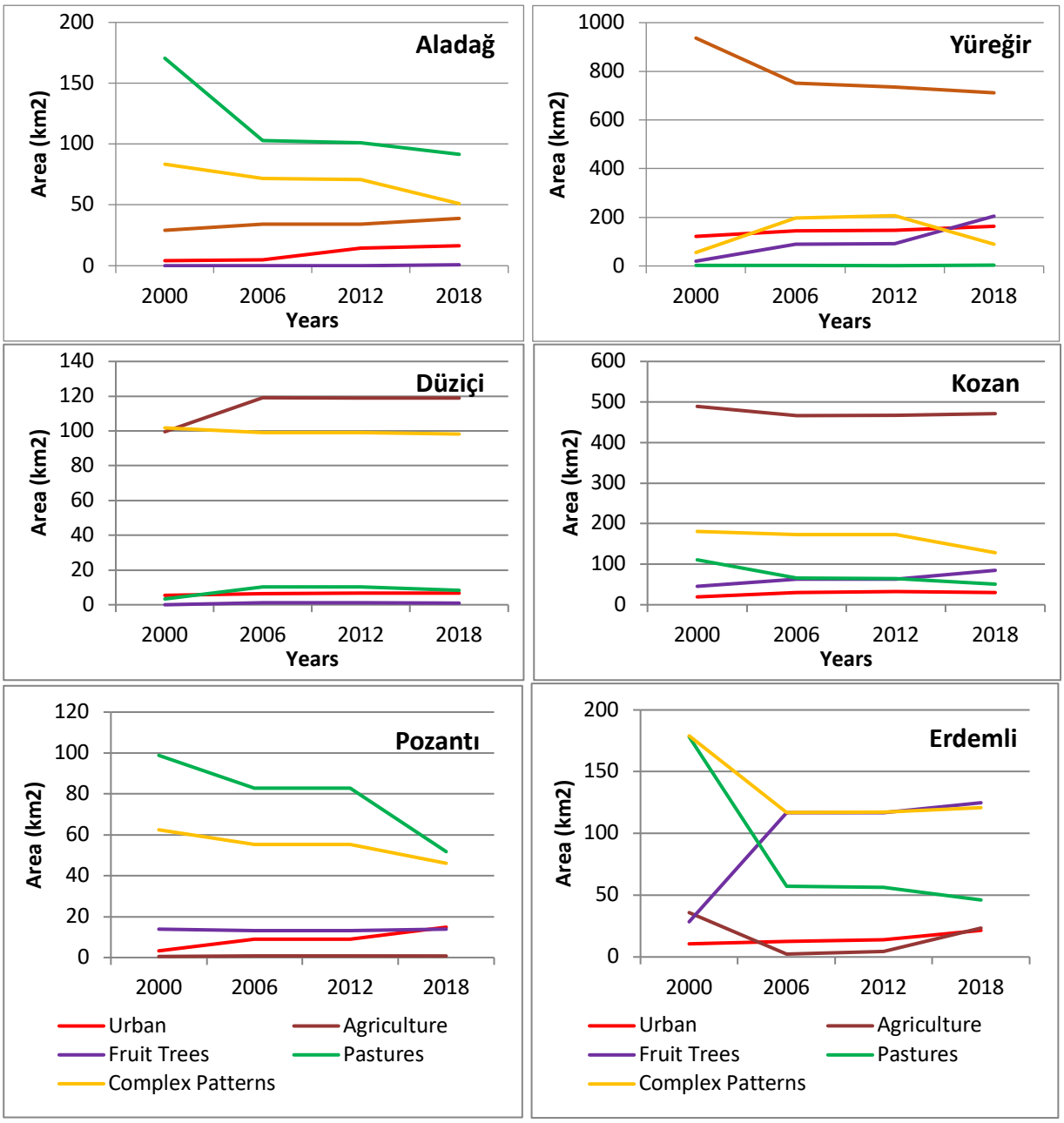


Figure 7. Land use changes in some districts which have high honey production

CONCLUSIONS

Land use changes are considered to be the primary threat for beekeeping activities all around the world. Sustainable beekeeping and ensuring productivity requires that urbanization and agricultural lands are managed with explicit plans that should be arranged by authorized institutes. Sustainable beekeeping activity requires high quality and quantity of nectar, pollen, propolis and water in natural areas. The natural plant areas are especially decreasing and this may be a potential threat for future beekeeping activities. Establishing new fruit tree areas should be transformed from bare lands or sparsely vegetated areas which do not have an economic impact on beekeeping. We determined that a large number of fruit tree land use cover expansion results in high economic stress for beekeeping activities and this can occur rapidly. The future land use maps can be used as predictive models to aid in determining effective land use regimes to balance and sustain both economic income and beekeeping activities.

The land use changes also should be evaluated together with climate change, rural development and environmental factors for comprehensive and applicable land use management establishment. Using past and present land use cover data can act as a guide for future land use change models which might aid in optimizing land use when considering a multifactorial profession such as beekeeping. Thus, the future land use models and related beekeeping activities could guide us on how to best manage the use of land and estimate the projection of the best areas for beekeeping activities. This application can be expanded to cover all of Turkey so that we can understand and monitor how land use changes are impacting the beekeeping industry.

REFERENCES

Brown, M.J.F., Paxton, R.J. (2009). The conservation of bees: a global perspective. Apidologie, (40), 410–416. DOI: 10.1051/apido/2009019.

Damián, G.C. (2016). GIS-based optimal localisation of beekeeping in rural Kenya Master degree thesis, 30/ credits in Master in Geographical Information Sciences Department of Physical Geography and Ecosystems Science, Lund University

DeFries R.S., Foley J.A., Asner G.P. (2004) Land-use choices: balancing human needs and ecosystem function, Frontiers Ecol. Environ. 2, 249–257. DOI: 10.1890/1540-9295(2004)002[0249:LCBHNA]2.0.CO;2

Estoque, R.C., Murayama, Y. (2010). Suitability Analysis for Beekeeping Sites in La Union, Philippines, Using GIS and Multi-Criteria Evaluation Techniques. Research Journal of Applied Sciences, 5(3), 242-253. DOI: 10.3923/rjasci.2010.242.253

Estoque, R.C., Murayama, Y. (2011). Suitability Analysis for Beekeeping Sites Integrating GIS & MCE Techniques. Spatial Analysis and Modeling in Geographical Transformation Process. 978-94-007-0670-5. Springer Netherlands.

Guan, D., L, H., Inohae, T., Su, W., Nagaie, T., Hokao, K. (2011). Modeling urban land use change by the integration of cellular automaton and Markov model. Ecological Modelling, 222, 3761-3772. DOI: 0.1016/j.ecolmodel.2011.09.009

Halmy, M.W., Gessler, P.E., Hicke, J.A., Salem, B.B. (2015). Land use/land cover change detection and prediction in the north-western coastal desert of Egypt using Markov-CA. Applied Geography, 63, 101-112. DOI: 10.1016/j.apgeog.2015.06.015

Huang, W., Liu, H., Luan, Q., Jiang, Q., Liu, J., Liu, H. (2008). Detection and prediction of land use change in Beijing based on remote sensing and GIS. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVII, 75–82.

Johansen, C.A. (1977). Pesticides and pollinators. Annual Review of Entomology, 22, 177–192.

Klein A.-M., Vaissière B., Cane J.H., Steffan-Dewenter I., Cunningham S.A., Kremer C., Tscharntcke T. (2007) Importance of pollinators in changing landscapes for world crops, Proc. R. Soc. London B 274, 303–313. DOI: 10.1098/rspb.2006.3721

Lambin, E.F. (1997). Modeling and Monitoring Land-Cover Change Processes in Tropical Regions. Progress in Physical Geography, 21, 375-393.

Muller, M.R., Middleton, J. (1994). A Markov model of land-use change dynamics in the Niagara Region, Ontario, Canada. Landscape Ecology, 9, 151-157.

Murray, E.T., Kuhlmann, M., Potts, S. (2009). Conservation ecology of bees: populations, species and communities. Apidologie, Springer Verlag, 40 (3), ff10.1051/apido/2009015ff. DOI: ff10.1051/apido/2009015.

Pimm S.L., Ayres M., Balmford A., Branch G., Brandon K., Brooks T., Bustamante R., Costanza R., Cowling R., Curran L.M., Dobson A., Farber S., da Fonseca G.A., Gascon C., Kitching R., McNeely J., Lovejoy T., Mittermeier R.A., Myers N., Patz J.A., Raffle B., Rapport D., Raven P., Roberts C., Rodriguez J.P., Rylands A.B., Tucker C., Safina C., Samper C., Stiassny M.L., Supriatna J., Wall D.H., Wilcove D. (2001) Can we defy nature's end? Science 293, 2207–2208. DOI: 10.1126/science.1061626

Requier, F., Garnery, L., Kohl, P.L., Njovu, H.K., Pirk, C.W., Crewe, R.M., & Steffan-Dewenter, I. (2019). The Conservation of Native Honey Bees Is Crucial. *Trends in ecology & evolution*. DOI: 10.1016/j.tree.2019.04.008

Subedi, P., Subedi, K., Thapa, B., (2013). Application of a Hybrid Cellular Automaton – Markov (CA-Markov) Model in Land-Use Change Prediction: A Case Study of Saddle Creek Drainage Basin, Florida. Applied Ecology and Environmental Sciences, 1(6), 126-132.

Thomas, H., Laurence, H.M. (2006). Modeling and projecting land-use and land-cover changes with a cellular automaton in considering landscape trajectories: An improvement for simulation of plausible future states; EARSeL eProc. 5 63–76.

Ye, B., Bai, Z. (2008). Simulating land use/cover changes of Nenjiang County based on CA-Markov model. International Federation for Information Processing Publications IFIP, 258, 321-330.