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ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

USING GEOGRAPHICAL INFORMATION SYSTEMS AND REMOTE SENSING TO DETECT RESIN-RICH AREAS FOR PROPOLIS PRODUCTION FROM APIARIES

Arı Kovanlarından Propolis Üretimi için Reçine Bakımından Zengin Alanları Tespit Etmek için Coğrafi Bilgi Sistemlerini ve Uzaktan Algılamayı Kullanma

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ABSTRACT

Propolis (bee glue) is considered among bee products with medicinal properties. The majority of plants in Egypt are field crops which cultivated by farmers. Such crops may supply bee colonies with nectar/pollen, but are not good sources for resin due to their short life cycles. This study aimed to explore potential sites for producing high amounts of propolis from bee colonies based on a remote sensing analysis. The study was performed on a Governorate with intensive agricultural activity in Egypt (Assiut Governorate). The methodology depended on isolating trees from the satellite image using unsupervised classification followed by supervised classification based on numerous geographical coordinates of trees. Trees were transferred into points, and then point density was calculated to classify the study location into classes according to density. Sites with the very high numbers of trees were especially recommended for producing propolis on a commercial scale by beekeepers. Giving more attention to propolis production can enhance the income of beekeepers and maximize the economic benefit from bee colonies.

Keywords: Resin, GIS, Trees, Density, Beekeeping

ÖZ

Propolis (arı tutkalı), tıbbi özellikleri olan arı ürünleri arasında sayılmaktadır. Mısır'daki bitkilerin çoğu, çiftçiler tarafından yetiştirilen tarla bitkileridir. Bu tür mahsuller, nektar/polen ile arı kolonilerine besin sağlayabilir, ancak kısa yaşam döngüleri nedeniyle reçine için iyi kaynaklar değildir. Bu çalışma, uzaktan algılama analizine dayalı olarak arı kolonilerinden yüksek miktarda propolis üretmek için potansiyel alanları keşfetmeyi amaçladı. Çalışma Mısır'da yoğun tarımsal faaliyet gösteren bir Valilik (Assiut Valiliği) üzerinde gerçekleştirilmiştir. Metodoloji, ağaçların çok sayıda coğrafi koordinatlarına dayalı olarak denetimli sınıflandırmanın ardından denetimsiz sınıflandırma kullanılarak uydu görüntüsünden ağaçların yalıtılmasına dayanıyordu. Ağaçlar noktalara aktarılmış ve daha sonra çalışma yerinin yoğunluğa göre sınıflara ayırmak için nokta yoğunluğu hesaplanmıştır. Çok yüksek sayıda ağaç bulunan alanlar, özellikle arıcılar tarafından ticari ölçekte propolis üretimi için tavsiye edildi. Propolis üretimine daha fazla önem verilmesi, arıcıların gelirini artırabilir ve arı kolonilerinden ekonomik faydayı en üst düzeye çıkarabilir.

Anahtar kelimeler: Reçine, CBS, Ağaçlar, Yoğunluk, Arıcılık

GENİŞLETİLMİŞ ÖZET

Çalışmanın amacı: Propolis (arı tutkalı), antimikrobiyal özellikleri nedeniyle özel bir öneme sahiptir. Arı kolonilerinden propolis üretimi, çoğunlukla ağaçlardan elde edilen reçine kaynaklarının mevcudiyetine bağlıdır. Mısır'daki bitkilerin çoğu, çiftçiler tarafından yetiştirilen tarla bitkileridir. Bu tür mahsuller, nektar/polen ile arı kolonilerine besin sağlayabilir, ancak kısa yaşam döngüleri nedeniyle reçine için iyi kaynaklar değildir. Bu nedenle, bu çalışma, çok sayıda ağaç içeren alanları belirleyerek uzaktan algılama görüntülerini analiz etmeye dayalı olarak arı kolonilerinden yüksek miktarda propolis üretmek için potansiyel alanları keşfetmeyi amaçladı.

Gereç ve yöntem: Çalışma Mısır'da yoğun tarımsal faaliyet gösteren bir Valilik (Assiut Valiliği) üzerinde gerçekleştirilmiştir. Bu Valiliği kapsayan Landsat 8 Operasyonel Arazi Görüntüleyici (OLI)/ Termal Kızılötesi Sensör (TIRS) Koleksiyon 1 (C1) Seviye 1 görüntülerinden alınan uydu görüntüsü 30 metre çözünürlüklü analizde kullanılmıştır. Uydu görüntüsünün bantları (1'den 5'e ve 7) ArcGIS'te birleştirildi. 1'den 5'e kadar olan bantlar sırasıyla ultra mavi, mavi, yeşil, kırmızı ve yakın kızılötesidir; 7 numaralı bant ise kısa dalga kızılötesidir. Metodoloji, ağaçların çok sayıda coğrafi koordinatlarına dayalı olarak denetimli sınıflandırmanın ardından denetimsiz sınıflandırma kullanılarak uydu görüntüsünden ağaçların yalıtılmasına dayanıyordu. Ağaçlar noktalara aktarılmış ve daha sonra çalışma yerini yoğunluğa göre sınıflara ayırmak için nokta yoğunluğu hesaplanmıştır.

Bulgular: Çalışma alanı için haritalar analizlerden oluşturulmuştur. Bu haritalar, çalışma alanını ağaçların mevcudiyetine göre kategorilere ayırdı. Ayrıca, çalışma alanı için çok yüksek sayıda ağaç, çok sayıda ağaç ve orta sayıda ağaç bulunan yerleri gösteren çokgenler oluşturulmuştur. Arı kolonilerinden ticari yolla propolis üretimi için dört alan çok yüksek olarak kabul edildi. Çok yüksek ve yüksek derecede uygun sitelerin çokgenleri, orta derecede uygun sitelerden farklı olarak ayrıldı. Propolis üretimine çok uygun olarak sınıflandırılan dört alanın toplam alanı 76.83 km2'dir. Bununla birlikte, orta derecede uygun olarak sınıflandırılan siteler, oldukça uygun veya çok uygun olarak kabul edilenlere göre en yüksek toplam alana sahipti.

Tartışma ve sonuç: Propolis üretimi için potansiyel alanları belirlemek için çalışma yerine (Assiut Valiliği) uzaktan algılama tekniği uygulandı. Dört bölge reçine kaynakları olarak çok uygun olarak kabul edildi. Bu sahaların ticari miktarlarda propolis üretmeyi amaçlayan arıcılar tarafından kullanılması tavsiye edilmektedir. Seçilen dört site için saha ziyaretleri ve gerçek görüntüler, buralarda çok sayıda ağacın varlığını desteklemektedir. Gelecekteki bir adım olarak, sorumlu kurumlar, özellikle çalışmadan belirtilen alanları ziyaret ederek, arıcıların gelirlerini artırmak için kolonilerinden propolis üretimine yönelik farkındalıklarını artırmalıdır. Gelecekteki çalışmalarda mükemmel yerlerde kovan başına ortalama propolis üretimi hesaplanabilir

Çok yüksek sayıda ağaç bulunan alanlar, özellikle arıcılar tarafından ticari ölçekte propolis üretimi için önerildi. Propolis üretimine daha fazla önem verilmesi, arıcıların gelirini artırabilir ve arı kolonilerinden ekonomik faydayı en üst düzeye çıkarabilir. Ayrıca, arı sağlığını geliştirmek için propolisten arı hastalıkları için bazı doğal tedaviler hazırlanabilir.

INTRODUCTION

Beekeeping is among the agricultural activities which assist in alleviating poverty and boost national income in many countries (Qaiser et al. 2013, Al-Ghamdi et al. 2016, Amulen et al. 2019). Beekeeping is also essential for crop production due to the role of honeybees, *Apis mellifera* L., in pollinating plants (Morse and Calderone 2000, Reyes-Carrillo et al. 2007, Blazyte-Cereskiene et al. 2010, Calderone 2012, Klatt et al. 2014). The major products from honeybee colonies are honey and pollens. So, beekeepers transfer their colonies from location to another in search for good sources of nectar/pollen (Sharma and Bhatia 2001, Güler and Demir 2005, Pilati and Prestamburgo 2016). There are other valuable products with medicinal properties which can be produced from bee colonies including bee venom, royal jelly and propolis (bee glue) (Nagai et al. 2006, Jingli and Zhsgg 2008, Fratellone et al. 2016, Habryka et al. 2016). These products can increase the profitability form bee colonies especially beekeepers can produce them after or between honey seasons. The production of royal jelly and bee venom depends on the strength of bee colonies while the production of propolis depends on the availability of resin-rich plants (resin is the raw material of propolis) (Bankova et al. 2000, Bankova et al. 2019). Therefore, propolis can be produced from specific sites with resin-rich plants (Abou-Shaara and Eid 2019). The production of propolis is common in countries with forests while searching for resin sources is essential in countries without forests such as Egypt.

There are various sources of resin especially trees (Bankova et al. 2000, Salatino et al. 2005), as resin from wounds in tree trunks is collected by bees (Drescher et al. 2014). The short life cycles of some plants negatively affect their suitability as major sources of resin to bee colonies including field crops which cultivated seasonally by farmers (Abou-Shaara and Eid, 2019). Honeybees tend to collect materials resemble resin from wired sources such as asphalt and artificial paints (König 1985) or recycle previously used propolis when very few resin resources are available around colonies (Abou-Shaara 2014a). In fact, bees use propolis to reduce hive entrance, fill in hive cracks, cover hive intruders to prevent their spoilage inside beehives, and to strength wax combs (Abou-Shaara 2014a, Conrad 2016, Bankova et al. 2019), and can enhance bee immunity and colony health (Borba et al. 2015). Propolis has been used by researchers to control some bee diseases including Varroa mites (Garedew et al. 2002, Damiani et al. 2010, Abou-Shaara 2017). Moreover, propolis has anti-microbial, anti-viral and anti-fungal properties (Grange and Davey 1990, Cheng and Wong 1996, Jingli and Zhsgg 2008). Thus, it has many medicinal usages. Indeed, the commercial production of propolis from bee colonies requires more attention from beekeepers especially in developing countries to increase the profitability from their bee colonies especially after or between honey seasons.

Recently, computer sciences have been used to develop beekeeping. In fact, Geographical Information System (GIS) in combination with remote sensing have many applications in beekeeping (Abou-Shaara 2019, Abou-Shaara and Kelany 2021) including the analysis of land cover around apiaries (Jo et al. 2001, Abou-Shaara et al. 2013,* Fernandez et al. 2016, Ambarwulan et al. 2017, Zoccali et al. 2017, Ausseil et al. 2018). It is possible to identify specific plant types from the satellite images (Abou-Shaara 2013, Abou-Shaara and Kelany, 2020). Potential resin sources (mainly trees) can be identified from satellite images using unsupervised and supervised classification tools (Abou-Shaara and Eid 2019). Therefore, this study aimed to classify the study area (Assiut Governorate) according to the availability of major resin sources (trees) using geographical information system and remote sensing technique. Beekeepers can increase the profitability from their colonies by producing propolis on a commercial scale especially from sites with high resin sources as classified from this study.

MATERIALS AND METHODS

Location

This study was performed on Assiut Governorate (Lat: 27° 15' 7.2" °N, Lon: 31° 5' 24" °E) located towards the South of Egypt (Figure 1). This Governorate has a good vegetation cover especially with field crops cultivated seasonally alongside the Nile River by farmers.

Isolating trees

The analysis was done following the method by Abou-Shaara and Eid (2019) using the ArcGIS 10.5. A satellite image from Landsat 8 Operational Land Imager (OLI)/ Thermal Infrared Sensor (TIRS) Collection 1 (C1) Level 1 images covering this Governorate was used in the analysis with 30-meter resolution. The bands (1 to 5 and 7) of the satellite image were combined (Figure 2A). These bands are band 1 (ultra-blue), band 2 (blue), band 3 (green), band 4 (red), band 5 (near infrared), and band 7 (shortwave infrared). Then, the unsupervised classification considering high number of classes (15 classes) was used to discriminate between different land objectives (Figure 2B). After that, coordinates of trees were tested on the classified image to separate only classes that represent them (supervised classification based on field visits and Google earth). The reclassify tool was used to reclassify all classes into No Data except those representing trees (i.e. to show only trees). Then, the trees were converted into points (Figure 2 C).

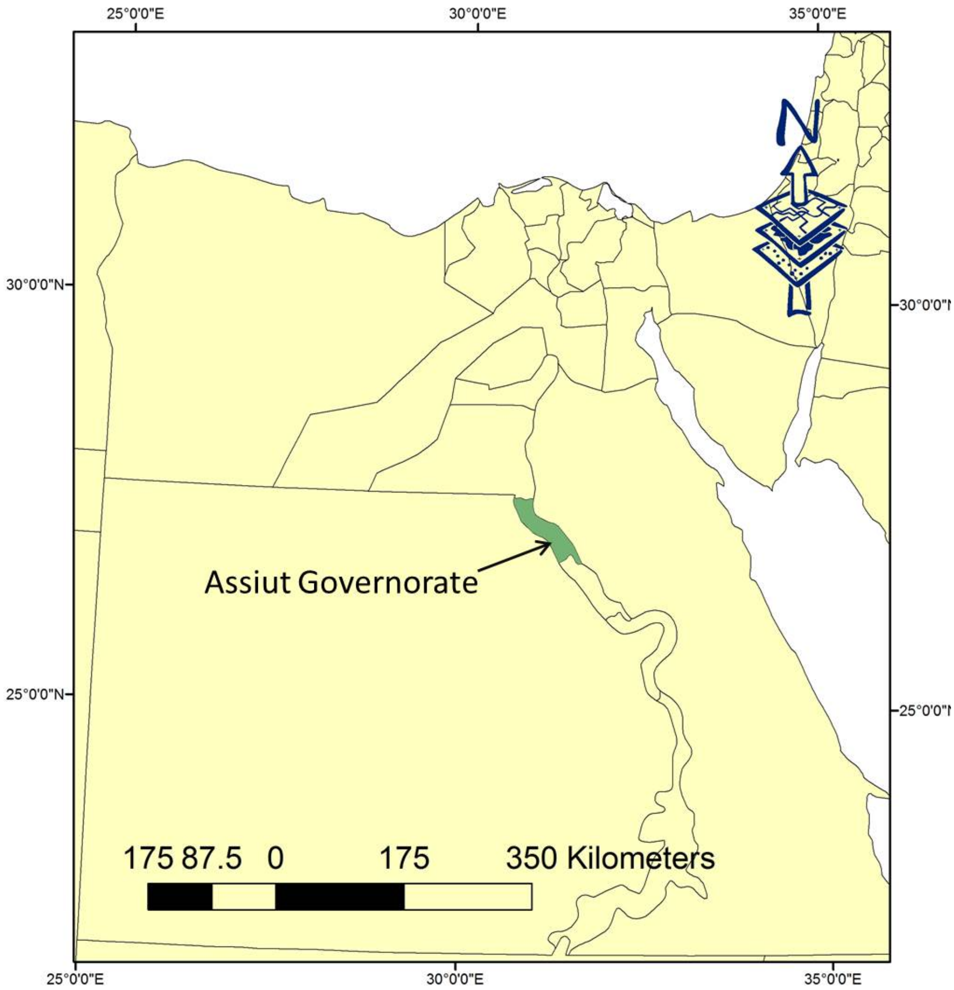

Figure 1: Map showing location of Assiut Governorate (green color).

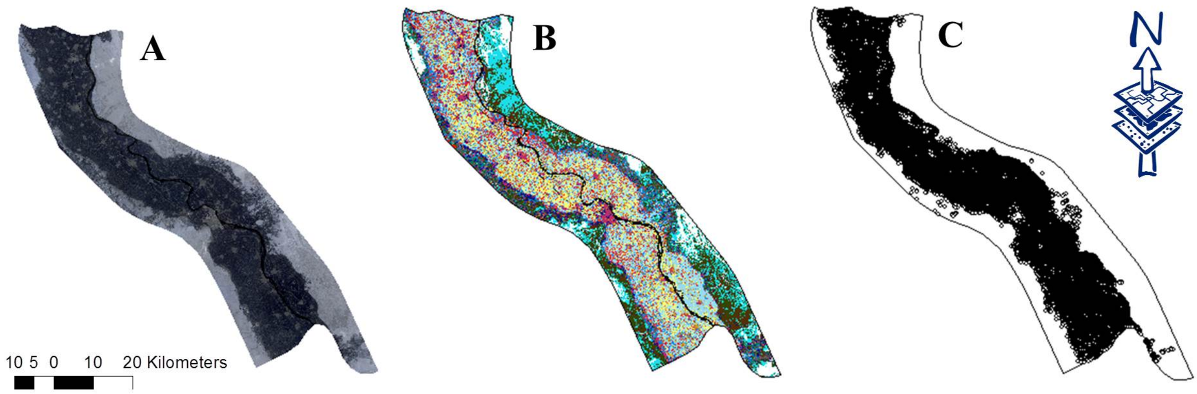

Figure 2: The satellite image of the study location (A), the unsupervised classification of the image (B), and trees as points (C).

Classifying sites according to their suitability for propolis production

Points represent trees were analyzed using point density tool. This tool calculates density as number of points per square map unit. Accordingly, sites were classified into four equal degrees: very high suitable (332.81-443.75), high suitable (221.87-332.81), moderately suitable (110.93-221.87), and low suitable (0 -110.93) according to the method by Abou-Shaara and Eid (2019). The very high suitable sites are especially anticipated to be the perfect places for beekeepers wishing to produce propolis from their colonies. Hence, the results focused on these sites. The four classes were converted into polygons. Then, areas of these polygons were calculated in square kilometers.

Verification of the analysis

Real images from Google earth for the sites classified as very high suitable for producing propolis were firstly inspected to be sure from the presence of high number of trees at them. This was done according to Abou-Shaara and Eid (2019). Additionally, several field visits were conducted to observe the availability of trees in these sites.

RESULTS

Suitability maps

The study location was divided into four classes according to numbers of trees (Figure 3A and B). It is clear that four sites were exclusively considered as very high suitable for propolis production due to the presence of high tree numbers at them. Indeed, these sites are surrounded by other sites with relatively high numbers of trees enveloped with sites classified as with moderate numbers of trees. The rest of the study location was considered as with low numbers of trees which is not suitable for propolis production on the commercial scale.

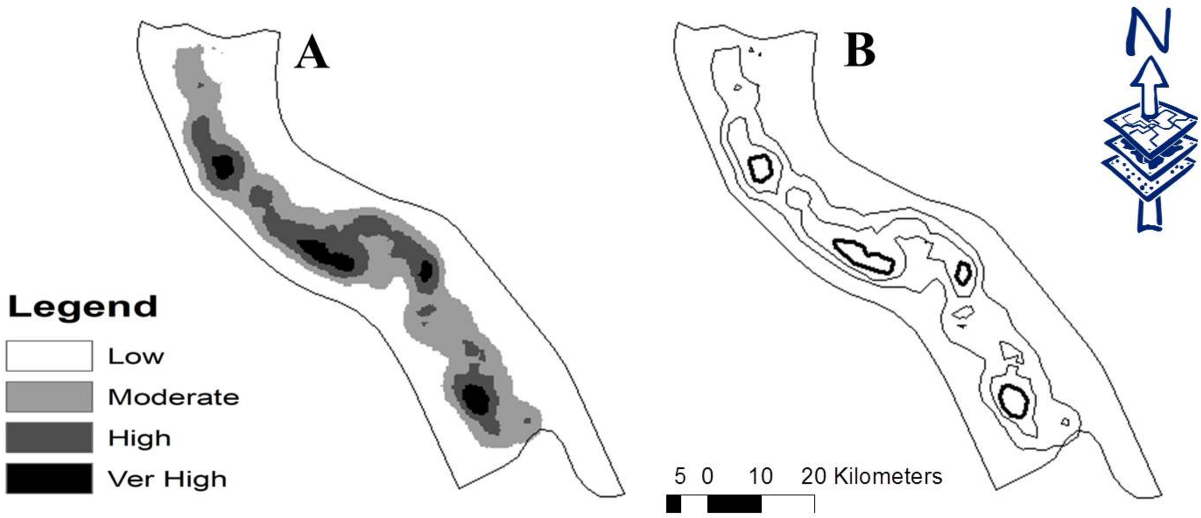

Figure.3: The study location classified into four classes according to numbers of trees: raster image (A), and image as polygons (B).

In fact, four sites were considered as very high suitable for commercial production of propolis from bee colonies (Figure 4A). The polygons of the very highly and highly suitable sites are separated clearly than each other (Figure 4A and 4B) unlike the moderate suitable sites (Figure 4C). The areas of the four sites classified as very high suitable for propolis production were 7.56, 15.03, 22.57, and 31.67 km^2 in ascending order with total of 76.83 km^2. However, the sites classified as moderately suitable had the highest total area than those considered as highly suitable or very highly suitable (Table 1).

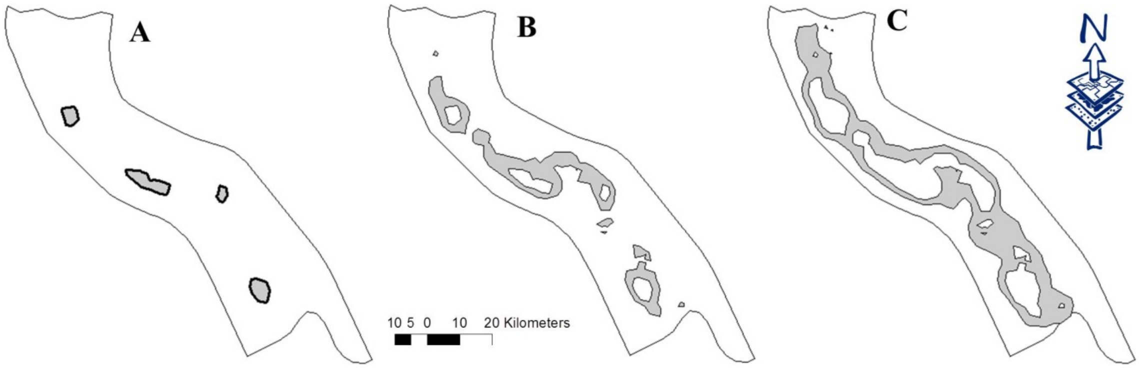

Figure 4: Polygons showing sites with very high numbers of trees (A), high numbers of trees (B), and moderate numbers of trees (C).

Table 1. Information about sites with different numbers of trees.

Numbers of trees	Number of polygons	Mean of areas ± S.D.	Sum of area (km^2)
Very high	4	19.21±10.32	76.83
High	9	36.94±65.56	332.49
Moderate	4	168.83±337.36	675.32

Verification of locations

he four sites classified as very high suitable for propolis production were inspected to ensure the validity of the study. The four sites are typically located in agricultural lands with high numbers of trees (Figure 5). The first three sites (Figure 5 A to C) contain villages which may cause some limitation in utilizing the whole site area for beekeeping. The 4th site (Figure 5D) is approximately empty of villages except some individual houses and can be utilized completely by beekeepers.

DISCUSSION

It is apparent that agricultural crops are available beside trees. This indicates that various food resources are available for bee colonies at these sites beside permanent resin sources. Generally, there are various plant species suitable as food sources for honey bees in Egypt but there are no forests (Abou-Shaara 2015). Thus, fruit and roadside trees represent the major resin sources (Abou-Shaara and Eid, 2019). Accordingly, date palm, banana, casuarina and eucalyptus are the main resin sources in Assiut.

The first three sites contain villages. It is better for beekeepers to place their colonies away from inhabited locations as much as possible. Fortunately, the foraging distance of honey bees is high (Abou-Shaara 2014b), and beehives can be placed anywhere within the very high suitable sites. Although the presence of wild bees beside honey bees in the study location (Assiut area), honey bees represent the major visitor to many crops (Hussein and Abdel-Aal, 1982). This reflects the importance of beekeeping in Assiut for crop production. Therefore, producing propolis from bee colonies is anticipated to be an additional benefit for beekeepers. Additionally, Egyptian propolis has shown antimicrobial activity against some pathogens (Hegazi et al. 2014). This encourages production and studies on propolis from different Egyptian locations.

Remote sensing technique was applied on the study location (Assiut Governorate) to identify potential sites for propolis production. Four sites were considered as very high suitable as sources for resin. These sites are recommended to be utilized by beekeepers aiming to produce commercial amounts of propolis. Field visits and real images for the four selected sites support the presence of high numbers of trees at them. As a future step, responsible agencies should increase the awareness of beekeepers towards the production of propolis from their colonies to increase their income, especially by visiting the sites specified from the study. The average production of propolis per beehive at the perfect sites can be calculated in future studies.

Figure 5: Google images for the four sites classified as very high suitable for propolis production. Site 1 (A and A1), site 2 (B and B1), site 3 (C and C1), and site 4 (D and D1).

CONCLUSIONS

It can be concluded that the study area contains some locations which can be further utilized by beekeepers to produce significant amount of propolis. In the future studies, bee colonies will be placed in the slected locations to evluate propolis production per colony. Also, the perfect season for the production will be specified. Without any doubt, the use of geogrphical information system and remote sesning can help in locating the areas that conatin potential sources for resin. The methodology described herein are benificial to other researchers as they can use it in their local areas to boost propolis production from bee colonies.

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Author contribution: The authors contributed equally in the study. They designed, performed, analyzed the data, wrote and revised the manuscript.

Ethical issue: Not applicable because this study on honey bees and not animals or humans.

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