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Wine Production Potential and Wine Economy of the Ancient City of Perre

Perre Antik Kenti Şarap Üretim Potansiyeli ve Şarap Ekonomisi

Kahraman Yağız* - Ahmet Oğuzhan Karaçetin**

Abstract

This study aims to determine the viticulture and wine production potential of the ancient city of Perre, located in Southeastern Turkey. For this, the characteristics and production models of the six wineries discovered in the city were elaborated. Then, agricultural areas in the city and its vicinity were identified and analysed by means of remote sensing, photogrammetry, and geographical information systems, using the digital elevation model. The elevation analysis yielded a total agricultural area of 180 hectares. Since it is commonly accepted that the maximum slope should be 15% for viticulture, areas with more than 15% slope were removed from the slope map made for the identified 180 hectares, leaving 130 hectares suitable for viticulture. Studies on viticulture assert that at most 70% of agricultural land is used for viticulture. Hence,

* Assoc. Prof. Dr., Adıyaman University, Faculty of Arts and Science, Department of Archaeology-Doç. Dr., Adıyaman Üniversitesi, Fen Edebiyat Fakültesi, Arkeoloji Bölümü, Adıyaman/TÜRKİYE, https://ror.org/02s4gkg68 kyagiz@adiyaman.edu.tr
https://orcid.org/0000-0001-7410-5014

** Assist. Prof. Dr., Muş Alparslan University, Faculty of Arts and Science, Department of History-Dr. Öğr. Üyesi, Muş Alparslan Üniversitesi, Fen Edebiyat Fakültesi, Tarih Bölümü, Muş/TÜRKİYE, https://ror.org/009axq942 a.karacetin@alparslan.edu.tr
https://orcid.org/0000-0002-1688-6657

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the maximum area suitable for viticulture in Perre was calculated as approximately 90 hectares. Entering data into the software we developed, it was found that at most 491,400 litres of wine could be produced annually in Perre. Assuming that 10% of the produce was discarded during the production phase, the maximum amount of wine that could be produced annually was determined as 442,260 litres. The proximity of Perre to the legions positioned along the Euphrates, which formed the Roman-Parthian border, its being on a trade route, the existence of veteran soldiers settled in the city, and its becoming a bishopric centre in the Late Antiquity must have incentivized the people of Perre to produce wine on an industrial scale.

Keywords: Commagene, Perre, Viticulture, Wine, Production, Trade, Winery.

Öz

Bu çalışma, Türkiye'nin Güneydoğu Anadolu Bölgesinde yer alan Perre Antik Kenti'nin antik tarım peyzajı kapsamında bağcılık ve şarap üretim potansiyelini belirlemeye yöneliktir. Bu bağlamda kentte ortaya çıkarılan altı şarap işliğinin özellikleri ve üretim modelleri üzerinde durulmuştur. Daha sonra kent ve çevresindeki tarımsal alanlar belirlenmiş, arazi yükseklik modeli kullanılarak, uzaktan algılama, fotogrametri ve coğrafi bilgi sistemleri yardımı ile analizler yapılmıştır. Buna göre yükseklik analizleri yapılmış ve 180 hektarlık bir tarımsal alan belirlenmiştir. Belirlenen 180 hektarlık alanda eğim haritası yapılmış ve bağcılık için gerekli olan %15 eğimin üzerindeki alanlar çıkarılarak, 130 hektarlık bir bölümün bağcılığa uygun olduğu tespit edilmiştir. Bağcılık ile ilgili çalışmalarda tarımsal alanların en fazla %70'inin bağcılık için kullanıldığı öne sürülmektedir. Bu bağlamda Perre Antik Kenti'nde bağcılık yapmaya uygun maksimum alan ortalama 90 hektar olarak hesaplanmıştır. Perre'de 90 hektar üzerinden şarap üretim miktarını ölçmek için hazırlanan yazılıma veriler girildiğinde bir yılda en fazla 491.400 litre şarap üretilebileceği belirlenmiştir. Üretim aşamasında ürünün %10'luk bir bölümünün ıskartaya çıktığı varsayılmış ve yıllık üretilebilen şarap miktarı en fazla 442.260 litre olarak bulunmuştur. Perre Antik Kenti'nin Roma-Parth sınırını oluşturan Fırat Nehri boyunca konuşlanmış olan Lejyonlara olan yakınlığı, ticaret yolu üzerinde bulunması, kentte sonradan yerleştirilen veteran askerlerin varlığı ve kentin Geç Antik Çağ'da piskoposluk merkezine dönüşmüş olması, Perre toplumunu endüstriyel çapta şarap üretimi konusunda teşvik etmiş olmalıdır.

Anahtar Kellimeler: Kommagene, Perre, Bağcılık, Şarap, Üretim, Ticaret, İşlik.

Introduction

The ancient city of Perre, one of the major settlements of the Kingdom of Commagene, is located approximately 5 km northeast of the Adıyaman Province in the Southeastern Anatolia Region of Turkey, below the residential and agricultural areas of the modern Örenli Neighbourhood, formerly Pirin Village. Perre is situated on the eastern slopes of the southern ridge of Kara Dağ and on the flat arable land close to water sources. Information about Perre is quite limited and was obtained simultaneously with the discovery of King Antiochus I's tomb sanctuary (*hierothesion*) on Nemrut Dağ towards the end of the 19th century. Although their studies were focused on Nemrut Dağ, the researchers passed through Perre during their journey and recorded their observations about the city[1]. The first archaeological excavations at Perre were carried out by Adıyaman Museum between 2001 and 2009 under the direction of Fehmi Erarslan as rescue and cleaning excavations at the necropolis area[2]. The second phase of archaeological excavations at Perre, which started in 2020, is being carried

1 William Francis Ainsworth, *Travels and Researches in Asia Minor, Mesopotamia, Chaldea, and Armenia*, Vol.1, John W. Parker West Strand, London 1942, pp. 263-264; Karl Human-Otto Puchstein, *Reisen in Kleinasien und Nordsyrien*, Berlin 1890, pp. 401-402; Edhem Eldem, *Le Voyage a Nemrud Dağı D'Osman Hamdi Bey et Osgan Efendi (1883)*, Paris 2010, p. 89; Eugène Pittard, *À travers l'Asie-Mineure, le visage nouveau de la Turquie*, Paris 1931, pp. 147-154; Hans Henning Von der Osten, *Discoveries in Anatolia 1930-31.* Chicago-Illinois 1933, pp. 129-131; Friedrich Karl Dörner-Rudolf Naumann, "Forschungen in Kommagene", *IstForsch* 10, 1939, pp. 66-69; İsmail Kılıç Kökten, "1945 Yılında Türk Tarih Kurumu Adına Yapılan Tarihöncesi Araştırmaları". *Belleten* Vol. XI/No. 43, 1947, pp. 439-440, 459; İsmail Kılıç Kökten, "Anadolu'da Prehistorik Yerleşme Yerlerinin Dağılışı Üzerine Bir Araştırma", *Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi*, 10/3-4, 1952, pp. 174-175, 177, 187; Enver Bostancı, "Adıyaman Çevresinde Proto-Solutreen ve Adıyamaniyen Paleolitik Kültürler Üzerinde Bir Araştırma", *Antropoloji Dergisi*, V, 1971, pp. 52-68.

2 Fehmi Erarslan, "Perre Antik Kenti Nekropol Alanı Kaya Mezarları Kurtarma Kazısı", *13. Müze Çalışmaları ve Kurtarma Kazıları Sempozyumu*, Ankara 2003, pp. 129-136; Fehmi Erarslan-Nevruz Esma İnce-Mehmet Alkan, "Perre Antik Kenti Nekropol Alanı 2007 Yılı Kazı ve Temizlik Çalışmaları", *17. Müze Çalışmaları ve Kurtarma Kazıları Sempozyumu*, Ankara 2009, pp. 171-184; Fehmi Erarslan, Engelbert Winter, "Perrhe (Pirun). Geographische Lage, Topographie und (Forschungs-) Geschichte", *Asia Minor Studien 60*, Bonn, 2008, pp. 179-187; Fehmi Erarslan-Recep Özman-Fuat Şancı-Muhammet Arslan-Mehmet Nuri Karaca-Mehmet Alkan, "Perrhe Antik Kenti Nekropol Alanı 2008 Yılı Kazı ve Temizlik Çalışmaları", *18. Müze Çalışmaları ve Kurtarma Kazıları Sempozyumu*, Ankara 2010, pp. 91-104; Fehmi Erarsla-Turgut Hacı Zeyrek-Recep Özman-Fuat Şancı-Enver Akı-Muhammet Arslan-Mehmet Alkan-Mehmet Nuri Karaca-Muhammet Sunullah Koca, "Perre Antik Kenti Nekropol Alanı 2009 Yılı Kazı ve Temizlik Çalışmaları", *19. Müze Çalışmaları ve Kurtarma Kazıları Sempozyumu,* Ankara 2011, pp. 363-377; Fehmi Eraslan, "Die antike Stadt Perrhe und ihre Nekropole", ed. J. Wagner, *Gottkönige am Euphrat, Neue Ausgrabungen unda Forschungen in Kommagene*, Mainz 2012, pp. 147-150.

out again by the Directorate of Adıyaman Museum and under the scientific consultancy of Adıyaman University[3].

During the excavations in Perre between 2020 and 2022, settlement units belonging to the Late Antiquity were unearthed at the south of the city centre, extending to the rocky area around the necropolis[4] (**Fig. 1**). These are complex structures consisting of multiple spaces around a central courtyard. An architectural model with a courtyard, living space, kitchen, storage, and production areas was adopted to meet the needs of rural life. Walls built with mud mortar and irregular stones predominate the construction of the structures. However, it was also observed that blocks, column capitals, and column drums probably collected from public and religious buildings of the city's earlier periods were used in thresholds, wall corners, and door lintels. The top cover is made of terracotta tiles on a wooden roof construction. Thresholds raised from the bedrock, iron locks and large nails, as well as a large number of roof tiles, found in some of the discovered wineries (no. 1-2 and 4), suggest that these were part of the rural settlement units in question.

Finds such as the military diploma, bronze phalera, and iron sword found in the Late Antiquity settlement area show that soldiers who retired after 25 years of service in the Roman army also settled in Perre[5]. Although the discovered structures exhibit rural settlement characteristics, mosaic and brick floored spaces reveal that the city was inhabited by persons of various social statuses besides retired soldiers[6]. In addition, numerous finds related to wine production, such as collecting vats, pithoi for storing wine[7], and amphorae for transporting wine, were discovered in the city.

3 Kahraman Yağız-Murat Tosun-Taylan Doğan, "Seramik Buluntuları Işığında Perre İşliklerinin Kullanım Evreleri Üzerine Bir Ön Değerlendirme", *Höyük*, Issue 10, 2022, pp. 145-175; Kahraman Yağız-Mehmet Alkan-Murat Tosun, "Perre 2021 Yılı Kazıları", *Kazı Sonuçları Toplantısı* 42, Vol. 3, T.C. Kültür ve Turizm Bakanlığı Yayınları, Ankara 2023, pp. 341-356; Kahraman Yağız-Taylan Doğan, "Perre Nekropolisi'nden Bir Hypogeum Mezar", *Arkeoloji Dergisi*, XXXI/2, İstanbul 2023, pp. 49-69.

4 Yağız-Alkan-Tosun, ibid, pp. 341-356; Kahraman Yağız-Mehmet Alkan-Mehmet Turan-Ümran Bigeç-Yıldız Ersönmez, "Perre 2022 Yılı Kazıları", *Kazı Sonuçları Toplantısı* 43, Vol. 5, T.C. Kültür ve Turizm Bakanlığı Yayınları, Ankara 2024, pp. 421-424, Fig. 1-7.

5 For the military diploma see Werner Eck-Mustafa Hamdi Saya-Mehmet Alkan-Mehmet Turan-Kahraman Yağız, "Neus Zu den Statthaltern Von Iudaea Und Syria Unter Hadrian", *Zeitschrift für Papyrologie und Epigraphik* 225, Dr. Rudolf Habelt Gmbh, Bonn, 2023, pp. 261-270; Yağız-Alkan-Tosun, ibid, p. 344, Fig. 9; for the bronze phalera and the iron sword see Yağız-Alkan-Turan-Bigeç-Ersönmez, ibid, p. 424, Fig. 8.

6 Yağız-Alkan-Turan-Bigeç-Ersönmez, *ibid.*, p. 423, Fig. 5-6.

7 Yağız-Alkan-Tosun, ibid, p. 343, Fig. 7; Yağız-Alkan-Turan-Bigeç-Ersönmez, ibid, pp. 422-423,

The number and capacity of wineries, the existence of leather workshops, and Pompeii-type mills show that the economy of Late Antiquity Perre was shaped by agriculture and animal husbandry, notably viticulture. In addition to being a commercial product, wine played a major role in the religious celebrations of King Antiochus I of Commagene. The inscriptions found on the *hierothesion*[8] and *temenos* founded by Antiochus I state that celebrations were to be made every month on 16 Audnaios, the King's birthday, and on 10 Loos, the day of his coronation, and that pure wine produced at the wineries in Commagene lands was to be served in these celebrations by mixing with water[9]. Although these inscriptions contain rules to be observed in Antiochus I's *hierothesia* and *temene*, they are also significant in terms of showing that winemaking was practiced during this prosperous period of the Commagene Kingdom, namely 69-36 BCE. Moreover, the ceramic finds discovered in wineries during recent excavations revealed that production continued from the 3rd century CE to the first half of the 7th century CE and that it increased from the 5th century CE onwards[10]. In addition, wineries in Yenigüven Village, approximately 2 km east of Perre, are significant in terms of showing the importance of viticulture and wine as a commercial product in this geography[11] **(Fig. 2)**.

426, Fig. 3-4; For amphorae see. Yağız-Tosun-Doğan, ibid, pp. 152-153, Fig. 8; Yağız-Alkan-Tosun, ibid, p. 347, Çizim 1.

8 Antiochus I had a *hierothesion* founded each for himself on the summit of Nemrud Dağı, for his father Mithridates I Callinicus at Arsameia-on-the-Nymphaios and for his grandfather Samos II at Arsameia-on-the Euphrates at Gerger. For Arsameia-on-the Euphrates see Humann-Puchstein, *ibid*, pp. 353-368; Helmut Waldmann, *Die Kommagenischen Kultreformen Unter König Mithradates I. Kallinikos und seinem Sohne Antiochos I*, Leiden 1973, pp. 123-141; For Arsameia-on-the-Nymphaios see. Friedrich Karl Dörner, "Kommagene. Forschungsarbeiten von 1967 bis 1969", *İstMitt* 19/20, 1969/70, pp. 256-264; Waldmann, *ibid*, pp. 80-122; Michael Blömer-Engelbert Winter, *Toros ve Fırat Arasındaki Tanrılar Ülkesi Kommagene*, İstanbul 2011, pp. 76-87; Herman A. G. Brijder, *Nemrud Dağı: Recent Archaeological Research and Conservation Activities in the Tomb Sanctuary on Mount Nemrud*, De Gruyter, Berlin-Boston 2014, pp. 238-271; For Nemrud Dağı see Humann-Puchstein, *ibid*, pp. 232-353, Tafel XIX-XL; Brijder, *ibid*, pp. 298-400; Waldmann, *ibid*, pp. 59-79, Fig. 6-8; For the *temenos* see Charles Crowther-Margherita Facella, "Yeni Epigrafik Buluntular Işığında I. Antiokhos'un Kutsal Alanları", *Fırat Kıyısında Tanrı Krallar. Kommagene'de Yeni Kazılar ve Araştırmalar*, Arkeoloji ve Sanat Yayınları, İstanbul 2018, pp. 65-91; Brijder, *ibid*, pp. 130-160; Jörg Wagner, "Kommagene Kralları ve Kral Kültü", *Fırat Kıyısında Tanrı Krallar. Kommagene'de Yeni Kazılar ve Araştırmalar*, ed. Ö. Yılmaz , Arkeoloji ve Sanat Yayınları, İstanbul 2018, pp. 51-71.

9 Waldman, *ibid*, p. 204; Friedrich Karl Dörner, *Nemrud Dağı'nın Zirvesinde Tanrıların Tahtları. Kommagene-Doğu Anadolu'da Arkeolojinin Büyük Macerası,* transl. Vural Ülkü, Ankara 1990; Brijder, *ibid*, pp. 165-166.

10 Yağız-Tosun-Doğan, ibid, p.154.

11 Kahraman Yağız, "A Preliminary Report on Wineries and Wine Production in Yenigüven Village and Its Vicinity," *Çağlar Boyunca Üretim ve Ticaret: Prehistorya'dan Bizans Dönemi'ne*, ed. O.

In this study, viticulture and related wine production capacity of Perre in Late Antiquity will be estimated from the agricultural land, as well as the wineries discovered during archaeological excavations. Settlement boundaries of the ancient city could not be determined precisely due to the presence of the modern settlement on it. However, Karadağ, which lies to the west of the ancient city and curves towards the south, limits the settlement from the west and partly from the south. Partly preserved fortification walls on the north and east of the city limit the settlement from these directions. Rocky territory on the west and south of the city is not suitable for agriculture and was therefore used as a necropolis and quarry. On the east, Kalburcu Stream passes just below the city walls with very little arable land between it and the walls. In contrast, the lands to the north outside the city walls are suitable for agriculture, and these are identified as agricultural land in this study. Still today, the agricultural areas of the Örenli Neighbourhood (formerly Pirin Village) are mostly located in the north of the settlement.

While identifying Perre's production areas, interpreting the ancient landscape correctly will enable accurate calculation of the amount of potential production. For this reason, settlement areas, defence systems, necropolises, and all land unsuitable for production should be omitted from the total area covered by the city **(Fig. 3)**. Since the city has not been completely excavated, data obtained from geographical information systems will be used, and a general outline of the ancient landscape will be drawn. However, it should be noted that these general assumptions may contain a margin of error, even if it is small. In addition, cases in which the product fails to appear on the market, such as production wastes, discarded products, and accidents during shipment, should also be taken into account for ancient wine production.

Typology and Production Models of Perre Wineries

One of the major economic inputs of ancient cities was the export of goods or products to various places. Evidence of goods transported by cities to each other shows us the sophistication of the trade network system[12]. In addition to this, the quantity of the groups of goods shipped during commercial activities could usually

Dumankaya, Ankara 2019, pp. 563-578.

12 André Tchernia, *The Romans and trade*, Oxford University Press 2016, pp. 38-72; Anthony John Parker, *Ancient Shipwrecks of the Mediterranean and the Roman Provinces*, BAR Publishing, Oxford 1992, pp. 16-23.

be assessed from ceramics or inscriptions[13]. However, it has been shown that only the traces of shipment that we can track are insufficient to accurately assess commercial activities in terms of economic inputs. For this reason, in recent years, researchers have evaluated export potential on the basis of production potential, thus calculating the maximum amount of annual production of cities and trying to understand what proportion of this was exported[14]. Moreover, determining the amount of production can be the best way of tracking the consumption of the product[15].

Traces of wine production discovered through excavations in Perre reveal that one of the major economic inputs of the city was wine export. To assess the scale of the city's wine export, efforts were made to understand the production potential from agricultural areas, considering the ancient landscape. In addition to settlement units in Perre, industrial areas containing wineries discovered during excavations indicate that there was intense wine production at the city[16]. Moreover, it is understood that wine was stored in the pithoi discovered at the city and exported to various places in amphorae[17]. However, it is necessary to determine the production areas in order to understand the contribution of wine production at Perre and its hinterland to the economy of the city or the people who participated in the production and trade of wine. In this context, it is very important to interpret the ancient landscape of Perre and its vicinity correctly. To identify the agricultural areas in the city and its vicinity, analyses were performed by means of remote sensing, photogrammetry, and geographical information systems, using the digital elevation model. Through these analyses, the maximum amount of the city's wine production was estimated.

13 Andrew Ian Wilson, "Approaches to quantifying Roman trade", *Quantifying the Roman economy: methods and problems*, Vol. 1, eds. A. K. Bowman-A. I. Wilson, Oxford University Press, 2009, pp. 213-249; Walter Scheidel, *The Cambridge Companion To The Roman Economy*, Cambridge University Press, 2017, pp. 1-17.

14 Helen Goodchild, "GIS models of Roman agricultural production", *The Roman agricultural economy: organization, investment, and production*, eds. Alan K. Bowman-Andrew I. Wilson, Oxford University Press, pp. 55-86; Ahmet Oğuzhan Karaçetin, *Pax Romana Dönemi'nde Campania Şarabının Akdeniz'deki İhracat Modelinin Geliştirilmesi*, Ege University, Unpublished PhD Thesis, İzmir 2023, pp. 168.

15 Karaçetin, *ibid*, pp. 168-169.

16 Yağız-Tosun-Doğan, ibid, pp. 145-175; Yağız-Alkan-Tosun, ibid, pp. 341-356; Yağız-Doğan, ibid, pp. 49-69.

17 Yağız-Tosun-Doğan, ibid, pp.145-175.

Six wineries have been discovered in Perre so far. Five of these (wineries no. 1-5) are at the rocky area where the necropolis is located and hewn in the bedrock. Wineries no. 1-4 are placed side by side (**Fig. 4**). In this area, there are other workshops probably used for tanning animal skins. Therefore, this area was organized as an industrial production area with both wine and leather workshops. Winery no. 5 is located 150 m north of wineries no. 1-4, again on a rocky area. Winery no. 6 is at the centre of both the modern Örenli Neighbourhood and the ancient city, and is made of processed and rubble stones together.

All of the wineries consist of two main parts: the treading floor and the collecting vat. However, the treading floors and collecting vats differ in their form. Accordingly, wineries no. 1 and 3 are examples with a rectangular treading floor, a channel, and a collecting vat which is circular at the bottom and rectangular or square at the top (**Fig. 5, 6**). The collecting vat of winery no. 5 has a similar form to those of wineries no. 1 and 3. However, it differs from these two with its triangular treading floor (**Fig. 7**). Winery no. 6 is similar to wineries no. 1 and 3 with its rectangular treading floor, while it differs from the other wineries with its square collecting vat and channel in the shape of a gutter. In addition, unlike the other wineries, which are hewn in bedrock, the walls of its treading floor are made of block and irregular stones, and its collecting vat is made only of block stones (**Fig. 8).** The collecting vat of winery no. 6 is 1.70 m wide and 2.10 m deep. The depths of the collecting vats of wineries no. 1-5 in Perre vary between 0.90 m and 0.93 m, and their diameters vary between 0.80 m and 0.85 m. This points at large-scale production in winery no. 6. In another type of winery in Perre, the treading floor and the collecting vat are in the same area, without a wall or ridge separating them from each other. A raised line on the floor sloping towards the collecting vat guides the must towards the collecting vat. These wineries have a circular collecting vat and a shallow pit at the bottom for collecting pulp. Winery no. 2 and the eastern part of winery no. 4 are of this type (**Fig. 9, 10**). Winery no. 4 is also the only winery with two layouts. In the eastern part of the winery, the treading floor and the collecting vat are in the same area, without a wall or ridge separating them from each other, as stated above. The collecting vat is circular and hewn into the bedrock floor, as in winery no. 2. In the western part of the winery, there is a wall raised from the bedrock between the treading floor and the collecting vat. The channel inside this wall connects to a terracotta pithos. It is also noteworthy that both the eastern and western parts of winery no. 4 have two units consisting of a platform and a rectangular vat in front of it, which are found in leather workshops. This suggests that it was used as both a winery and a tannery.

Considering the architectural organization and features of the wineries discovered at Perre, two production models were identified: "*lever and weight press*" and "*simple press*." In wineries no. 1, 2 and 3, rectangular fulcrums for anchoring the lever (*prelum*) on the high southern walls and the beam weight (*litus*) found *in situ* in winery no. 1 indicate that "*lever and weight press*" model was used during production in these wineries. The fact that there was no press beam recess in winery no. 4 suggests that production was made mostly using the *simple press* model, and the circular shallow recess on the eastern wall of winery no. 5 suggests that probably "*lever and weight press*" model was applied. No data could be obtained regarding the production model of winery no. 6, which is located at the city centre. However, in Rough Cilicia examples where the winery walls are built with block and irregular stones, the press beam recess is placed on the long wall of the winery[18]. Only a single row of the walls was preserved in winery no. 6 in Perre due to damage. This probably resulted in the press beam recess on the wall not being preserved. However, the collecting vat of size 1.70 x 2.10 m and the treading floor of size 3.70 x 2.70 m of the winery indicate that there was industrial-scale production. Thus, it seems more likely that *lever and weight press* model was used for such kind of production.

Determination of Production Areas Using Remote Sensing Methods and Geographical Analyses

In this study, open-source satellite map and digital elevation model datasets were obtained, and various geographical analyses were performed using geographical information systems (GIS). The amount of production was calculated from these analyses and datasets using software **(Fig. 11).** Additionally, assumptions related to situations such as production wastes, discarded products, and accidents during shipment were used in calculations.

12-metre DEM (Digital Elevation Model) dataset of Perre was obtained from the open-source earth observation data system of NASA satellites[19] **(Fig. 12).** Using this data, the surface of the city was digitized with the QGIS software so that analyses could be performed[20]. Through these analyses, areas where agricultural production could be made were identified. In accordance with the purpose of the study, elevation, slope and intersection analyses were performed respectively.

18 Ümit Aydınoğlu-Erkan Alkaç, "Rock-Cut Wine Presses in Rough Cilicia", *Olba*, XVI, 2008, pp. 281-282, Fig. 6-8.

19 https://worldview.earthdata.nasa.gov

20 Version 1.34.7 of QGIS software was used.

Elevation Analysis

To understand the surface profile, firstly, elevation analysis was performed, and the city was mapped. Considering that vineyards cannot be planted at altitudes above 1000 metres, areas higher than 1000 metres in the topography were removed from the map, and the remaining areas were calculated[21]. According to these calculations, since Perre and its hinterland are at an elevation of less than 1000 metres, the entire map was included in the calculation **(Fig. 13).** The created maps were coloured using the QGIS program. According to the analyses performed, the total area was found to be 180 hectares.

Slope Analysis;

In order for vineyards to be planted, the territory should have an average slope of less than 15%. Although there are certainly exceptions to this, general assumptions are taken as a basis. Therefore, parts of the territory with a slope greater than 15% were omitted, and the remaining portion was calculated and formed into polygons by using the software program[22] **(Fig 14).** According to the analyses performed, 130 hectares of the total area were found to be suitable for viticulture.

Intersection Analysis

The intersection of the abovementioned analyses was calculated to determine the areas with a slope less than 15% and an elevation below 1000 metres[23]. The area obtained thereof was calculated as 130 hectares **(Fig. 15).**

Calculation of the Amount of the Product

Identifying the areas where production can be made is important for calculating the amount of production. Although it is disputed how much wine was obtained from vineyards in antiquity, especially ancient writers who lived in the Roman period gave information about how much wine could be produced from an area of 1 *iugerium*[24]. The amount of production definitely depends on various factors such

21 David Wheatley-Mark Gillings, *Spatial Technology and Archaeology: The Archaeological Applications of GIS*, United Kingdom: CRC Press, London 2002, pp. 95-96. Karaçetin, *ibid*, pp. 169-170; Pedro Trapero Fernández-Isabel Rondán Sevilla-Lázaro Lagóstena Barrios, "Studying Roman Viticulture in Baetica with GIS Modelling and Geophysical Survey", *Methods in Ancient Wine Archaeology: Scientific Approaches in Roman Contexts*, eds. Dimitri Van Limbergen-Emlyn Dodd, Bloomsbury Publishing, 2024, pp. 147-160.

22 Wheatley-Gillings, *ibid*, pp. 85-87; Karaçetin, *ibid*, pp. 171-172.

23 Karaçetin, *ibid*, pp. 174.

24 Karaçetin, *ibid*, pp. 174-176.

as soil quality, climate, and specialization in production. However, considering the data given by writers such as Cato, Varro, and Columella, an average amount can be determined[25]. Columella states that approximately 1,365 litres of wine can be obtained from 1 *iugerium*[26]. 1 hectare is equivalent to 4 *iugeria*, and thus 5,460 litres of wine can be obtained from 1 hectare. Using simple software developed for this calculation, data such as the amount of wine produced and the number of amphorae in which this amount of wine can be transported can be obtained[27] (**Fig. 16**). With the help of the collecting vats in Perre, information on how many times the vats were used for total production can also be obtained.

Studies on viticulture state that at most 70% of production areas can be used, whereas the remaining 30% is used for other agricultural activities. Of course, various factors are considered in these evaluations, and it should be noted that an approximate calculation is made in this study on Perre. In this context, the maximum area for viticulture in Perre was calculated as approximately 90 hectares.

Entering the data obtained from GIS into the software developed for estimating the amount of wine production, it was found that at most 491,400 litres of wine could be produced annually from a total of 90 hectares of production area. Of course, one of the general assumptions in these calculations is that the vineyards are mature and at their best time to yield fruit. The reason is that the geography in which Perre is located is favourable for viticulture in terms of soil composition, and climate and that viticulture had been practiced for long periods of time, even before the Roman period[28].

Discarded Products

One of the major criteria of production is that the products are partly unusable or unsellable. It is particularly noticeable that the amount of products discarded

25 Cato, *De Agricultura/Tarım Üzerine*, transl. Mehmet Seferbay, Doğu Batı Yayınları, Ankara 2021, 3; Varro, *Ziraat İşleri*, transl. A. Doğucan Hanegelioğlu, Doğu Batı Yayınları, Ankara 2021, I,13, 6-7; Columella, *On Agriculture, Volume III: Books 10-12. On Trees,* Translated by E. S. Forster-E. H. Heffner, Loeb Classical Library 408. Cambridge, MA, Harvard University Press, 1955, III, 12; Richard Duncan-Jones, *The Economy of the Roman Empire: Quantitative Studies,* Cambridge Press, 1974, p. 37; Karaçetin, *ibid*, p. 62.

26 Columella De Re Rust., III, 7-11; Girolamo Ferdinando De Simone, "The Agricultural Economy of Pompeii: Surplus and Dependence", *The economy of Pompeii*, eds. M. Flohr-A. I. Wilson, Oxford University Press, pp. 36-37.

27 Karaçetin, *ibid*, p. 184.

28 Brijder, *ibid*, pp. 165-166.

under the harsh conditions of antiquity was higher than today[29]. Thus, it is assumed that at least 10% of the production in Perre and its hinterland was discarded. Accordingly, it can be suggested that at most 442,260 litres of wine were produced annually in Perre.

Evaluation and Conclusion

While making evaluations on areas where wine production is concentrated in terms of the economy of Antiquity, it will not be sufficient to only assert soil fertility and favourability of climate. Exceptional cases such as the political situation, military legions, safety of trade routes, economic stability, and natural disasters should also be taken into account. Another factor that should be considered in a settlement such as Perre, where there was intense wine production compared to nearby regions, is the supply and demand relationship. Particularly, the existence of the legions *Legio XII Fulminata* in Melitene, *Legio XVI Flavia Firma* in Samosata, and *Legio IIII Scythica* in Zeugma, from north to south, to ensure border security along the Euphrates, which formed the border with the Parths, can be a major motivation[30] (**Fig. 17**). Moreover, Perre's being located on the road between Melitene and Samosata provided an important advantage for trade, since Samosata is a major crossroads on the east-west and north-south trade routes[31]. Therefore, products produced in Perre may first go to Samosata, then follow two different routes over Zeugma and Doliche to Antiocheia, and finally reach the port of Seleucia Pieria. In addition, there is another route from Cilicia that reaches Perre and again Samosata over Germaniceia[32]. This must have incentivized the people of Perre for industrial wine production and trade. Besides, the city's becoming a bishopric

29 Karaçetin, *ibid*, p. 177.

30 Terence Bruce Miltford, "Some Inscriptions from the Cappadocian Limes" *Journal of Roman Studies 64,* 1974, pp.166-169; Rıfat Ergeç-Mehmet Önal- Jörg Wagner, "Seleukeia am Euphrat/ Zeugma-Eine Bedeutende Garnisons-und Handelsstadt an der Ostgrenze des Römischen Reiches", *Gottkönige am Euphrat. Neue Ausgrabungen und Forschungen in Kommagene*, ed. J. Wagner, Mainz 2012, p. 185,190; Martin Hartmann-Michael Alexander Speidel, "The Roman Army at Zeugma: Recent Research Results", Zeugma: Interim Reports, *Journal of Roman Archaeology*, Supplementary Series Number. 51, 2003, pp. 100-126; Hüseyin Uzunoğlu, "Anadolu'da Roma Lejyonları", *Eskiçağ Yazıları 2*, eds. E. Akyürek Şahin-B. Takmer.-F. Onur, Arkeoloji ve Sanat Yayınları, İstanbul 2012, pp. 104-109; Dicle Kaya, "Roma'nın Anadolu'daki Doğu Sınırında Bulunan Karargahlar Üzerine Bir İnceleme", *Colloquium Anatolicum* 2018/17, pp. 60-65.

31 Anthony Martin Comfort, *Roads on the frontier between Rome and Persia, Euphratesia, Osrhoene, and Mesopotamia from AD 363 to 602*, University of Exeter, PhD Thesis, Exeter 2008, pp. 157-158.

32 Comfort, *ibid*, pp. 151-153, 157-161, Fig. 14-16.

centre in the Late Antiquity must have been another source of motivation for wine production. Therefore, the abundance of wineries and wine production in Perre and the rural settlement units in its vicinity should be the result of the supply and demand relationship due to one or more reasons, such as providing for the need of religious rites in early times, the soldiers in legions, for trade, and the need of the church in later periods.

The wineries discovered in Perre showed that viticulture and related wine production had an important place in the city's economy. The motivation of the producer class to engage in viticulture and wine production must surely have been due to the city's favourable soil and climate for viticulture and the fact that wine was a profitable commercial instrument for producers or traders. According to Columella's pricing based on Italian wine, the price per amphora was 15 HS. In that case, the approximate price per litre was 1.7 HS. This, of course, varies depending on various factors such as inflation rate, market equilibrium, and wine quality[33]. This quantity shows that Perre was a major actor in the wine market of the region. Thus, wine being a quite profitable product in terms of trade, its being in high demand in the market, and the city's having natural conditions favourable for viticulture, as shown by both archaeological excavations and GIS analyses, can be shown as reasons behind the motivation for viticulture in Perre.

As a result of the measurements at Perre, of the 180 hectares of total area, 90 hectares were determined to be suitable for viticulture, considering the elevation and slope values. The results obtained from GIS data reveal that at most 491,400 litres of wine could have been produced annually in the city. Deducting 10% of discards from this figure, the total amount was determined to be 442,260 litres.

At first glance, Perre's 442,260 litres of annual wine production might seem like a rather high figure. Davies states that the daily diet of a soldier in a Roman legion contains 2 pints (approximately 1 litre) of wine in addition to bread, meat, and oil[34]. Also, there are 5000 to 6000 soldiers in a Roman legion[35]. A simple calculation for a legion with a minimum of 5000 soldiers over 2 pints (approximately 1 litre) yields 5000 litres of daily and 1,825,000 litres of annual wine consumption. Talking about food rations for farm workers, Cato recommends a daily allowance

33 Duncan-Jones, *ibid*, p. 364; De Simone, ibid, p. 48; Karaçetin, *ibid*, p. 179.

34 Roy William Davies, "The Roman Military Diet", *Britannia*, Vol. 2, 1972, p. 122.

35 Adrian Goldsworthy, *The Complete Roman Army*, Thames &Hudson, London 2003, p. 38.

of 0.5 litres of wine for field workers[36]. Even when the 1 litre consumption of a legionnaire is reduced to the 0.5 litre consumption of a farm worker, that legion requires 2,500 litres of daily and 912,500 litres of annual wine. This shows that even if all of the 442,260 litres of wine produced annually in Perre had been exported, it could meet only half of the wine requirement of *Legio XVI Flavia Firma* in Samosata, located approximately 50 km south of Perre.

The collecting vats of wineries no. 1-5 discovered in Perre have an approximate capacity of 900-1100 lt. Winery no. 6, which is situated at the centre of the city and was unearthed in 2021, has a collecting vat of approximately 6000 liters, with a width of 1.70 m and a depth of 2.10 m[37]. This suggests the existence of a large-scale production beyond personal need. This winery also shows that it is highly probable that there are other wineries in Perre, of which only a small part has been excavated. Moreover, it is not known how many times the wineries were used in a year. Therefore, while estimating the production volume of a city, an evaluation based on the collecting vat capacity of the wineries or the capacity of the pithoi in warehouses will be insufficient to determine the maximum capacity. For this reason, an evaluation based on agricultural areas makes it possible to reach more accurate results.

442,260 litres of wine produced in Perre must have been exported in at most 15,795 of the North Syrian Amphorae, which have an average capacity of 28 litres. Similarly, 983 of the pithoi discovered during excavations, which have an average capacity of 450 litres, are needed for storing the obtained product.

The finds in Perre related to Roman soldiers, its being located on military routes, relationship with legions, and the city's becoming a bishopric centre with the acceptance of Christianity may suggest answers to the question of for whom the wine was produced, or may be an indicator of the supply and demand relationship. If more data, such as underground water sources, soil permeability, and climate analyses, are obtained through geographical studies at the city, and analyses of suitability for viticulture are conducted, the production potential can be calculated closer to reality.

36 Cato, *ibid*, p. 57; Dimitri Van Limbergen, "What Romans ate and how much they ate of it. Old and new research on eating habits and dietary proportions in classical antiquity", *Revue belge de philologie et d'histoire*, Vol. 96/No. 1, 2018, p. 1052.

37 Kahraman Yağız, "Perre Şarap İşlikleri", *Olive Oil and Wine Production in Aegean and Mediterranean in Antiquity*, *International Symposium Proceedings, Bodrum, Turkey, 24-26 November 2022, Bildiriler,* eds. Ümit Aydınoğlu-A. Kaan Şenol, Bilgin Kültür Yayınevi, Ankara 2024, p. 279.

In addition, considering the commercial relationships of the city, assessments can be made through export potential as well. Although researchers try to understand the economy of antiquity by focusing on large cities and port cities, studies should focus on cities such as Perre, whose commercial activities are not known but where traces of large-scale wine production have been found, and have conditions favourable for production, and try to understand the economy of antiquity from a larger perspective.

Wine production had an important place in the Commagene Kingdom, and legions positioned on borders along the Euphrates during the Roman Empire period, veteran soldiers settled in Perre, the city's being on commercial and military routes, and finally its becoming a bishopric centre in the Late Antiquity stand out as factors that promoted industrial-scale wine production.

In addition, viticulture is the main agricultural activity in the modern Örenli Neighbourhood (formerly Pirin Village), which is located on the site of Perre. This reveals that viticulture was not only the main agricultural activity in the economy of the people of Perre in Antiquity but continues to be so for people living in the same geography today.

Author Contributions

Conceiving the Study	Author-1 (%50) - Author-2 (%50)
Data Collection	Author-1 (%50) - Author-2 (%50)
Data Analysis	Author-1 (%50) - Author-2 (%50)
Writing up	Author-1 (%50) - Author-2 (%50)
Submission and Revision	Author-1 (%50) - Author-2 (%50)

The Author(s) declare(s) that there is no conflict of interest / Çıkar çatışması beyan edilmemiştir.

Ethical Statement/Etik Beyan

It is declared that scientific and ethical principles were complied with during the preparation of this study and all the works referred are mentioned in the bibliography./Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.

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https://worldview.earthdata.nasa.gov. (access date: 23.06.2024)

FIGURES

Fig. 1: Late Antiquity settlement area (Perre excavation archive).

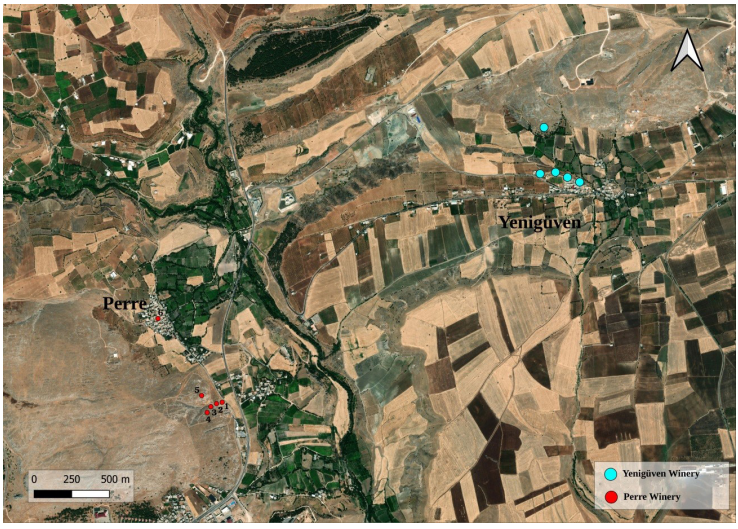

Fig. 2: The location of the Perre winery and the Yenigüven winery (Map A. O. Karaçetin)

Fig. 3: Location of Perre (Map A. O. Karaçetin)

Fig. 4: Location of wineries no. 1-5 (Perre excavation archive).

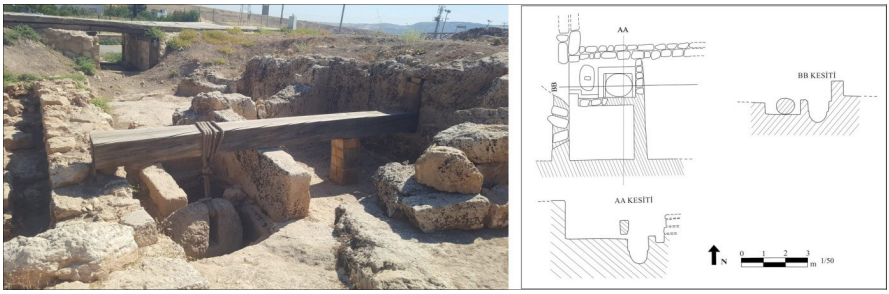

Fig. 5: Winery no. 1 (Perre excavation archive)

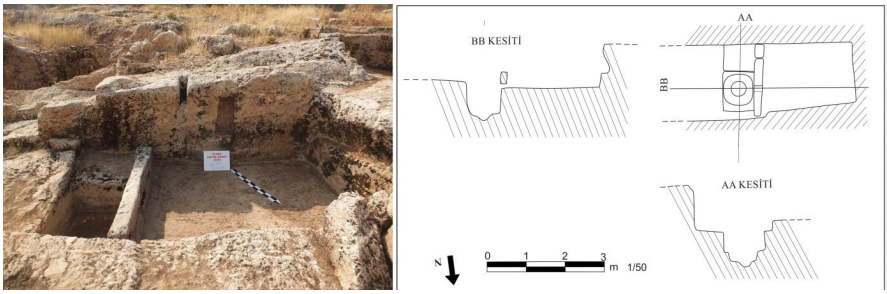

Fig. 6: Winery no. 3 (Perre excavation archive)

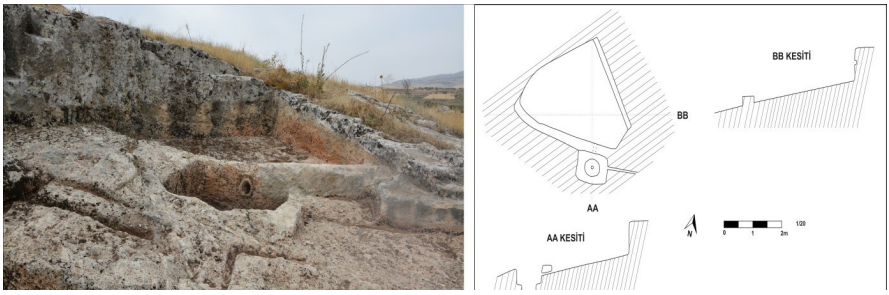

Fig. 7: Winery no. 5 (Perre excavation archive)

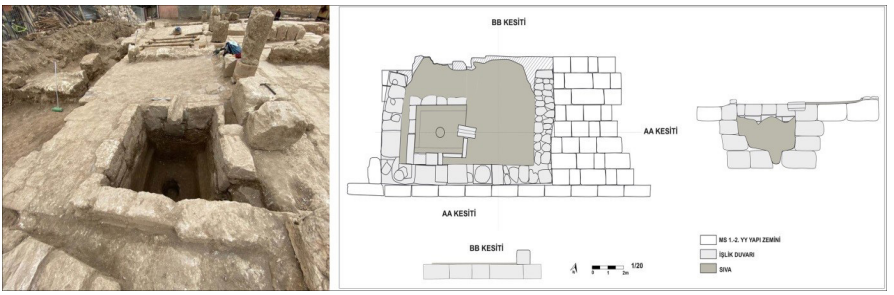

Fig. 8: Winery no. 6 (Perre excavation archive)

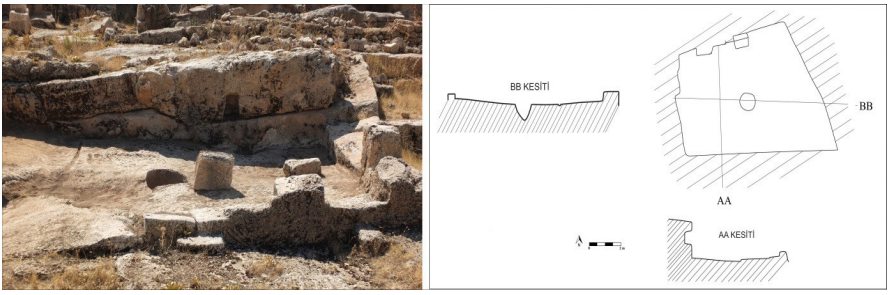

Fig. 9: Winery no. 2 (Perre excavation archive)

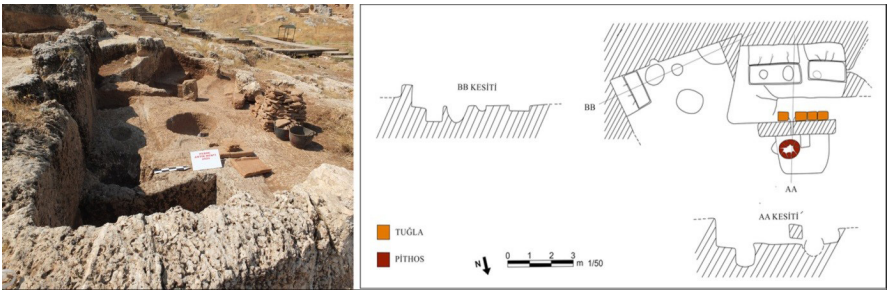

Fig. 10: Winery no. 4 (Perre excavation archive)

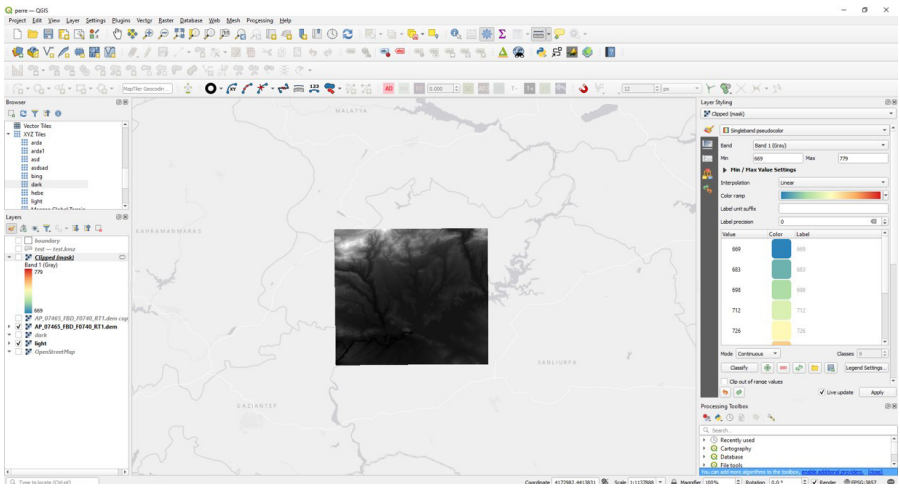

Fig 11: Analyses on the Qgis program (A. O. Karaçetin)

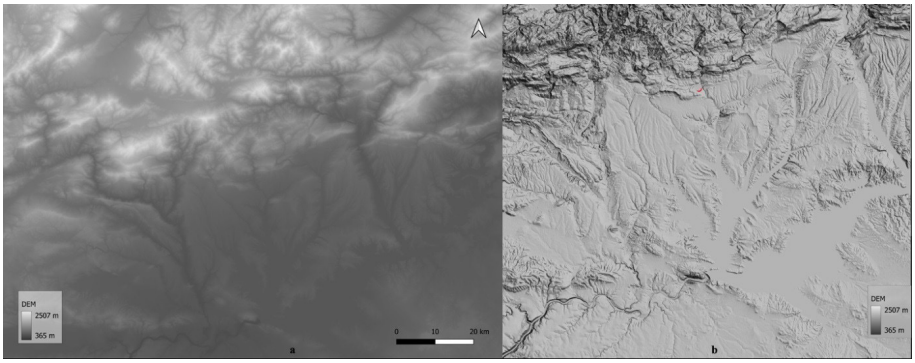

Fig. 12: a- 12m DEM data used in the analyses; **b-** relief map of the region created by using DEM data (Map A. O. Karaçetin)

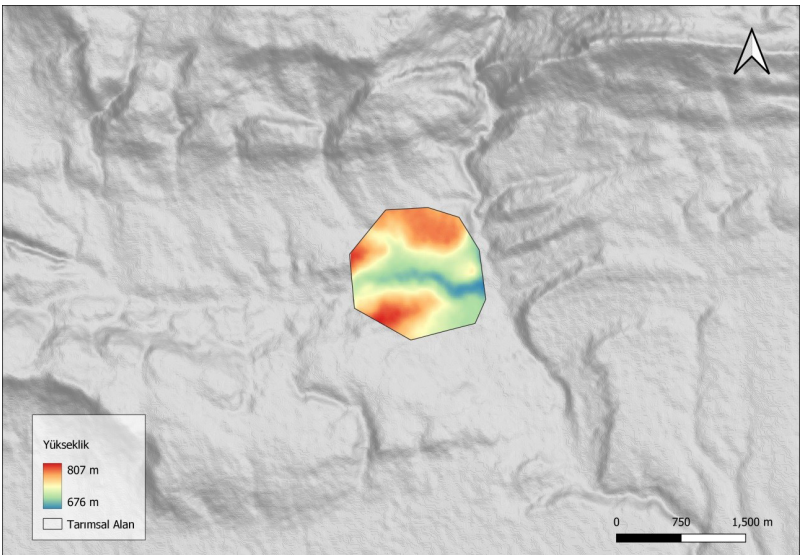

Fig. 13: Elevation analysis of the identified agricultural areas (Map: A. O. Karaçetin)

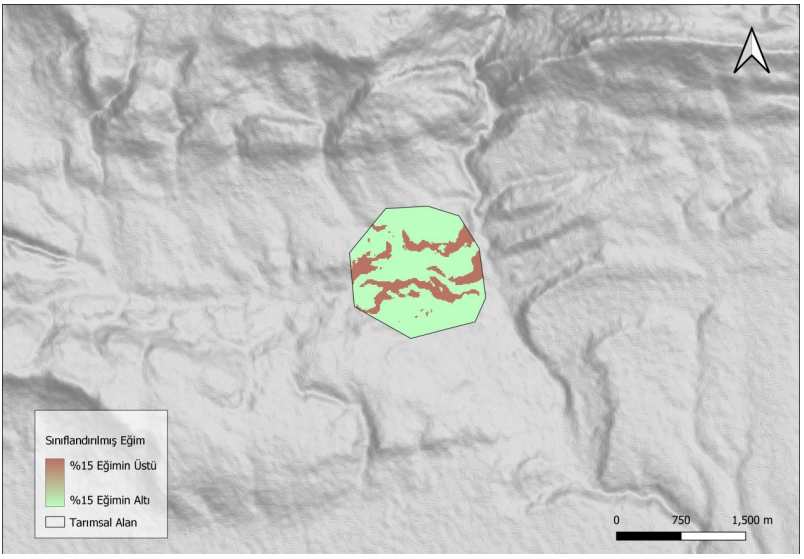

Fig. 14: Slope analysis of the identified agricultural areas (Map: A. O. Karaçetin)

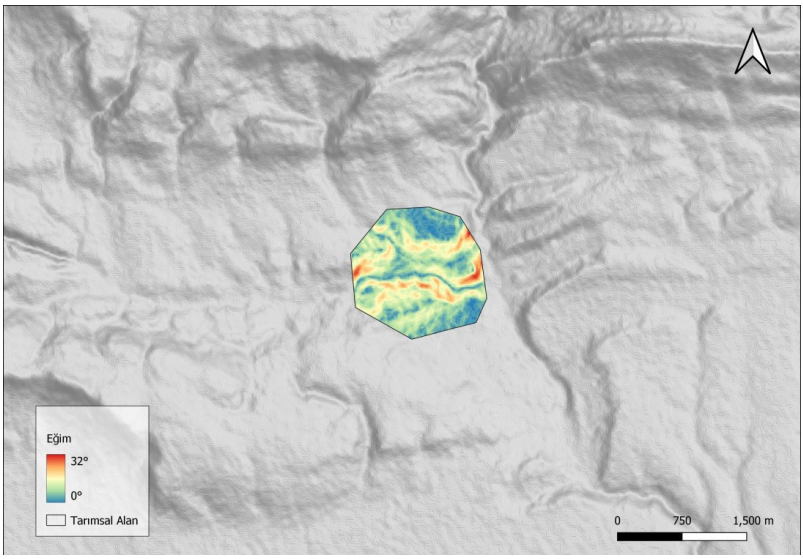

Fig. 15: Intersection analysis applied to the identified agricultural areas (Harita: A.O. Karaçetin)

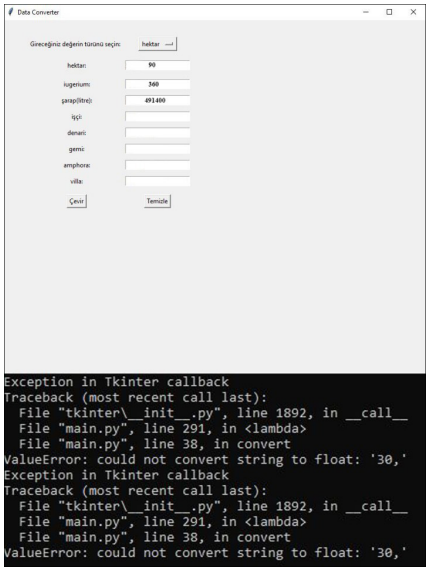

Fig. 16: Python-coded software and data calculation (A.O. Karaçetin)

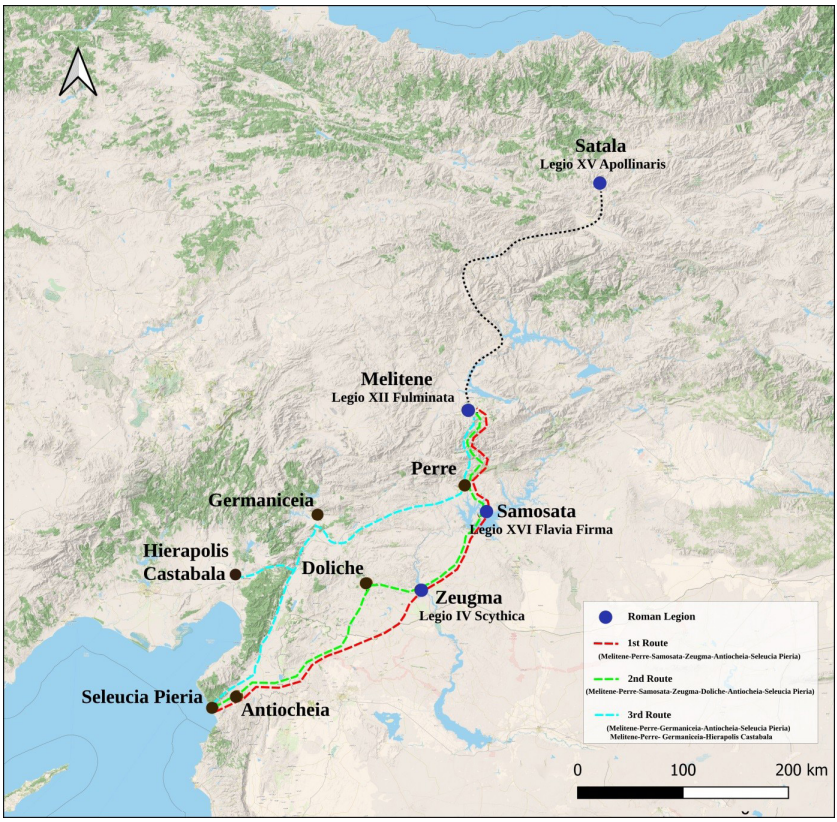

Fig. 17: Military legions along the Euphrates and possible trade routes (Map: A.O. Karaçetin)