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Historical Roots of Heritage Horticulture in the Southern Coastal Plain of Israel

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Abstract: This study reconstructs the agricultural landscape of the southern coastal plain of late Ottoman and British Mandatory Palestine (today southwestern Israel) utilizing late 19th and early 20th century cartographic materials and aerial photographs. Immense human effort and ingenuity were required to maintain sustainable agricultural on the fringes of the desert. Given today's increasingly severe climate crisis, the lessons drawn from these historical agricultural practices have particular resonance. The agricultural land use described in this work extended into the coastal dunes of the region where the shallow water table was exploited to create complex agricultural systems that enabled the growth of citrus trees, grapes, and other crops for export and trade. Aerial photos and maps reveal the critical aspects of this region's neglected agricultural history. The stability and resilience of these systems, some of which are still in existence 76 years or more after they were abandoned, as seen in the survey conducted for this study, point to the importance of understanding and preserving this chapter of the region's agricultural heritage. The unique varieties of fruit trees adapted to the local climate of the western Negev still have significant economic value and are threatened with extinction from rapid urban encroachment. The remnants of this tradition serve as historical testimony of a bygone agricultural era which was replaced by mechanized monoculture. The discussion centers on the ways n which the study of heritage agriculture in rapidly changing areas can contribute to the broader field of historical geography by reconstructing landscapes that preserve the knowledge and societal patterns of behavior of past communities for future generations.

Keywords: late Ottoman and Mandatory Palestine; traditional agriculture; expansion of agricultural production; population growth; dunes

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1. Introduction

The southern coastal plain of present-day Israel (Figure 1) is historically known for its sustainable dryland horticulture [1–4]. Local dryland farmers have adeptly blended a pragmatic understanding of effective water management and soil improvement techniques to raise hardy, drought-resistant landrace crops whose consistent robust yields are vital to farmers' survival in these unforgiving environments. A field survey conducted between 2021 and 2023 in the framework of this study revealed that the region still hosts hundreds of relic fruit trees which survive in feral conditions in assorted plots. These heritage orchards, which can provide profound insights into their centuries of resilience, remain insufficiently explored. Since the 1948 War, the region has undergone tremendous development and landscape change which, as time goes by, impedes our ability to reconstruct its history and

preserve what is left of its agricultural heritage for future generations. The endangered status of many ancient trees inspired us to research and record their historical locations. This helps us to better understand how horticulture in drought-prone rural areas of the ancient Mediterranean basin has influenced previous societies and local land use. Over the last few decades, studies have confirmed that this type of research can contribute enormously to conservation and heritage planning by establishing benchmarks for preservation and restoration [5,6].

Figure 1. The study area (delineated by the red polygon) extending from present-day Netiv Ha-'Asara to Ashdod along the southern coastal region of Israel. The red circles indicate 21st century settlements (~15 settlements labelled in black on a white background, within the research area and environs). The pre-1948 settlements (late Ottoman-British mandate period) are labelled in white with yellow backgrounds (10 settlements within the research area).

Old cartographic materials and aerial photos can be used to reconstruct the drastic changes that occurred in the agricultural landscape of the southern coastal plain of Israel during the late Ottoman and British Mandatory periods. This study charts the historical origins of agricultural systems in this area mainly by using historical maps and aerial photos produced from the early-19th to the mid-20th centuries. We conducted a historical-geographical examination of the agricultural production of orchards, cultivations, and plantations in Israel's southern coastal plain that constituted the agricultural hinterland of several Palestinian villages prior to 1948 (Figure 1). This region is characterized by a unique combination of a semi-arid Mediterranean climate and a harsh, arid Sahara-Arabian topography. The spatiotemporal analysis of the evolution of the region

using historical GIS (geographic information systems) made it possible to examine old cartographic material [7–9] and characterize its historical transitions through the lens of modern techniques in geography.

To sustain agriculture on the fringes of the desert, much human effort and resourcefulness were needed, and farmers faced constant struggles. As shown below, from the early 1870s to the mid-1940s, the population of the region grew fivefold or more, and the cultivated area increased by over eightfold. This was due to a combination of several factors, including better sanitation conditions, new technologies such as pumping engines which made it possible to dig deeper wells and shunt water to more remote fields, the higher demand for agricultural products, better means of transportation which enabled farmers to sell their products in distant urban markets, and the dismantling of communal holdings which were an obstacle to more effective agricultural cultivation.

As part of this process, agriculture could spread far beyond the immediate vicinity of the villages into the dunes by exploiting the shallow water table. The expansion of the parcels enabled the cultivation of citrus, grapes, and other crops for export and trade. By combining a series of aerial photos and maps, we capture a major component of this bygone arid agriculture, which gave way after the 1948 War to industrialized modern monoculture agriculture. Given today's severe climate crisis, important lessons can be learned from the experiences of the agriculturalists in this region.

Understanding the uniqueness of the agricultural heritage of Israel's southern coastal plain prior to 1948 also contributes to efforts to preserve its remnants in the face of rapid development and construction. It can serve as a basis for comparative research on other agricultural systems located in arid environments at the fringe of the desert, an issue with vast implications in light of global warming and the impending climate crisis.

2. Historical Background

During the late Ottoman and British Mandatory periods, Palestine's southern coastal plain to the north of the city of Gaza was populated by dozens of relatively small- to medium-sized villages, mostly built of mud bricks [10,11], whose primary source of subsistence was orchards of various kinds, grain farming, and vegetable plots [12–16]. The western part of the region, not far from the Mediterranean coast, consisted of sand dunes with no permanent settlement activity but was occasionally frequented by shepherds and foraging gatherers from nearby communities and semi-nomadic Bedouins. Towards the end of the Ottoman period, and much more so during the British Mandate, agriculture gradually expanded toward the dunes surrounding the villages and moved westwards towards the coast by penetrating them [17–20]. This is likely to have been a response to the rapid growth of the rural population in the region, the growing demand for products, improvement in means of transportation that allowed farmers to market their products in more distant localities via the train that passed through the region and the Gaza–Jaffa road which was upgraded, the introduction of new technologies such as pumping engines which made it possible to dig deeper wells and distribute water to the fields, and efforts on the part of the British to dismantle communal village land holdings (*musha'*), which undermined production, and encourage individual holders instead to register the land in their own names [21]. The latter policy, which dates back to the Ottoman Land Law of 1858, had only limited success by the end of the Ottoman period but was pushed forward by the Mandate authorities during their almost three decades of rule and led to a dramatic decrease in communal land holding. A recent study of the village of Hamama indicates that land registration was completed in this village by the British authorities already by the end of the 1920s [22]. In other localities in the region, the effort continued until the mid-1940s.

During the Ottoman and Mandatory periods, three main agricultural systems were implemented to achieve food security in Palestine's southern coastal plain on the fringes of the desert where it meets the Mediterranean Sea (Figure 2). The first system, known in Hebrew as *Bustan* (plural *Bustanim*) or "irrigated orchards", typically consisted of plantations of fruit trees, including various kinds of citrus fruit, dates, mulberries, plums, guava, and quince, in addition to seasonal vegetables and herbs. The region still contains numerous remnants of its horticulture infrastructure, such as large wells, clay water channels, and irrigation installations which radiate from the well to the trees, and seasonal vegetable patches, the remains of pumps, as well as numerous fruit trees that have survived despite years of neglect. The second agricultural system consisted of the small-scale cultivation of fruits and vegetables in certain areas in the dunes near the sea where, by constantly removing accumulating sands covering the ground, the high-water table could be accessed [23]. The cultivation of land amid the dunes was called *Mawasi*, an ancient method in this area [1,24]. *Mawasi* farming was commonplace from the southern coastal plain of Israel to Gaza and present-day northern Sinai, where it is used to grow fruit trees, vines, and vegetables [3,25]. The third system consisted of non-irrigated dryland rain-fed farming (in Hebrew, *Ba'al*) which was limited primarily to grains and vegetables during the winter months, as well as plantations that can survive without watering during the summer, except for in the first years after planting, when their roots have not yet gone deep enough into the ground (for instance, olives, grapes, almonds, pomegranates, and figs).

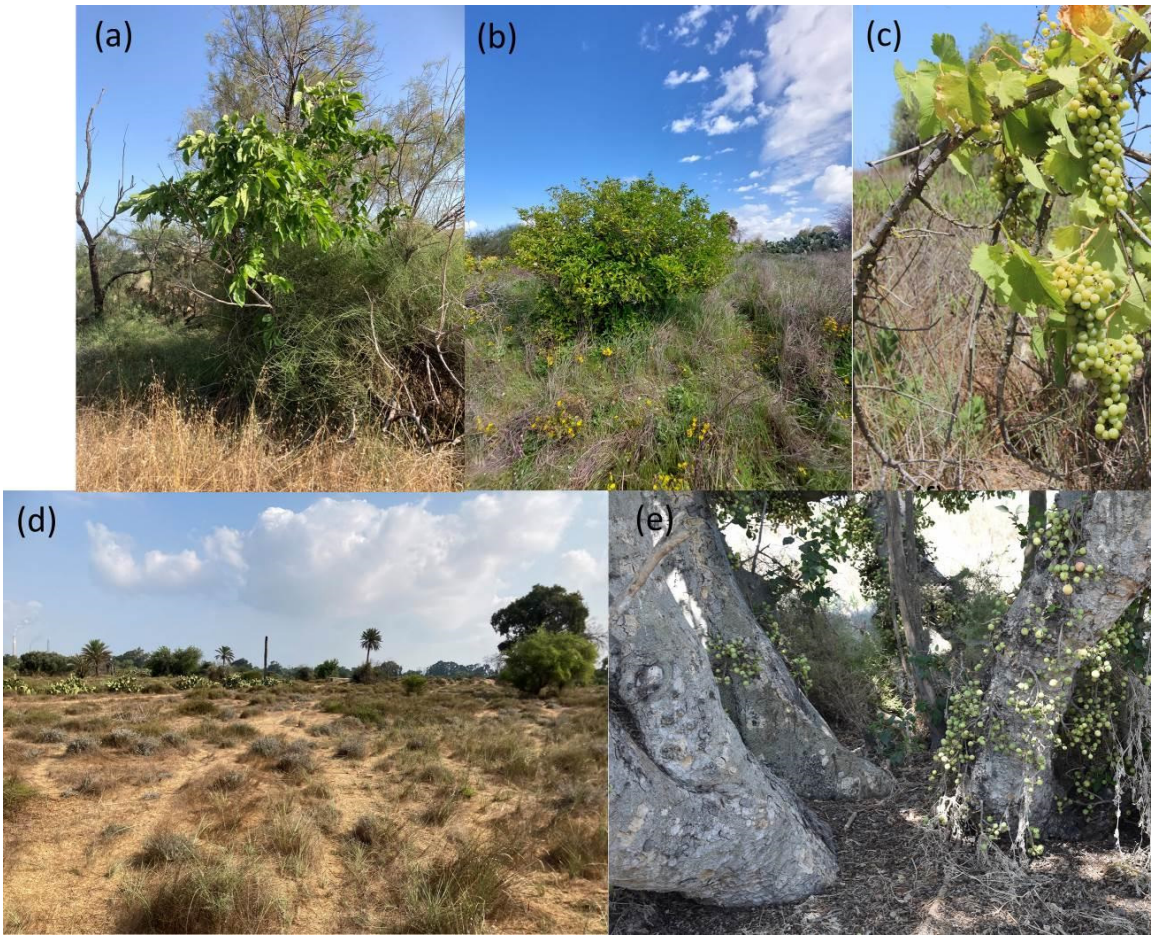


Figure 2. Present-day vegetation in the research area: (**a**) mulberry (*Morus*) and Ephedra (*Ephedra foeminea*) near Kibbutz Gvaram; (**b**) Mushki orange trees in irrigated orchards in the Karmiya reserve; (**c**) traditional dabouki grapes (*Vitis vinifera*); (**d**) irrigated orchards in the Karmiya reserve; (**e**) sycamores (*Ficus sycomorus*).

During the 1948 War, most of Gaza's rural hinterland was destroyed and evacuated, and its residents became refugees in the newly created Gaza Strip [26,27]. Whereas the *Mawasi* irrigation systems near the sea were abandoned and neglected after 1948 and became part of several national parks, the vast agricultural fields more inland to the east were given by the government to collective communities (*Moshavim* and *Kibbutzim*), which continued to cultivate them. Over the next few decades, they were gradually replaced with modern cash crops. This intensive agriculture replaced the dryland and irrigated fields and was based on market demand (e.g., various kinds of citrus, mango, and avocado). This led to the gradual destruction of the historical orchards and plantations with their unique in situ landrace fruit tree cultivars. However, remnants of these trees and vines have survived to this day on the fringes of their original fields or in isolated pockets, decades after they were abandoned. A survey conducted in the framework of this study revealed that many of these remnants can still be found in and around the dunes of the Nitzanim, Karmiya, and Ziqim nature reserves. These old heirloom fruit trees have powerful symbolic importance as living testimony of their endurance and sustainability despite the harsh conditions of their environment.

3. The Research Area

This study focused on Israel's southern coastal plain that extends from the ruins of the Palestinian villages of Isdud (east of the current-day large city of Ashdod) in the north and Dayr Sunayd in the south (next to current-day Kibbutz Erez on the border of the Gaza Strip) (see Figure 1 for settlement details). Within this region, eight other villages existed prior to 1948: Hamama, al-Majdal, al-Jura, Ni'ilia, Barbara, Hirbiya, Bayt Jirja, and al-Jiyya, in addition to one Jewish *Kibbutz*, Yad Mordechai (established in 1943) [26–28]. A large portion of this region is made up of sand dunes that are characteristic of the southern coastal plain and serve as a unique land corridor, where the northeast extension of the Saharo-Arabian sand dunes meets Mediterranean geography [23]. This area is considered a semi-arid climatic zone despite its relatively high level of precipitation (a mean annual precipitation of ~450 mm/year and aridity index < 0.10) [29]. This is due to the type of sand grains found there, which permit water to rapidly trickle down, alongside high exposure to the sun, and the lack of vegetation coverage which further dries the soil. This microhabitat blends into the surrounding traditional cultural landscape of the southern coastal plain and today hosts several unique heritage cultivars.

4. Input Data

Old cartographic material, such as maps, drawings, photographs, and aerial photographs, is extremely important for reconstructing past landscape, and can contribute to resolving historical enigmas [9,30–33]. The period examined here ranged from the late Ottoman to British mandate periods, i.e., roughly between the first half of the 19th and the mid-20th century (~150 years). The landscape reconstruction was based mainly on maps from Ottoman and British Mandatory Palestine along with aerial photographs taken towards the end of World War II. The maps used to extract evidence of the agricultural and cultivated areas are listed in Table 1. We started with a map prepared by the French cartographer Pierre Jacotin who surveyed the region in 1799 [34]. We ended with the Palestine 1:20,000 map revised in 1946 by the Survey of Palestine [20]. The maps were curated from several repositories, including the map collection at the Department of Geography at the Hebrew University of Jerusalem, the Laor collection at the National Library of Israel, and the collection at the University of Haifa Library.

Apart from the Palestine Exploration Fund (PEF) map that was georeferenced and stitched by Levin (see [35] for the complete process of map registration), the remainder of

the maps (Table 1) were georeferenced to the Israel Transverse Mercator (ITM) Coordinate Reference System (CRS) [36]. This CRS was chosen because the study area is relatively small (~144.2 square kms, Figure 1), and it has the advantage of working in decimal units. As control points (CPs), we used geographic features such as the crossroads, monuments, river morphology, and settlements that appeared on each map. The equivalent locations on the PEF map and a 2018 orthophoto were utilized as the targets (referenced locations). The CPs were digitized and pinpointed within a scale of less than 1:3000 to avoid spatial errors or biases (Figure 3) [37].

The second important visual source was aerial photos. We used a dataset of aerial photographs taken in January 1945 and housed in the Department of Geography at the Hebrew University of Jerusalem [38]. Strips of the aerial photos were downloaded and matched to the existing settlements at the time and georeferenced to the ITM CRS. We also used census data for the population and household estimates extracted from the Palestine Exploration Fund (PEF) survey [32], records from the Ottoman census of 1905 [13], and the British censuses of 1922 and 1931 [14,15].

Table 1. List of maps used and notes on their accuracy and characteristics.

Map	Details and Characteristics
Jacotin 1799 [34]	The map was validated by Karmon [39]. He noted that the map mainly corresponded to roads used by French army ("The coast was only drawn correctly where a road ran along it"). The map was drawn almost 20 years after the survey was carried out. Since some of the place names were lost, settlements were often only noted as "village". Thus, although this map is the first trigonometric map of Palestine, large portions of the country, including the coastal region south of Isdud, are not accurately represented.
PEF 1871-7 [17]	The sheets of the PEF map were georeferenced, stitched together and validated by Levin in 2006 [35]). The root mean square error (RMSE) was evaluated to be 74.1 m, which in the worst case is roughly 0.81 mm on the map scale, thus corresponding to an accuracy that is consistent with modern maps.
1918 [40]	This map is a provisional publication of various editions based on a field survey conducted in September 1918 by the Survey of Palestine after WWI. The scale of the map is 1:40,000 and it contains 29 sheets covering Mandatory Palestine. The area under investigation contains the sheets for Megdel, Felugeh, and Yebnah stitched together for the purpose of the analysis.
1931 [41]	Surveyed in 1925 by the Survey of Palestine. Drawn and printed at the Survey Office. The map is provisional and is part of Palestine, 1:20,000, Topocadastral 7-7 map. We georeferenced and stitched together the sheets of Hamame, Ashkelon, el-Majdal, and Beit Hanun.
1936 [19]	Mapped at a scale of 1:100,000 by the Survey of Palestine after a plane table survey conducted in 1933-34. The contours of the map were adopted from military surveys made in 1918. The map contains 14 sheets extending from the northern Negev to northern Galilee. We used sheets 7 (Jaffa) and 9 (Gaza).
1946 [20]	Palestine map, 1:20,000 scale, based on the 1931 map [41], with revisions made by the authors (Mobile Ech. 512 Fd. Survey Coy., R.E. Drawn and printed at the Survey Office in 1946 and once again in 1951 by the new Mapping Department of Israel). The CRS of the map is based on the Cassini–Soldner projection ("Old Israel").
1947 [42]	The Ashkelon sheet of the 1947 Survey of Palestine map at a scale of 1:20,000. It is part of the detailed topo-cadastral map that was reproduced and reprinted based on a map by the Survey of Palestine from May 1941. The map was edited by the Keren Kayemet of Israel. It presents a detailed cadastral mapping of parcels in the vicinity of Askelon (al-Majdal).

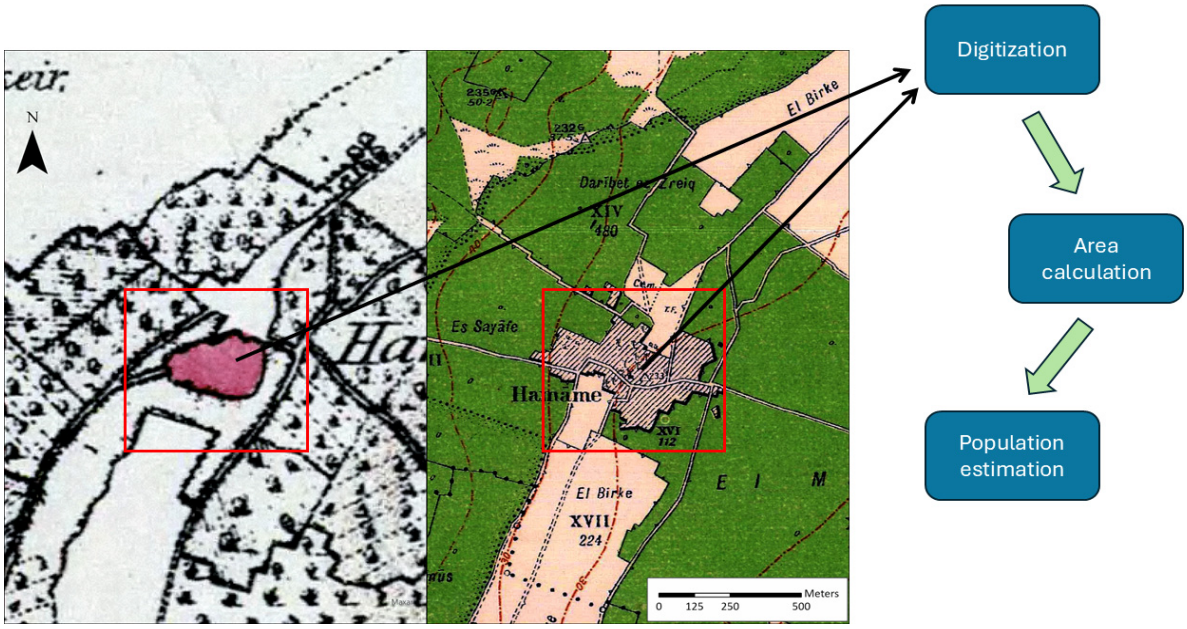


Figure 3. Examples of the shapes and structures of settlements depicted in old maps that were used for population estimates by area calculation (following the method presented in [32]); e.g., the village of Hamama, illustrating the differences between a map produced in 1871–7 (**left**) [17] and a map produced in 1931 (**right**) [41].

5. Methodology

To better characterize changes in the landscape, as well as the agricultural evolution of the research area, the population and cultivated areas (whether irrigated orchards, *Mawasi*, or dryland cultivation) of 10 villages in the region were estimated (Figure 1). Censuses are good sources for population assessments and at times also indicate the area of built and cultivated regions. Consistent, comprehensive censuses have been available since the beginning of the 20th century. The registers of the 1905 Ottoman census were recently analyzed by a research team led by Prof. Johann Buessow from Ruhr Universität Bochum, Germany. These registers are housed today in the Israel State Archives (ISA) in Jerusalem and are available online [43]. This census was the most accurate and extensive ever conducted and encompassed all household members, including women and children, unlike previous censuses that mainly concentrated on tax-paying men. After the British occupation of Palestine, they conducted two massive censuses in 1922 [15] and in 1931 [14]. These censuses included accurate detailed assessments of the population in each settlement, unlike the pre-20th century population estimates.

To correct for the lack of accurate census reports from the second half of the 19th century, we used household counting instead. In these cases, a population coefficient per household is needed to convert the household count into a population assessment—that is, how many people were living in a single household [44]. Consistent with previous studies, the value of this coefficient during the Ottoman period ranged from four [45] to seven [46], whereas during the British Mandate period, it was around six, as estimated in the survey conducted in 1944, which had a coefficient of 6.1 [16]. By using the ratio of the population to the number of households for the 10 villages examined based on Mills' reliable census, an average ratio of 4.78 was obtained (minimum: 3.93, maximum: 6.49) [14] Therefore, taking these estimates into consideration, we decided to use a coefficient of five people per household to extrapolate the population of each village in cases where no population assessment was available and where we only had records of the number of households.

Whenever household counting was not available, we used the geometric shapes of polygonal settlements portrayed on historical maps to obtain a rough estimate of the population size [32]. After the georeferencing and accuracy validation, the features denoting the built areas, vegetation, and traditional agriculture were digitized and extracted from the maps and stored in the GIS-based framework of the ESRI ArcGIS Pro (Version 3.3) software. The settlement areas were digitalized in high precision (scale < 1:3000) along the margins of the settlements to extract their area in square meters (Figure 3). A similar georeferencing process was applied to the aerial photographs to obtain a qualitative verification of the landscapes and agricultural parcels appearing on the maps and a cross-correlation of the expansion of vegetation during the period examined (~1800 to ~1945). The complete dataset is listed in Table 2.

Table 2. Assessments and census data for population and agriculture in the study area: **H**—households; **P**—population, **BA**—built area (*Dunam*); **Or**—orchards; **Ga**—green areas; **Ot**—other; **NCL**—non-cultivated land (*Dunam*); **CIBN**—citrus and banana; **PLIR**—plantation and irrigable land; **CR**—cereals.

Village	~1875 [1]							~1905 [2]		~1920 [3]		~1935 [4]			1945 [5]					
	H	P	BA	Or	Vn	Ga	Ot	H	P	P	BA	H	P	BA	P	BA	NCL	CIBN	PLIR	CR
Isdud	331	1001	84	308	-	1278	-	333	1831	2566	127	764	3140	196	4910	131	12,374	3277	8327	23,762
Hamama	291	610	55					470	2585	2731	76	865	3405	171	5070	167	6494	1356	4459	28,890
al-Majdal	2143	1500	181					921	5065	5097	232	1526	6398	265	9910	1346	1629	2377	2886	35,442
al-Jura	109	577	53	93.4	-	342	64.8	212	1166	1326	51	396	1754	69	2420	45	1535	481	7198	2965
Ni'ilya	37	312	31					75	412	687	40	169	863	35	1310	29	649	1084	1436	2215
Barbara	112	613	55					202	1111	1369	68	318	1546	100	2410	70	1209	132	2952	9615
Hirbiya	58	637	57	25.5	585	339	121	83	456	1037	38	234	1520	48	2300	92	6170	2765	6106	7179
Dayr Sunayd	51	336	33				70.2			356	19	103	475	21	730	13	535	158	512	4863
Bayt-Jirja	32	307	31							397	39	115	619	34	940	25	377	532	636	6911
al-Jiyya	39	268	27					106	583	776	37	188	889	62	1230	45	242	189	26	8004
Total	3203	6161	607	4513	585	13,073	2215	2402	13,209	16,342	727	4678	20,609	1001	31,230	1963	31,214	12,351	34,538	129,846

[1] The data on households (H) are based on the estimates made by Grossman [44] (pp. 238-257). The record of al-Majdal summarizes the estimations of al-Majdal (urban, 1478) and al-Majdal (rural, 665). The population (P) and built area (BA) are based on Zohar [32] after the PEF survey [10]; [2] references to the records are located in Pagis [13]. Specific records of Nüfus registers concerning the number of households are provided by Johann Buessow [personal communication, based on an ERC project "Late Ottoman Palestinians"]. For Dayr Sunayd and Bayt Jirja, Buessow comments: "No regular population register is available. There is only a birth register (Reg. 256, 1906–1913)." The population (P) was calculated using an extrapolation from the number of households based on a coefficient of 5.5 persons per household (see explanation in the text); [3] population (P) values were obtained from Barron [15], built area (BA) was obtained from the 1918 maps of the Survey of Egypt [40,47]; [4] Population assessments (P) are after Mills [14] while the area is based on GIS extraction from Salmon [19]. The record of al-Majdal households (H) summarizes the estimates of al-Majdal (urban, 1489) and al-Majdal (rural, 37), while the record of al-Majdal population (P) summarizes the estimates of al-Majdal (urban, 6226) and al-Majdal (rural, 172). The built areas are based on GIS extraction from the Survey of Palestine maps, 1935–1936 [19]; [5] the data in columns P, BA, NCL, CIBN, PLIR, and CR are based on [16].

6. Results

6.1. Agricultural Development as Reflected in Historical Maps

The European empires' growing interest in Ottoman Palestine [48,49] also led to an increase in the number and quality of the maps of the region [50,51]. They show such key features as cultivated fields, palms, citrus/sycamores, sand dunes, roads, and villages. The agricultural areas near villages are portrayed, but no clear indication of *Mawasi* parcels is indicated, although in some areas, the presence of this type of agricultural practice can be inferred. A good example is the cultivation of remote fields on the northern bank of Wady al-Hasy (present day Shiqma River, see Figure 1), despite the relative remoteness from populated villages. Later maps, such as [52], depict existing settlements but lack details on agriculture at the time.

Probably the first detailed map containing an accurate mapping of agricultural regions was the PEF map published in 1880 that was based on a British survey of Palestine conducted in 1871–1877 (Table 1). The map's 26 sheets [17] were produced and accompanied by a geographic and demographic corpus of the information surveyed [10]. The map delineates agricultural areas, including orchards, vines, woods, and garden parcels along with sand dunes, water resources, and roads. Most of the agricultural areas were concentrated near the 10 villages in the region, but, since some of them were relatively close to each other (e.g., Hamama and al-Majdal), the cultivated regions cannot be attributed to a specific village. Much of the study area consisted of sand dunes, but some cultivated parcels were mapped within the dunes that may have been associated with *Mawasi* agriculture [25]. Indications can be seen south of al-Jura and west of Hirbiya where many boreholes were also present (Figure 4b). Altogether, the total areas of orchards, vines, gardens, and other land uses within the entire study area portrayed in the PEF map amounted to 4513, 585, 13,003 and 2215 *Dunam*s, respectively (a metric *Dunam* equals 1000 square meters, whereas the size of an Ottoman *Dönüm* was 0.9193 metric *Dunam*s (1/11 hectares, 0.227 acre).

The British map of Palestine drawn by the Survey of Egypt in 1918 [51] is much more detailed than the PEF map and testifies to British surveying efforts in the region before WWI, as well as to their attempts to exercise sovereignty after taking control of southern Palestine in the fall of 1917. The map portrays several significant features (Figure 4c). In the north, a prominent strip of vegetation stretches from Isdud to Hamama, clearly denoting the border between the sand dunes in the west and the cultivated regions in the east. This strip was hardly portrayed at all on the PEF map (where instead there is a road) and clearly appears on the 1918 map, which shows that it ranged in width from 150 to 350 m (Figure 4c,d). This strip still exists today and may have been artificially cultivated at the time to block the accumulation of sand blown by the westerly winds from the sea. In the center of the region, between the villages of Hamama, al-Majdal, and al-Jura, the map shows vineyards in the dunes surrounding these villages. The green symbols indicate vegetation and are located approximately 1 km into the sand dunes west of Hamama and al-Majdal. In the dunes north of Hamama, no agricultural regions were mapped. In the south, agricultural areas are indicated around Barbara, Hirbiya, and Dayr Sunayd, mostly in and around the flood plain of Wadi al-Hasy (Figure 4c). The cultivated fields in this map appear to be irrigated with no indication of *Mawasi*.

The trend in the 1918 map towards agricultural expansion into the sand dunes in the vicinity of al-Jura, al-Majdal, and Hamama further intensified in the 1930s. The Survey of Palestine map [41] shows a massive expansion in that region and farther to the north into the dunes between Hamama and Isdud (Figure 4a). There are isolated agricultural parcels labeled "O" and "V", denoting orchards and vines. This agricultural growth extended practically up to the coastal region, which suggests that the residents of the surrounding villages were able to successfully set up a water supply for a larger region deep into the dunes. The vegetation line between Hamama and Isdud delineating the sand dunes from the east can clearly be seen on the map and seems much broader than on the 1918 map, perhaps indicating the expansion of cultivation east of the dunes that required additional protection. Similar agricultural parcels, perhaps denoting *Mawasi*-like cultivation, also appear in the region north of Hirbya and west of Barbara. It is hard to determine whether these were indeed *Mawasi*, but in any case, during the first years of cultivation, the trees planted there were irrigated until the roots penetrated 1–2 m into the soil.

Towards the end of the 1920s-early 1930s, the expansion of agricultural regions progressed deeper into the dunes, into regions that had yet to be cultivated. The 1931 [41] map shows cultivated regions west and north of Hamama and south of al-Jura and Barbara

into the dunes (Figure 4d). It is not clear from the legend or symbology whether these are indeed *Mawasi* parcels or dryland cultivation. The 1931 map is topo-cadastral and was carried out to delineate parcels and determine ownership. Since it was produced by the Survey of Palestine, which is considered highly reliable and professional, the mapping of parcels of cultivation is likely to be fairly accurate. It confirms the massive expansion of agricultural regions beyond the immediate proximity of the villages and deep penetration into the dunes even in remote areas such as north of the al-Ibtah dry riverbed (which still has the same name today).

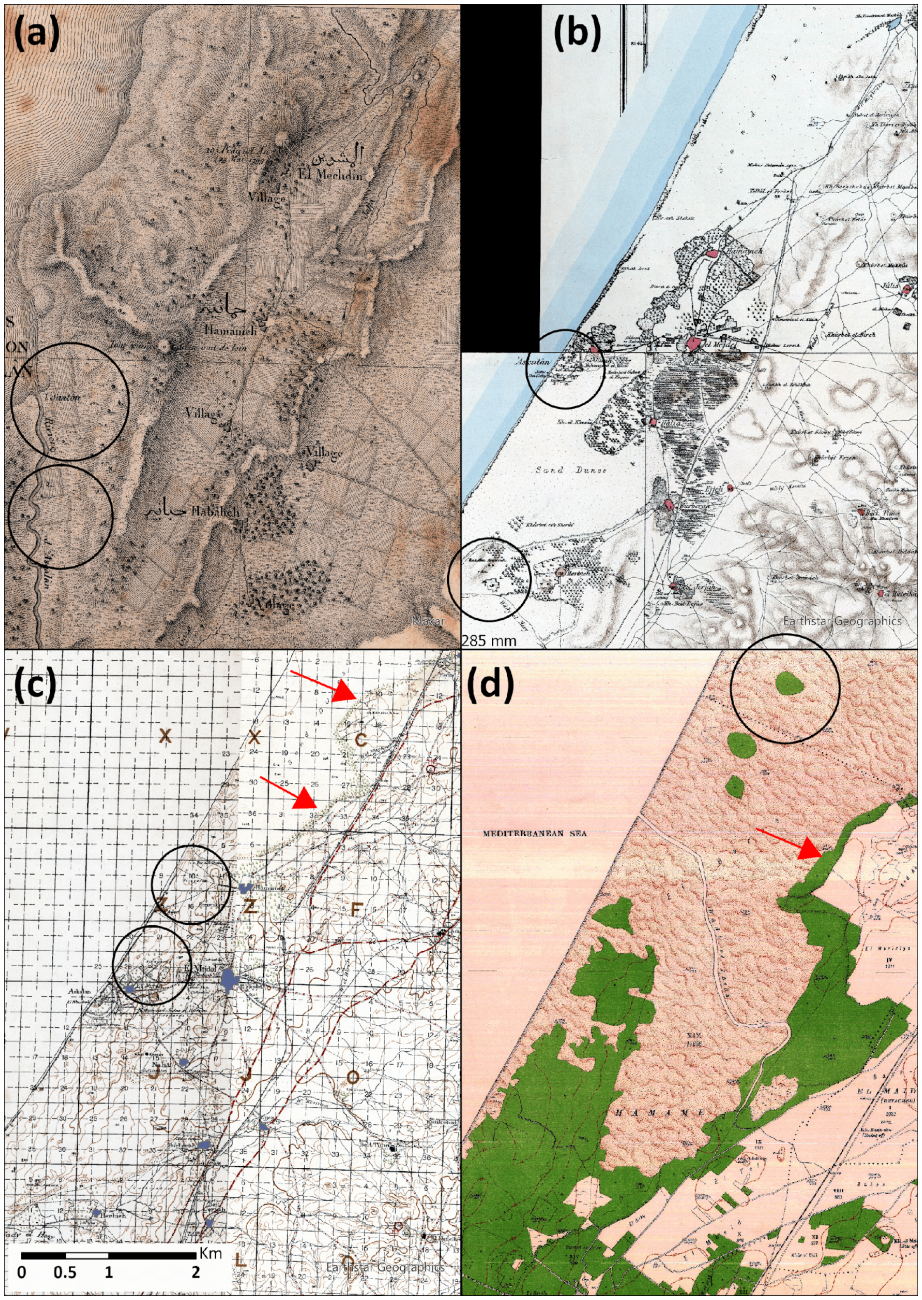


Figure 4. The region of al-Majdal and its surroundings during the 19th and the first half of the 20th centuries: (**a**) early 19th century [34]. Note the agricultural fields north of the al-Hasy river, which are suggestive of *Mawasi* parcels; (**b**) clustered cultivation around the villages in 1871–1877 [17]; (**c**) agricultural parcels close to the coast (black circles) denoting the beginning of agriculture in the dunes in 1918 after World War I [40]; (**d**) the expansion of cultivation into the dunes denoting potential *Mawasi* parcels in 1931 [41]. Note the strip of vegetation, probably sycamores, extending from Isdud to Hamama (red arrows, sub-figures (**c**,**d**)).

This trend continued from the mid-1930s onwards and resulted in tremendous changes in the regional landscape. In the 1936 Survey of Palestine map [19], much of the region north of Hamama to Isdud is cultivated (Figure 5a). Although the scale of the map is relatively large (1:100,000), dots representing scrub within the sand dunes and cultivated areas are portrayed north of al-Ibtah River up to Hamama and throughout the region between Hirbiya and al-Jura. There is also a massive expansion of agricultural areas surrounding the villages, including parcels of vines, olives, gardens (probably irrigated and used to grow vegetables), and citrus (also irrigated). The areas around the two dry riverbeds, the al-Hasy and al-Ibtah, were apparently also being cultivated to take advantage of the high level of groundwater and the existence of numerous wells. Overall, this constituted a major transition in the agricultural landscape during the 1930s.

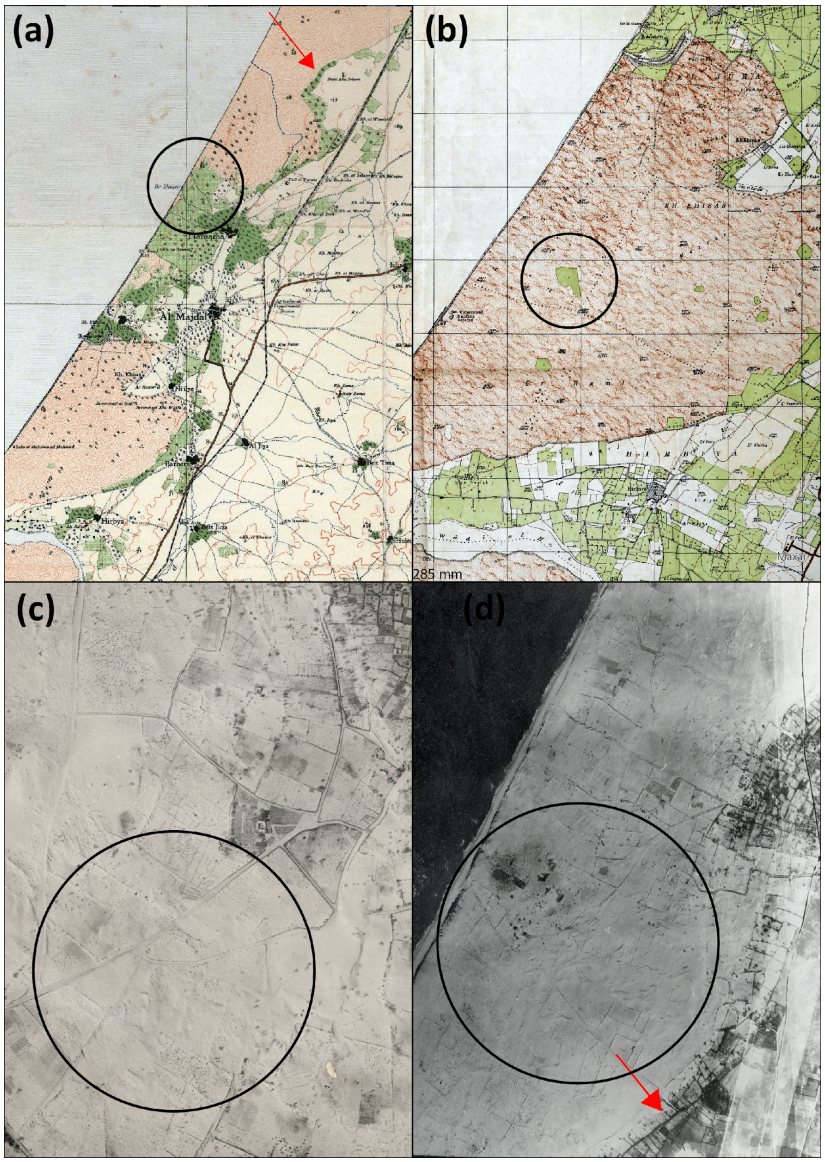


Figure 5. (**a**) Mid-1930s. The beginning of expansion into the dunes north of Hamama and south of al-Jura. Note the green polygons indicating vegetation but also the symbols showing cultivated areas within the dunes [19]; (**b**) mid-1940s, with cultivated areas deep into the dunes between al-Jura and Hirbiya [20]; (**c**) British aerial photo from 1945 capturing the large agricultural parcels south of al-Jura [53]; (**d**) the region north of Wadi al-Ibtah and east of Isdud. Note the black circle marking the vast *Mawasi* agriculture and the red arrow pointing to the strip of vegetation between Isdud and Hamama bordering the dunes [54]. Note the strip of vegetation marking the transition region between the sand dunes and the agricultural regions south of Isdud (red arrow, sub-figure (**d**)).

In the 1940s, the agriculture of the villages extended far beyond the Ottoman borders of the villages and went deep into the dunes. Although the precise borders of the parcels within the dunes at the time cannot be delineated, some look like typical *Mawasi* regions, especially those close to the coast [19]. On the map, the regions south of al-Jura to Hirbiya, north of Hamama, and up to Wadi al-Ibtah and north of it (west of Isdud) reveal a massive expansion of the cultivated area all the way to the coastline. Large plots in the dunes, which previously were only sand, are marked as cultivated, with numerous vineyards and orchards (Figure 5b). This map was produced for cadastral purposes and depicts vast agricultural development, which raises the question of whether what is shown on the map indeed existed on the ground. The enormous landscape development is clearly seen in 1945 aerial photos in Figure 5c,d that show representative examples of the regions south of al-Jura and southwest of Isdud, respectively. They indicate that almost the entire area in these regions was occupied by artificial cultivation delineated by natural fence scrub crisscrossed by narrow lanes enabling human access to cultivate these parcels. The aerial photos support the depiction on the maps of a massive expansion in the 1930s and 1940s.

6.2. Population Growth

Several population assessments and censuses were conducted between the mid-19th and mid-20th centuries. In the 19th century, most of the data relied on population assessments and partial surveys conducted by the PEF delegation and others that were later reappraised [32,46,55,56]. In 1905, the Ottoman government conducted a population survey in the region, which was partially updated until the end of Ottoman rule in the region in 1917 [13]. When the British occupied Palestine, they conducted two consistent and accurate census surveys in 1922 [15] and 1931 [14]. In 1945, the British Mandate published the Survey of Villages statistics which included relatively accurate information about land ownership in Palestine, and population statistics which were based on the 1931 census with adjustments based on estimates of the population's natural growth and immigration. No other population censuses were carried out before the end of the Mandate in 1948.

The population estimates, along with estimates of agricultural regions, are presented in Table 2. Since censuses were not conducted consistently during this period, we used the area of a given village as a proxy for the population. Figure 6a shows the correlation between the logarithm of the village area and the population. This correlation was high (R^2 = 0.74, significant), suggesting that a rough population assessment can be based on the area digitized from the historical maps. Thus, for villages with no census records, we extracted village polygons from a given historical map and used their area as proxies for the population (see also the process described in [32]).

Population growth between the mid-19th and mid-20th centuries is presented in Figure 6. The population growth rates were calculated based on census records and map-based assessments. The village with the highest growth rate was al-Majdal (Figure 6b). According to Amiran and Shahar [55], during the Mandate period, it was an urban area. In terms of population of the largest villages, al-Majdal, Hamama, and Isdud had the highest growth rates. Of the three smallest villages, al-Jura had the highest growth rate, followed by Ni'ilia and al-Jiya. Interestingly, the villages with the highest growth rate are those surrounded by expanding cultivated areas such as al-Majdal, Hamama, al-Jura and Isdud (Figure 5b–d). Altogether, the population grew from ~6000 in ~1875 to ~31,000 in ~1945, an increase of more than fivefold within 70 years. Some of this phenomenal growth had to do with the better sanitation and health conditions during Mandatory rule, the decline in infant mortality, and the rise in life expectancy.

Unlike the population, the values and figures for the agricultural regions are more complex to estimate. Specifically, the changes in population size cannot be fully correlated with

agricultural development. Nevertheless, summing the total agricultural areas extracted from the PEF map and comparing them to the 1945 values indicate major changes within a brief period of less than a century from 20,993 *Dunam*s in 1871-7 to 176,735 *Dunam*s in 1945. Although these figures are only estimates, they demonstrate a substantial growth in agriculture, which is also supported by historical maps and can be seen in aerial photography.

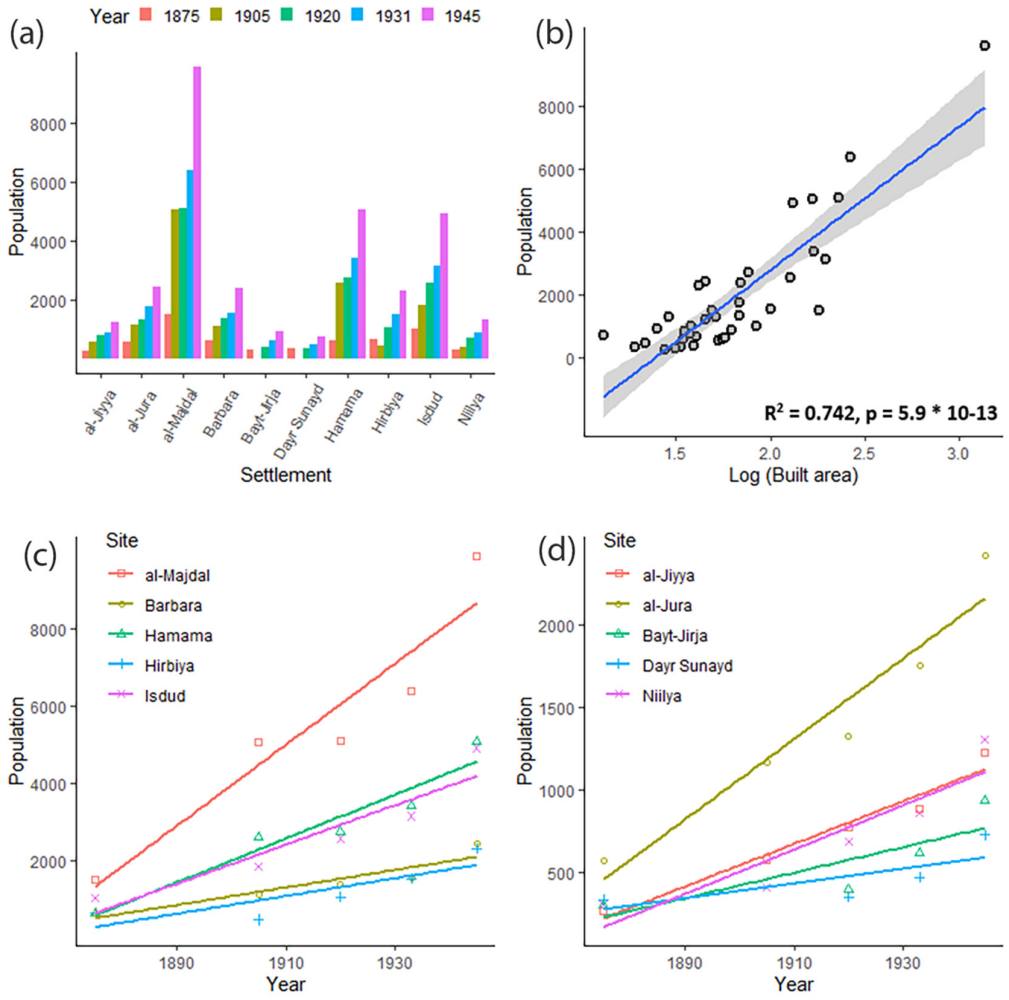


Figure 6. Population growth between the mid-19th and mid-20th centuries. (**a**) Population growth in the 10 villages; (**b**) correlations between the ratio of population size and the logarithm of the built area [32] (R^2 = 0.74, $p < 0.001$); (**c**) population growth rate in the five largest villages; (**d**) the population growth rate in the five smallest villages.

7. Discussion

The British maps and aerial photos (Figures 4 and 5) clearly demonstrate growth in agricultural areas, especially from the 1930s onwards. The number of cartographic materials depicting this growth leaves no doubt as to this trend, although one can question the level of growth. After the British takeover, in order to reorganize the area and resolve ownership rights, the Mandate authorities mapped and delineated many land parcels deep inside the dunes in locations that were probably not cultivated during the Ottoman period. A considerable proportion of this parcellation was probably cultivated, but there are large portions of land that were parceled on maps but with no traces of borders or cultivation in the field. Moreover, because of the topography and nature of the dunes, it is hard to determine the type of cultivation based on visual sources. The most reasonable speculation is that plots located close to the coastline (within 0.5–1 km) were *Mawasi*.

Several good examples can be spotted south of al-Jura and north of Hirbiya/Barbara and in the relatively large area extending from Hamama and Isdud. The extent is hard to determine from textual sources but is well-documented in the cartographic material. It is also supported by the large population growth within the relatively short period of time between the PEF survey (~1875) and the mid-20th century.

This massive expansion of agricultural areas within this short span of time raises the question of the causes for this rapid development. A recent study indicated a sharp rise in vineyard cultivation, mainly *dabouki*, in this region in the 1920s–1940s, in part in connection with the launching of a train line in the early 1920s by the British authorities that passed through this region and connected Palestine and Egypt. This allowed farmers to export their agricultural products to Egypt [4]. The line from Haifa to Qantara in Egypt had three stations in this area: al-Majdal, Dayr Sunayd, and Gaza. The daily trains allowed farmers in the region to export fresh produce to the north, as well as to Egypt, where there was a demand for products such as *dabouki* grapes [57]. The southern coastal plain of Palestine was known for the quality of its grapes, in particular *dabouki* (Figure 7) [26,27]. Another reason for the rise in demand for the region's agricultural products was the massive deployment of British forces in the region, including several large camps, especially from the mid-1930s onwards, during the time of the Great Arab Revolt in Palestine (1936–1939) and later WWII, when tens of thousands of troops were deployed to Palestine.

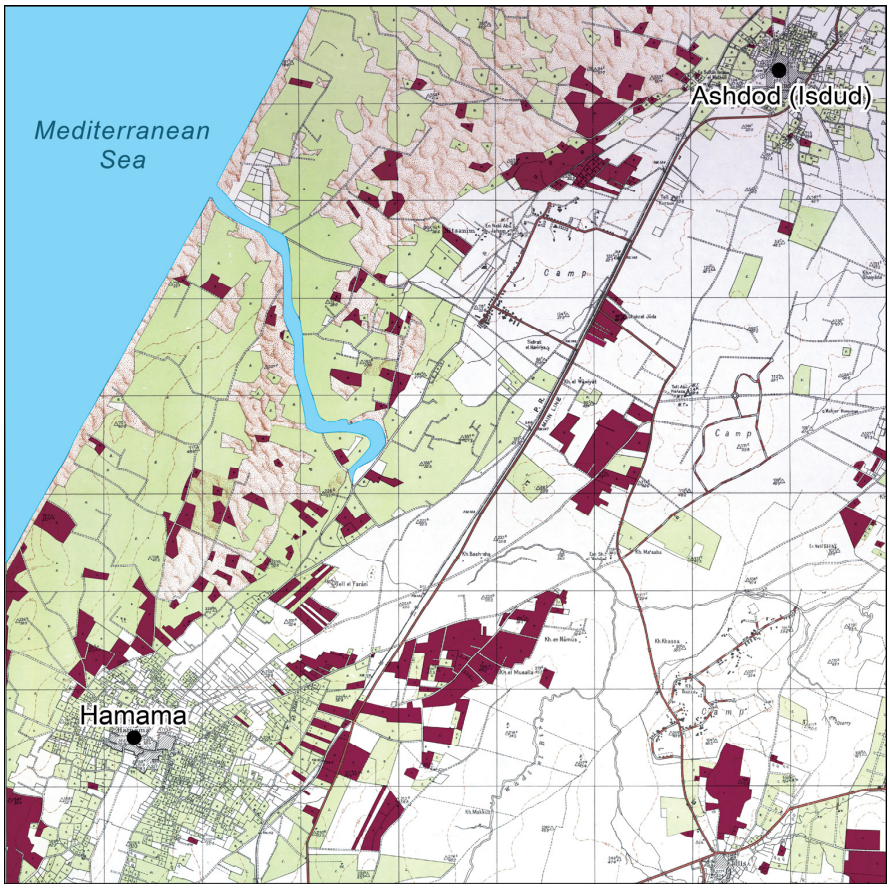
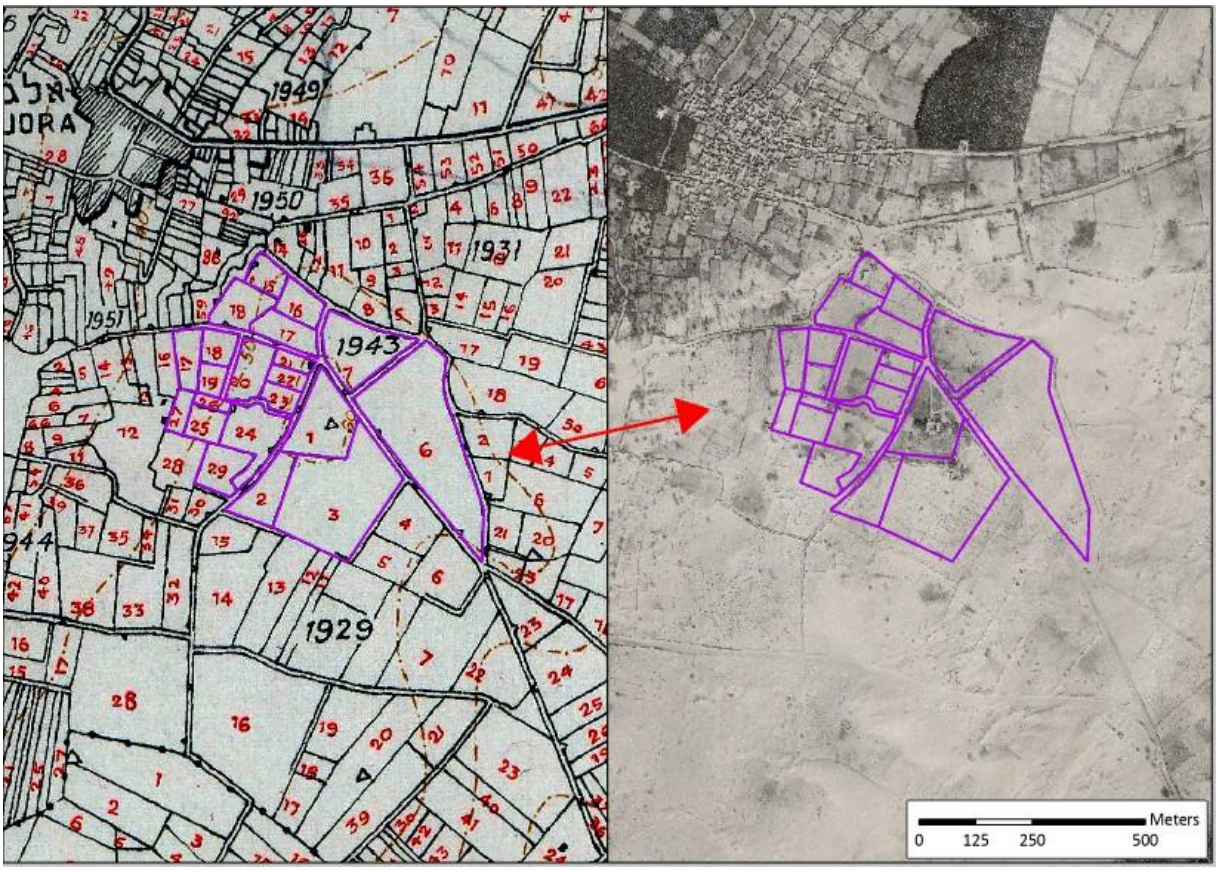


Figure 7. Agricultural areas between Hamama and Isdud during the mid-1930s. Adapted from Schmidt et al. (2024, Figure 11) [4].

The demarcation of plots at the end of the British Mandate that went up to the shore was connected to the completion of the village survey in the region by the Mandate authorities [21]. The rationale was to get individual holders to register this land in their name and dismantle communal holding. To a certain extent, the 1946 map may thus depict

de jure land ownership rather than de facto land cultivation. In some places, as seen in the aerial photos, few trees or vines had been planted.

Despite the cadastral delineation by the Mandate authorities, the ownership of these parcels remains unclear. Figure 8a depicts a representative region extracted from the cadastral mapping of the agricultural parcels south of al-Jura conducted by the Mandate authorities in 1947. This region is part of the Ashkelon sheet [42] that contains hundreds of blocks divided into parcels and numbered sequentially. For our purposes, several parcel borders were digitized on the map and compared to a 1945 aerial photo of al-Jura (Figure 8b). Although there were some discrepancies in terms of the location of the border (the map was rectified with a total RMSE of 22.1 m), the parcels (colored in purple) on the map correspond to the actual situation in the photograph. Clearly, the entire mapping of the Ashkelon sheet cannot be considered accurate, since only a small fraction of the map was examined. While the map presents parcellation throughout the entire area, the aerial photos only show partial cultivation, especially for more remote areas from the villages. To inspect the sheet in its entirety, hundreds of parcels would have to be digitalized and verified, which is beyond the scope of this article.



(**a**) (**b**)

Figure 8. (**a**) A 1947 Ashkelon sheet of the Survey of Palestine map [42] delineating the land parcels and ownership around al-Jura. Examples of parcel borders are outlined in purple; (**b**) the same region as in (**a**) from a 1945 aerial photo [53]. Note the similarities between the parcels delineated on the map and in the photo.

8. Summary and Conclusions

The stability and resilience of sustainable agricultural systems in Israel's southern coastal plain demonstrates the importance of preserving an important chapter in its agricultural history. These agricultural systems are illustrative of human resourcefulness when

cultivating land on the fringes of the desert, the challenges faced by the farmers of the time, and what they can teach us for the future in an increasingly environmentally conscious world. The unique varieties of fruit trees (landrace) grown in the past and adapted to the local climate of the western Negev are of high economic importance. There is an urgent need to continue studying these fruit trees and their unique genetic signature that preserves history, especially since some of them are in immediate danger of extinction due to the rapid urban development in the region. Attempts to continue cultivating these historical plantations and orchards during Israel's first years were soon abandoned, and the trees and vines were uprooted to make room for extensive monoculture and mechanized modern agriculture introduced by the newly established *Moshavim* and *Kibbutzim*. Thus, an important historical agricultural tradition which was adapted to local conditions and developed over years of trial and error was almost entirely lost. It can be seen as part of a worldwide phenomenon in which agricultural intensification leads to a decrease in biodiversity [58]. These processes happen very rapidly since the pre-modern era in response to imperial demand [59].

Remnants of this bygone agricultural system have survived in the region thanks to the establishment of three national parks by the State of Israel in Nitzanim, Karmiya, and Ziqim, which are administrated by the Israel Nature and Parks Authority. It is crucial to work together with the Authority to preserve and protect these remnants, rehabilitate some of the agricultural facilities, conduct research on the remaining cultivars, perhaps in experimental plots, and better inform the public about the rich agricultural tradition of the region. This can be carried out through community outreach and citizen science initiatives in communities in the region. Local educators and municipality/local government representatives can help implement an onsite educational plot based on the actual remnants of a local ancient farmstead. Such efforts will increase public knowledge of the shared horticultural past, as well as attract individuals to further contribute in a meaningful way to preservation efforts. The field school in Nitzanim run by the Society for the Protection of Nature in Israel (SPNI) would be a potential partner to lead this joint initiative. It should also include exploring the value of landrace relic fruit trees as a cultural heritage on regional and national levels [4]. Such an approach will allow the management of horticultural historical resources in the area to be integrated into joint science-based and educational programs.

The remains of the traditional agricultural system which can be seen today in southern Israel testify to an agriculture that no longer exists. Like other historical monuments eradicated physically from the landscape, the agricultural parcels, the technology used, and the insights one can gain from their study should be preserved and commemorated. This study thus contributes to the body of historical geography works aimed at landscape reconstruction in rapidly changing areas to preserve the know-how and societal patterns of past communities for future generations.

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