The Historical Changes of Open Spaces in the Old City of Jerusalem Over the Last 180 Years

Keywords: Jerusalem, land-use, land-cover, open spaces, historical-maps, GIS

Summary: The Old City of Jerusalem dates back to ~2000 BC and holds important holy sites for the three monotheistic religions. The present-day walls of the Old City were built at the beginning of the Ottoman period (16th century) and have undergone relatively small changes. The three main aims of this research were: 1. To digitize the land use changes within the Old City of Jerusalem over the last 180 years; 2. To analyze the land use changes with respect to the existing quarters and to link them to historical events; 3. To categorize the present-day open spaces and their future land designation. In this research the reconstruction of the past land use was based on historical maps, aerial photo, and satellite imagery. The digitization and analysis were done using different GIS tools. The results show that over the years 15% reduction in open spaces took place and the biggest decline started to occur from the end of the 1970s. Differences in open space areas were found between the four different quarters, whereas the biggest land use change occurred in the Muslim quarter. The research also demonstrates that in the middle of the 19th century the open space could be found in lots adjacent to the walls and in different enclosed compounds. By the middle of the 20th century most of open spaces were located around holy compounds, open archeological sites, and new public squares. This research also revealed that the changes in the land use were directly linked to population trends and to political factors in both the 19th and the 20th centuries.

Introduction

Historical maps are a common tool used by historians, geographers and other researchers to reconstruct past landscapes, places and customs (van Elzakker, 2004). In the last 30 years, the development of different Geographic Information System (GIS) programs has opened new possibilities to extract and quantitatively analyze spatial information from historical maps, thus allowing the reconstruction of past landscapes (Grossinger, 2007; Fensham, 2008; Schaffer & Levin, 2014, 2016; Svenningsen & Perner 2020; Knowles & Hillier, 2008; Sanderson, 2009). Palestine and especially Jerusalem is an important place for the three monotheistic religions for which it is known as the Holy Land. This is one of the main reasons for the abundance of available historical sources covering the land, including historical maps. The 19th century saw a revival of Palestine and Jerusalem mapping. Many European and American pilgrims came to Palestine with a mission to discover once again the exact sites that were mentioned in the Old and New Testaments. Academics and military personnel joined these pilgrims to investigate the country (Ben-Arieh, 1985). Although, there is abundance maps of the Old City of Jerusalem many of them are inaccurate and incomplete. Only in the 19th century did scientific mapping of Jerusalem began. These newer maps were created based on accurate geographical and topographic data and on trigonometric measurements and calculations. One of the first measured map
of Jerusalem to be found was mapped in 1818 by Franz Wilhelm Sieber and another one was published by Heinrich Berghau in 1825 (Ben-Arieh, 1974; Goren & Bruno, 2015). The Old City of Jerusalem is a historical and religious city which dates back to ~2,000 BC and holds many important religious sites for the three monotheistic religions. Jerusalem was conquered and ruled by many different forces which have contributed to the change in the size and shape of the city (Ben-Dov, 2002). From the 16th century until 1917, Palestine was under the Ottoman rule. Under the rule of Sultan Suleiman-I, between 1520-1566, it was ordered to build a new and stronger wall to the city of Jerusalem (Ben-Zvi, 1987; Schur, 1987). The construction of the wall continued from 1536 until 1542 (Ben-Zvi, 1987). The walls were 10 meters in height, 4.5 kilometers long. The present-day city walls are the same walls constructed by the Ottomans and have changed very little. The only modifications to the walls during the years were blocking or opening new gates in the wall (Ben-Dov, 1987). Today the Old City divided into five quarters, four residential quarters: Armenians, Jews, Christians, and Muslims and one religious’ compound, the Temple Rock. It is still unclear when the city was divided into these present quarters, but it is known, based on historical maps that already in the early 19th century the city was divided (Ben-Dov, 2002). Until the middle of the 19th century, Jerusalem was a confined area between the walls of the Old City and remaining outside the walls, especially at night, was considered dangerous (Ben-Arieh, 1987). Nonetheless, as the population and in consequence its density increased within the Old City, residents began slowly to emerge from the city walls (Ben-Arieh, 1987). The Christians were the first to start building outside of the walls, in 1852. A few years later, also the Jewish and the Muslims started to build other buildings and neighborhoods outside the walls (Ben-Dov, 2002). In 1917 the British took control over Palestine and Jerusalem and remained until 1948. In 1948, during the First Arab-Israeli war, Jordan captured and later annexed the Old City until the 1967 Arab-Israeli war when Israel captures and annexed it. Since then, the Old City is controlled by Israel (Zank, 2018; Sebag Montefiore, 2012). In 1981, Jerusalem Old City and its walls were declared an UNESCO World Heritage Site (UNESCO, 2020).

In the past, especially in a confined and arid area such as the Old City of Jerusalem, open spaces were critical. These areas were used to cultivate the land and fed the population of the city. Only in 1840s due to the crowding inside of the Old City, residents began to cultivate their land also outside the walls (Ben-Dov, 2002). At present times, urban open spaces are no longer as critical as in the past, in providing land for cultivation. However, urban open spaces do play an important role in the city life today. They provide many social benefits such as raising the quality of life, increasing the variety of opportunities, broadening cultural diversity, bettering social equality and creating a sense of community (Burgess et al., 1988; Germann-Chiari and Seeland, 2004; Martin et al., 2004). Moreover, they provide pleasant stress-free places for physical activity and relaxation and ultimately they facilitate health and wellbeing (Bertram & Rehdanz 2015). Last but not least, these are areas where vegetation can grow which consequently helps lower temperatures in their surroundings, filter pollutants, store carbon and release oxygen into the air, and protect local ecosystems (Bolund & Hunhammar 1999; Elmqvist et al. 2015; Tratalos et al. 2007). Identifying these open spaces, especially in such a confined area as the Old City of Jerusalem, is important for preserving them for future generations. As the Old City of Jerusalem has a large quantity of cartographical sources, the city is an easily demarcated area and, as mentioned above, its boundaries (city walls) did not change in the last 400 years, it is an excellent area to examine its spatial-human change throughout history.

The three main aims of this research were:
1. To digitize the land use changes within the Old City of Jerusalem over the last 180 years.
2. To analyze the land use changes with respect to the existing quarters and to link them to historical events.
3. To categorize the present-day open spaces and their future land designation.

**Methodology**

**Research Area**

The study area is the zone within the present-day walls of the Old City of Jerusalem and encompasses an area of \(\sim 1 \text{ km}^2\) (Figure 1). The research area is divided into five quarters. There are four residential quarters: Armenian, Christian, Jewish, and Muslim and the fifth is a compound surrounding the Rock of the Dome Mosque. The present-day (2016) population of the Old City is 35,173 residents (Jerusalem Institute for Policy Research, 2016).

Figure 1: The research area at present (2017) found within the walls of the Old City of Jerusalem. The figure shows two layers. The lower layer is the satellite imagery from 2017, and the upper layer the digitization of the land use is divided into three categories: built-up area, open space, and water pool. The Old City is divided into five quarters.
Study Sources

To digitize and analyze the land use changes within the Old City of Jerusalem over the last 180 years, this research used five different historical maps from the 19th century and the beginning of the 20th century (Table 1). Furthermore, this research also used one aerial photo and one satellite imagery (Table 1). There is a large quantity of cartographical sources of the Old City of Jerusalem (Ben-Arieh, 1977). Nevertheless, many of the sources were found to be inadequate for this research due to their large inaccuracies in dimension measurements and the lack of clarity about the included land uses. Three parameters were used for choosing the appropriate source to be used in this research. The first parameter was the accuracy of the maps. Although not all the historical maps used in this research were accurate as more recent sources used, the historical maps chosen where measured maps of the city, and hence had a higher accuracy rate. The only map that was the least accurate was the Kiepert 1841 map. In general terms it was detailed but had a large distortion in the North-East side of the Old City (see Figure 2 - map 1841). Nonetheless, it was used since it is the oldest measured map available that met the other two following parameters. The second parameter was a clear depiction of the representation of land uses to be investigated. The third parameter was the time laps between the sources i.e. of an average 29 years apart.

<table>
<thead>
<tr>
<th>Cartographer / Mapping agency</th>
<th>Type of Source</th>
<th>Publish year</th>
<th>Source Scale</th>
<th>Total RMSE</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Map</td>
<td>1841</td>
<td>1:100,000</td>
<td>33.6</td>
</tr>
<tr>
<td>Wilson, V. &amp; Saulcy</td>
<td>Map</td>
<td>1850</td>
<td>~1:85,000</td>
<td>6.7</td>
</tr>
<tr>
<td>Unknown (Hebrew Academy)</td>
<td>Map</td>
<td>189-</td>
<td>1:8,350</td>
<td>7.4</td>
</tr>
<tr>
<td>Ruze delt. E.</td>
<td>Map</td>
<td>1912</td>
<td>-</td>
<td>3.8</td>
</tr>
<tr>
<td>Survey of Palestine</td>
<td>Map</td>
<td>1947</td>
<td>1:5,000</td>
<td>3.0</td>
</tr>
<tr>
<td>Survey of Israel</td>
<td>Aerial photo</td>
<td>1979</td>
<td>-</td>
<td>4.6</td>
</tr>
<tr>
<td>Maxar (ESRI)</td>
<td>Satellite imagery</td>
<td>2017</td>
<td>-</td>
<td>used as a base map</td>
</tr>
</tbody>
</table>

Table 1: The cartographical sources used to digitize and analyze the land use changes in the Old City of Jerusalem. For each source used, the total Root Mean Square Error of the georeferencing process is presented.

Spatial Analysis

The entire area of the Old City of Jerusalem was reconstructed in seven time periods (Table 1). First, all the cartographic sources were georeferenced to the satellite imagery (2017). The satellite imagery was used as a base map and it was already georeferenced by the ArcGIS ESRI software. Second, the digitization of the land use was done in a scale of 1:5,000. The digitization was divided into three general categories: built-up areas, open space, and water pool. The built-up areas category included areas of residential, public, and religious buildings. The open space category included areas with no buildings and comprises empty nature areas, cultivated land, gardens, playgrounds and parking lots, and empty squares. Water pool category consists of only human made open water pools and underground water pools which also existed in the city. Both the georeferencing and the digitization process were performed using ArcGIS software. Since all the historical sources had some distortion (as
can also been seen in the Table 1, RMES) the calculations and sum were done mostly in percentages. The calculations regarding the five quarters were done using the intersect tool in ArcGIS.

**Present-day Open Space Analysis**

From the created digitized layer of 2017, all the open space areas were extracted to a new layer. This new layer was later divided into six different categories which included: square, garden, parking, archaeological site, playfield, and green open space. The Israeli government map site, GovMap (2020) was used to learn more about the future designation of these areas.

**Results**

**Land use mapping**

Overall, three land use categories, built-up area, open space, and water pool, were identified and digitized in the research area based on seven different historical sources (Figure 1 and Table 1). From Table 1 and Figure 1 and 2 we can see that the most dominant land use category from the middle of the 19th century until present-day was built-up areas. From Table 1 it is possible to appreciate that in 1841 built-up area amounted to 60% of the total area of the Old City and that presently it covers 76% of the total area, totally accounting for an increase of 16% over the last 180 years. By considering Table 1 data it is evident that the rapid increase in built-up area occurred in mainly two periods. The first period was between 1841 and 1850, with an increase of 5.5% in built-up areas. The second period was between 1979 and 2017, with an increase of 6.6%. The open space category that in 1841 amounted to 38.6% of the total area of the Old City at present is only 23.5% of the total area, meaning a total decline of 14.9% (Table1). Figure 1 and 2 show two water pools, appearing in the maps from 1841 until 1947. However, from 1979 onwards only one water pool appears. As shown in Table 1 the water pool area in the Old City has increased from 0.8% of the total area in 1841 to 0.9% in 1912 to then decrease drastically to 0.3% in 1979. Presently it covers an area of 0.5% of the total area of the Old City.

<table>
<thead>
<tr>
<th>Land use category</th>
<th>% of total area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1841</td>
</tr>
<tr>
<td>Built-up area</td>
<td>60.7</td>
</tr>
<tr>
<td>Open space</td>
<td>38.6</td>
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<tr>
<td>Water pool</td>
<td>0.8</td>
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</tbody>
</table>

Table 1: The land use changes in the research area divided into seven different periods. The land use changes are shown in percentage and represent the percentage out of the total area in each year examined.
Table 2 divide the results into the five different quarters of the city and shows that the biggest residential quarter is the Muslim one covering 34% of the total area of the Old City followed by the Christian (19%), Jewish (15%) and Armenian (13%). Moreover, the 5th quarter, which is the Dome of the Rock compound, covers 16% of the total area of the city. In 2017 the quarters with the least open spaces were the Christian quarter (3.5% of the total area of the quarter), followed by the Muslim quarter (9.6%). On the opposite side, the largest quarter with open spaces at present is the Dome of the Rock compound (70% of the total area of the compound) followed but the Jewish quarter (35%) and the Armenian quarter (19.8%).
From Table 2 the smallest decrease of open space areas inside the quarters was in the Dome of the Rock compound (-4.3%). With regards to the Armenian quarter, if we ignore for now the map of 1841, we can notice that there was a decrease then an increase and then again and increase in built-up and open space areas. However, examining the overall change, from 1850 to 2017, the built-up area increases, and the open space area has decreased in in 16.3%.

<table>
<thead>
<tr>
<th>Old City quarters</th>
<th>Total area in km²</th>
<th>% of total area</th>
<th>Land use categories / Years</th>
<th>1841</th>
<th>1850</th>
<th>189-1912</th>
<th>1947</th>
<th>1979</th>
<th>2017</th>
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<td>Armenian</td>
<td>0.16</td>
<td>13</td>
<td>Built-up area</td>
<td>82.4</td>
<td>69.5</td>
<td>64.1</td>
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<td>68.6</td>
<td>69.1</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Open space</td>
<td>17.6</td>
<td>30.5</td>
<td>35.9</td>
<td>26.4</td>
<td>31.4</td>
<td>30.9</td>
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<tr>
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<tr>
<td>Christian</td>
<td>0.23</td>
<td>19</td>
<td>Built-up area</td>
<td>79.8</td>
<td>79.2</td>
<td>83.7</td>
<td>75.0</td>
<td>86.9</td>
<td>95.6</td>
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<td>Open space</td>
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<td>19.0</td>
<td>14.7</td>
<td>11.4</td>
<td>2.8</td>
<td>3.5</td>
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<td></td>
<td></td>
<td>Water pool</td>
<td>1.7</td>
<td>1.8</td>
<td>1.6</td>
<td>2.3</td>
<td>1.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Jewish</td>
<td>0.18</td>
<td>15</td>
<td>Built-up area</td>
<td>66.3</td>
<td>58.4</td>
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<td>31.6</td>
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<td>Water pool</td>
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<tr>
<td>Muslim</td>
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<td>Built-up area</td>
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<td>80.0</td>
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<td>18.7</td>
<td>17.4</td>
<td>22.5</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Water pool</td>
<td>1.3</td>
<td>1.4</td>
<td>1.3</td>
<td>1.4</td>
<td>1.6</td>
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</tr>
<tr>
<td>Dome of the Rock</td>
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<td>16</td>
<td>Built-up area</td>
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<td>32.1</td>
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<td>28.1</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Open space</td>
<td>74.3</td>
<td>71.2</td>
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<td>70.8</td>
<td>71.9</td>
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<td></td>
<td>Water pool</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Total</td>
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<td>100</td>
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<td></td>
<td></td>
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<td></td>
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</table>

Table 2: The land use changes divided into five different areas of the Old City in seven different periods. The land use changes are shown in percentage out of the total area in each year examined.

Regarding the Jewish Quarter, Table 2 shows that until 1947 there was an increase in built-up area and decrease in open spaces. Then in 1979 a decrease in the built-up areas took place with an equal amount of built-up areas and open space areas i.e. 50% of the total area of the quarter. At present the built-up area has increased to 64.9% of the total area, but this is still lower than what found in 1947 i.e. 68.4%.

Moreover, in Table 2 it is evident that the major decrease of open space areas and increase of built-up areas occurred in the Christian and Muslim quarters. The Christian quarter saw a decrease of open spaces from 18.5% in 1841, to 3.5% of the total area of the quarter at this time. The Muslim quarter saw a decrease in open spaces (-24.5% of the total area of the quarter) and increase in built-up areas (+25.8% of the total area in the quarter) between 1841 to present. Lastly, Table 2 shows that the water pool area in the Christian quarter remained nearly the same over the years, from 1.7% in 1841 to 1.6% presently. In the Muslim quarter in the 19th century the water pool area amounted to 1.3-1.4% and reached an area of 1.6% in 1947. At present there is no water pool to be found in the quarter.
At present, 23.7% of the total area of the Old City is open space (Table 1). Table 3 and Figure 3 show the present-day open spaces divided into six categories.

![Figure 3: The present-day open space areas in the Old City divided into side different categories.](image)

From the results of Table 3 we can notice that largest categories of open spaces are gardens (37.7% of the total area of open spaces in the city) followed by squares (21.2%) and green open areas (15.2%). The smallest categories of open spaces are playfields 2.7% of the total area of open spaces. In Figure 3 we can notice the large open space in the Dome of the Rock compound and that most of the present-day open spaces are found adjacent to the walls of the Old City.
Discussion

Historical changes in the land use

Jerusalem, like other historical cities in the world, has undergone many upheavals over the years. Jerusalem was built, changed, conquered, destroyed, and rebuilt multiple times. Despite the many changes that the city has experienced, from the 16th century the area of the old city remained unchanged to this day, mainly because of the high and stable walls that kept the city unified and its inhabitants safe. However, the two variables that have changed in the city over the years were the number of residents and the type of land uses inside the city. The beginning of the 16th century started with the conquest of Palestine and Jerusalem by the Ottoman empire (Schur, 1987). Due to the importance of the Jerusalem to the Islam religion, the Ottomans decided to invest in it and in 1536 the construction of the new walls of the city began together with construction of other facilities such as new water pools (Schur, 1987). These improvements attracted new residents to the city. However, the flourishing period of the city did not last long. The Ottoman empire began to lose power and the city was once again abandoned until the 19th century. Towards the middle of the 19th century, with further deterioration in the power of the Ottoman empire, the European interest in the region began to increase. This European interest was bolstered with the Capitulation treaties (Feroz, 2000; Eliav, 1978). The Capitulation treaties, which were imposed on the Ottomans by the European governments, as part of race between the European powers, freed the way to facilitate foreign investment, development and exploration of Palestine (Ben-Arieh, 1985; Margalit, 1965; Shamir, 1985). This process was followed also by a growth in population, mainly due to Arab and Jewish immigration, that fostered further development with the construction of new infrastructures together with new settlements outside of the city walls (Gerber, 1982; Kark et al., 2004; Naveh, 1981; Reifenberg, 1950). The research has shown that overall, there was an increase in built-up areas and a parallel decrease in open areas. Between 1841 to 1890s the increase in built-up area was of 7.4% and the decrease of 7.4% in the open spaces (Figure 1 and Table 1). The 19th century saw a large increase in population of the city. At the beginning of the 19th century, the population of the Old City was ~8,000 residents (Ben-Arieh, 1987). In 1850 the population grew to 15,000 and by 1890 the population numbered 42,000 residents (Ben-Arieh, 1977). In the 19th century, the Jewish were the fastest growing ethno-religious group and by 1840s they surpassed the Muslims and became the biggest ethno-religious group in the Old City.
(Ben-Arieh, 1977). Because of the increase in the population of the city, the built-up area increased at the expense of open space areas in the city. Indeed, we know that from the middle of the 19th century the city became very crowded. From 1840s the residents of the city began to cultivate their land outside the walls most probable due to the raise in demand for food by the growing population but also due to the decrease of open spaces. From the year 1852, the exiting the walls of the Old City gradually evolved. First the Christians built public buildings and different compounds for Christian pilgrims. Then the Jewish and Arabs started to move outside of the walls and build residential houses and small neighborhoods.

We can note from the maps that many open space areas in the past and the ones that remained in the present were areas next to the city walls (Figure 1, 2, 4). Indeed, these areas were areas of cultivation (Ben-Arieh, 1977; Ben-Dov, 2002). It is specifically known that the North-East corner of the Old City in the Muslim quarter was a cultivation area (Ben-Arieh, 1977). Two other areas were the South-West corner of the Old City in the Armenian quarter and a third large area was from Zion Gate to Dung gate in the Jewish quarter (Ben-Arieh, 1977). With the expansion of the Old City, those cultivation areas near the walls, started to shrink and in some areas have almost disappeared completely.

From the maps used in this research we learn that two water pools existed in the Old City (Figure 2). The first is Hezekiah’s Pool (also named Pool of Pillars/Towers) located in the Christian quarter (Reich et al., 2009). The pool was constructed ~700 BC and it was filled both by rainwater and both by an aqueduct that poured water from the Mamilla pool located outside the walls (Ben-Arieh, 1977). Historical sources mention that the pool was filled with water also in the 19th century (Ben-Arieh, 1977). In the last few years there is an attempt by various agencies included the Israeli Antiquities Authority to clean and returns some of the beauty of the pool which over the years has been filled with trash and wastewater (IAA, 2013). The second water pool “Pool of Israel” is in the Muslim quarter (Reich et al., 2009). From different sources in the 19th century, it seems that the pool was already dry and not used since it did not hold the water well and with the passing of years it was filled with trash, stones and debris (Ben-Arieh, 1977). In the 1930s the British mandate decided that this pool was an environmental hazard and it filled it with soil (Ben-Arieh, 1970). Today this area is a parking
area. It is interesting to note that although the water pool was already dry and filled with stones and debris from the middle of the 19th century, the pool still appeared on the cartographic sources until 1947.

Historical changes divided by quarters

It is not entirely clear when the Old City's division into the present quarters began. But, according to 19th century maps, it is known that the present quarters have existed at least from the beginning of the 19th century (Ben-Ariel, 1977). Apart from the four quarters there is also a large compound, the Temple Rock compound, which is located where the ancient temple once stood. Today the compound houses the Temple Rock and Al Aqsa Mosque and a small Museum of Islam. Regarding open space areas this Temple Rock compound is a unique area due to the fact that it has the largest open space area in the Old City at present and also because the change in open space during the last 180 years was the smallest, a decrease of just 4.3%. The obvious reason for the minimal change in this area compound is its historical, sacred, and highly politically sensitive nature.

Another area with almost minimal land use change is the Armenian quarter. This quarter is the smallest size wise (0.16 km²) and smallest also in population, 2,513 residents (Jerusalem Institute for Policy Research, 2016). The map of 1841 shows that 17.6% of the total area was open spaces and 9 years later the map of 1850 and onward sources demonstrate that the total open space areas was in average 30% of the total area. There are no historical sources that could explain the decrease of 13% in the total built-up area in this period and we can conclude that there was a mistake in the mapping of the 1841 map. The rest of the sources used up to 1979 show an average of 70/30 ratio between built-up areas and open space areas. The Armenian population in the Old city grow slowly over the years. In 1844 there were ~350 Armenian residents in the Old City, in 1876 the population reached ~515 residents (Vilnay, 1972). The dramatic change happened following the Armenian genocide in 1918, which brought 10,000 Armenian to Palestine. Out of the 10,000 refugees 4,000 were placed in Armenian Monastery in the Old City and the rest in other communities in Palestine (Har El, 1972). However, most of the refugees did not remain in the Old City and in 1968 the number of Armenian living in the Old City was 2,500 residents (Vilnay, 1972). It seems that although the population of the Armenian quarter grew to 4,500 residents over the last 180 years, this did not influence much the land use as during these years there was only a growth of 10.7% in the built-up areas.

In the Jewish quarter we have another unique case. From the start of the 19th century the population in the Jewish quarter grew and in the middle of the 19th the crowding in the quarter was remarkable. At the beginning of the 19th century there were 2,000 Jewish residents living in the Old City and by the end of the 19th century the Jewish population reached 20,000 people (Ben-Arieh, 1987). Indeed, between 1860 and 1880, nine new Jewish neighborhoods that dwelled 2,000 Jewish were built outside the walls (Ben-Arieh, 1987). Nonetheless, the Jewish population in the Old City continued to grow over the years. The results of the research found an increase of 10% in the built-up area from 1850 to 1947 where the built-up area reached 68.4% and the open-space area reached 31.6% of the total area of the Jewish quarter. Interestingly by 1979 the ratio between the built-up areas and the open space areas was 50/50. The explanation to the dramatic decrease in built-up areas and increase in open spaces is linked to the 1948 Israel-Arab war and its consequences. At the end of the 1948 war the Old City was conquered by the Jordanians and remained under its controls until 1967. During the war, the Jordanians blew-up several Jewish religious buildings and by the end of the war they expelled all the
Jewish residents from the Old City. During the Jordanian control, other Jewish owned buildings were also demolished (Har El, 1972; Ben Dov, 2002). Only after Israel took control of the Old City, at the end of the 1967 Arab-Israeli war, the Israeli government started to rebuild the quarter. However, until today many of the areas that were destroyed were never rebuilt and some became public squares such as the HaHurva square built on buildings which were destroyed and never rebuilt (Ben Dov, 2002). Other destroyed buildings were rebuilt by Israel, such as the new HaHurva Synagogue in 2006. This is the reason that the results from 1979 onwards show an increase in built-up areas but still open spaces areas amount to 35.1% of the total area of the quarter.

The largest changes in the land use categories can be found in the Muslim and the Christian quarters. In both quarters we can see a high increase in built-up areas (21.3% in the Muslim quarter and 15.5% in the Christian quarter) and a consequent decrease in the open space areas. Regarding the Muslim quarter three possible reasons for the increase in built-up areas in the quarter exist. The first reason is that the Muslim population increased over the years. In the 19th century the gradual decline in the Ottoman power and the rise in foreign impact, brought an economic development to the region. This economic growth influenced the city of Jerusalem leading to a rapid population growth, especially coming from neighboring areas (Ben-Arieh & Bartal, 1983; Shpak Lissak, 2018). The number of Arab Muslims at the beginning of the 19th century was ~4,000 and by the end of the 19th century the number reached ~12,000 Muslims (Ben-Arieh, 1977). A second reason for the increase of built-up areas in the Muslim quarter was that many Jewish who did not find a place to live in the Jewish quarter (due to high density in the quarter) lived in the Muslim quarter (in the close vicinity of the Jewish quarter) (Har El, 1972; Ben-Arieh, 1977). This could have caused a lack in residential areas in the Muslim quarter and the construction of new ones in the empty areas in the northern side of the quarter. A third reason for the increase in the built-up areas in the Muslim quarter could be due to the very fact that the Muslim area had the largest empty open space areas for future development than other quarters. Unlike the Muslim quarter, the Christian quarter at the beginning of the 19th century was already mostly built-up. The built-up areas in the 1841 and 1850 maps amount to 79.8-79.2% of the total area of the quarter. The empty spaces in the beginning of the 19th century were quite small to start with, with 18-19% of the total area of the quarter. During the 19th century the Christian population living in the Old City grew from ~2,755 residents in 1800, to ~4,450 in 1890 reached ~8,000 residents (Ben-Arieh, 1977). The raise in population over the year in a limited area which was mostly already built can explain the reason that at present the open spaces amount to only 3.5% of the total area of the quarter.

The state of the present-day open spaces in the Old City of Jerusalem

The role and importance of open spaces in urban areas have changed with time. In the past, open spaces in urban areas were mostly considered important as crop land for cultivation. Until the 19th century, Jerusalem was a confined city and the area outside the walls was considered dangerous (Reich et al. 2009; Ben-Arieh, 1977; Har El, 1972). Therefore, especially in Jerusalem, the open spaces within the walls of Jerusalem were priceless. Today the role and importance of open spaces have changed and their importance as cultivation land has almost disappeared completely. At present, open spaces include different type of spaces that can include, forests, gardens, playgrounds, squares, open sport facility compounds just to mention a few. Various studies have found that these areas are
important under several aspects such as raising the quality of life, improve social equality, facilitate health and wellbeing, lowering the city temperature etc. (Burgess et al., 1988; Germann-Chiari & Seeland, 2004; Martin et al., 2004; Bertram & Rehdanz 2015). The results of the present open spaces in the Old City show that the largest open space can be still found in the Dome of the Rock Compound and in the Armenian and Jewish quarters. Except from the Dome of the Rock compound the rest of the open space areas are areas in most part adjected to the Old City walls and are a reminder of past times when these areas were larger as can be seen on the 19th century maps (Figure 2, 4). In the Dome of the Rock the open spaces are gardens and squares while in the Jewish quarter they are archeological sites, parking lots and squares. In the Muslim and Armenian quarters there are a different type of open spaces that include gardens, some playfields and parking lots. In the Christian quarter where the open spaces are the smallest, the only open space remaining are gardens adjacent to different religious and public buildings. Presently, the less at-risk open space areas form future developments are the Dome of the Rock compound due to its historical, religious, and political importance. Moreover, also the archeological sites are limited area for development under the Israeli statutory law of 1978 (Hysler Rubin, 2018). Other green open areas adjacent to the city walls are mostly designated as “open space areas” by the Israel Land Authority (GovMap, 2020) The open spaces that are at the highest risk of future development are parking lost areas found in the Armenian, Jewish and Muslim quarter. For example, the parking lot found in the Jewish quarter is marked by the Israel Land Authority as designated for tourism and recreation development (GovMap, 2020). The National Recreation and Park Association recommends 0.04 km² of open spaces for every 1000 residents while the National Playing Fields Association recommends 0.02 km² of open spaces for 1000 residents (Dahmann et al., 2010). If we calculate the present total open space areas (0.281993 km²) and divide them by the present number of residents in the Old City (35,173 residents), it turns out that on average there are 0.008 km² of open spaces for every 1,000 residents in the Old City. This figure, 0.008 km² is much below the average recommended area and of 0.02-0.04 km² which means that there is a serious lack in open space areas.

Conclusion

This research has examined the changes in the land use of the Old City and specifically focused on the changes that happened to the open spaces. These changes were examined by different historical maps of the 19th and 20th century as well as with aerial photo and satellite imagery. First, the research has shown that historical maps are relevant and important in examining land use changes in the past while keeping in mind that cartographical sources, as any other historical source, can be incomplete and inaccurate. To overcome these challenges, using many sources, as was done in this research, could minimize these errors and still provide a good general idea of the changes. Second, this research has shown how, in general terms, the land uses in the Old City have changed over a period of 180 years with an increase of built-up areas and a decrease in water pools and open space areas. Moreover, this research has shown that difference in the land use changes exist between the different quarters of the city. Lastly, this research has shown that at present the open space areas are diverse and few. There is a shortage of open spaces in the Old City and this should ring a warning bell concerning the future of these areas.
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