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ARTICLE

Landscape change in Ramallah—Palestine (1994–2014)

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ABSTRACT
The Palestinian landscape has always been subjected to dynamic processes of change. This article examines the landscape change in Ramallah city during the last 20 years by analysing two aerial photographs from two periods—1994 and 2014—to create land cover maps which illustrate the change in different landscape classes in the city. The article aims to quantify the landscape change in the specified periods using GIS and FRAGSTATS analysis, and to identify and explain spatial patterns of the landscape, taking into consideration the political, social, and economic circumstances. The results reveal a considerable change and fragmentation. The main change is an increase in the built-up area at the expense of a decrease in the permanent trees and scrub areas. This change, due to the occupation policies, is a reflection of many indicators, including population growth, migration, and an economic boom in the construction sector.

KEYWORDS
Landscape change; land cover; GIS; Ramallah city; Palestine

Introduction

The ever-changing socio-political status of Ramallah city has not only affected its inhabitants but also its landscape. Since 1994, the city has been growing with limited planning direction causing distinct change in its urban fabric. Shaheen (1994), in his article '*What is happening to Ramallah*', noted the rapid growth and urbanisation of Ramallah city stating that 'at every turn [he] saw buildings going up on a massive scale… [while] many old and historic buildings [were] being destroyed in the name of "progress"'. While Shaheen's article was written two decades ago, the recent situation has become more dramatic than ever, indicating landscape change through urban growth and loss of green areas. The objectives of this article are to quantitatively investigate the landscape change in Ramallah municipal area from 1994 to 2014, while also elaborating on the spatial patterns and the special significance of the Palestinian context; the diverse greenery combined with the political tensions creating highly contested landscapes. This study is part of a larger research project based in Ramallah and Al-Bireh Governorate, that includes Ramallah, Al-Bireh, and Betunia cities, and their surrounding villages and open areas. The project investigates the landscape change, drivers of change, and their impact on the environment and biodiversity.

The Ramallah and Al-Bireh Governorate is one of the largest governorates in Palestine with a total area of 85 500 ha (about 15% of the total area of the West Bank) (PCBS, 2016) (Figure 1). Its central location, and political and socio-economic importance has attracted many migrants, becoming a home to 348,110 Palestinians, with a population density of 4.07 capita/ha in 2015 (PCBS, 2016). Due to its liveliness and central location, Ramallah city often houses the headquarters of many companies and organisations, such as insurance and telecommunications companies, and local and international NGOs (Ramallah Municipality, 2015). Since the Oslo Agreements I and II in

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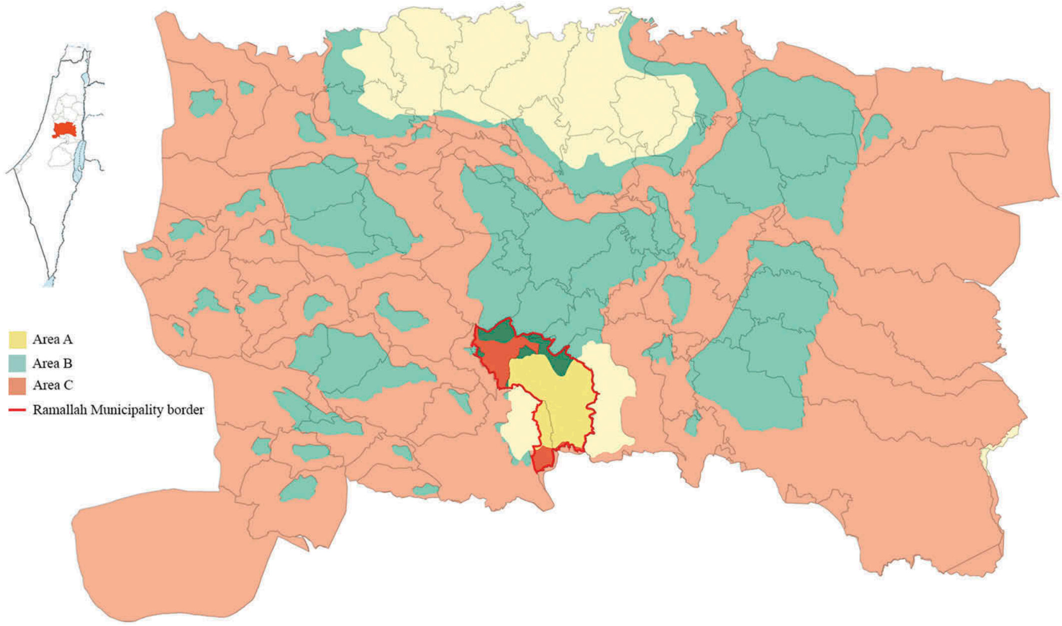

Figure 1. Ramallah and Al-Bireh Governorate map (2014), with A, B, and C area land designations.
Source: The Ministry of Local Government.

1993 and 1995 respectively, Ramallah has become the temporary centre for the Palestinian National Authority (PNA), and hence, the political, financial, and cultural centre of the West Bank. This article investigates how this socio-political shift has affected the landscape of Ramallah city.

Landscape change

Landscapes are always subjected to dynamic processes of change. Physical changes have been defined in relation to area, geographical locations, and time differences that can be investigated through quantitative data. A range of literature studies landscape change and drivers of change, including Antrop (1998), Burgi et al. (2004), Forman and Godron (1986), and Hull and McCarthy (1988).

Many factors affecting landscape are attributed to either natural processes or human activities (Antrop, 1998; Burgi et al., 2004; Green & Vos, 2001). However, this article focuses on human caused changes, which can be attributed to a variety of driving forces, such as, population growth (Antrop, 2005; Burgi et al., 2004; Hull & McCarthy, 1988), socio-economic, cultural, political, technological activities (Burgi et al., 2004; Gobster & Rickenbach, 2004; Nüsser, 2001), calamities and disaster (Antrop, 2005), agricultural practise (Marker et al. 2008), globalisation (Gobster & Rickenbach, 2004), accessibility (Antrop, 2005; Burgi et al., 2004), and urbanisation (Antrop, 2005; Van Eetvedle, 2004).

Landscape change can be approached from two perspectives; the physical perspective related to the natural science of ecology, and the perceptual perspective which relates to humanistic and social science approaches. This article focuses on physical landscape change, investigating the magnitude and the frequency of change over time.

Several papers have studied landscape change over different time periods to understand the quantitative amount of change, the quality of change, and the reasons behind it; whether on local level or global scale (Alnather, 2008; Ayad, 2005; Ellis, 2011; Friedman & Zube, 1992; Rocchini, Perry, Salerno, Maccherini, & Chiarucci, 2006). Some of the main examples which introduced GIS analysis include Friedman and Zube (1992), who analysed change in the San Pedro River Riparian Conservation Area over 53 years by studying aerial photographs which were examined from two perspectives: the landscape matrix and the elemental scale. Moreover, Antrop (1998) proposed a methodology to study landscape change based on transect sampling of landscape features on old and new topographical maps, aerial photos, and field surveys to create time series. The results show that different landscape types are characterised by different entropy distributions, and that change can be monitored, indicating different complex processes of overall landscape change. Another study, which used aerial photos was conducted by Rocchini et al. (2006) to detect change over 44 years, investigating landscape change in the natural reserve of Poggio all'Olmo in Italy. During the research, the ecological dynamics of the landscape change by means of multi-analysis was studied using a GIS vector format grid to classify landscapes. They applied landscape pattern matrices based on landscape composition, shape and size of patches, and patch isolation.

Similar studies were conducted in the Middle East. For example, in 2005, a study assessed the visual changes of the landscape in the coastal area in Egypt using GIS (Ayad, 2005). The objective was to examine how GIS analysis can be used to measure the change in visual quality by assessing the changes between a period characterised by a vernacular, relatively natural landscape of the 1950s and the beginning of the exploitation of the region for resorts in the 1990s. By measuring the degree of naturalness, it was found that the magnitude of change was dramatic.

Natural science—'ecological' approach

Landscape ecology involves the study of landscape configuration, which refers to a combination of elements, mosaics, and patterns that strongly influence its ecological characteristics (Bell, 1999; Forman and Godron, 1986). This involves studying patterns, the interactions among patches within a landscape mosaic, and how these patterns and interactions change over time (McGarigal & Marks, 1995). Among the scientists who consider landscape change based on ecological theories are Forman and Godron (1986), who conceptualise the living system into three characteristics: structure, function, and change. They define the landscape structure as 'the spatial pattern and arrangement of landscape elements, the distribution of energy, materials and species in relation to the sizes, shapes, number, kinds and configurations of the ecosystem'. Function is defined as 'the movement and flow of animals, plants, wind, water, materials and energy through the structure'. And change is seen as 'the dynamic or alteration in spatial pattern, structure, and function of the ecological mosaic over time'. (Forman and Godron, 1986, 11).

The functional changes caused by human activities affect the landscape structure and pattern, influencing the mosaics and the patches of landscape classes. Therefore, to study the landscapes' structure, function, and change, it must be quantified. (Dramstad, Olson, & Forman, 1996; Forman and Godron, 1986). Many researchers emphasise studying different landscape metrics that provide quantitative analysis for land cover, patch distribution, and the level of fragmentation (Li, 1990; Turner, 1990; Turner & Gardner, 1991). These metrics are studied on three levels: landscape, class, and patch levels. (Forman & Gordon, 1986; Turner, 1989). Analysing the landscape and class levels provide a base to study the heterogeneity, structure, and function of the landscape, which aids in quantifying patterns to understand the distribution and fragmentation through studying the number of patches, density, and total and mean sizes (Forman & Gordon, 1986; McGarigal & Marks, 1995). Through the quantitative analysis of these metrics, the increase of the number of patches (NP) in a certain class, coinciding with the decrease of its area—increase in patch density (PD)—represents fragmentation. On the other hand, the progressive reduction in the size of the patches also forms a key component of habitat fragmentation. Thus, a landscape class experiencing a decrease in mean patch size (MPS) might be considered more fragmented (McGarigal & Marks, 1995). Consequently, landscape metrics' studies can strongly represent patterns, change over time, and quantify the landscape configuration.

Landscape change—the palestinian context

In Palestine, some researchers and organisations have started addressing the issue of landscape change through various publications and recommendations. In 2014, the Applied Research Institute—Jerusalem (ARIJ), for example, argued that '[The fragile Palestinian environment] has been exposed to pressures ensuing from the practices of the Palestinian population, on the one hand, and from the practices of the Israeli Occupation, on the other hand, which have significantly contributed to changing the environmental features of [the occupied Palestinian territory]' (ARIJ, 2014b). The same research stated that the main reasons behind this landscape change are restrictions on the available resources, poor management, and unsustainable practices. In 2015, a research conducted by the Centre for Development Studies at Birzeit University described the rapid change in the urban fabric of Ramallah, transforming the landscape of the city into multi-storey, multi-apartment buildings constructed for commercial use (Hilal & El-Sakka, 2015). Similar researches have been conducted at various locations in Palestine. As an example, Ismail. N. M (2012) studied the physical landscape change in three different areas in Palestine: Al-Bireh city, Jiffna village and Al-Jalazoon refugee camp. The study revealed that there was a considerable change due to construction, which has been considered a threat by negatively affecting agricultural land and open areas. Moreover, Alnather (2008) studied the landscape change in Artas Valley in Palestine; the research revealed that the main change was a decrease in the scrub areas and open tree plantation, and an increase in the built-up area. It also revealed that the change was attributed to factors related to population growth, people's needs, and social, economic, cultural, and political reasons (Alnather, 2008).

Materials and methods

Study area

This study looks at landscape change in Ramallah city, which is located 16 km north of Jerusalem. The municipal border of Ramallah has an area slightly above 1900 ha (Figure 2), and is inhabited by 32 000 Palestinians (Ramallah Municipality, 2015). Ramallah city is one of 73 geographical localities which lie within the borders of Ramallah and Al-Bireh Governorate. To fully understand the complexity of the city, the larger political and socio-economic context of the Governorate must be considered.

During the 1948 war, Israel was established on more than 78% of the total area of mandate Palestine. In 1949, the armistice line (also known as the Green Line) was drawn along the boundary between the land occupied by Israel and the remaining Palestinian land in the West Bank, which came under Jordanian control. After signing the Oslo II interim agreement in 1995 between the Palestinian Liberation Organization (PLO) and Israel, land designations in the West Bank were redefined and divided into three areas; A, B, and C, which are distinguished by different levels of control (Area A is under the control of the Palestinians; Area B is under Palestinian civil administration, but has an overriding Israeli security, and Area C is under full Israeli control) (ARIJ, 2014a). Based on the agreement, Ramallah municipality was divided into 59.50% Area A, 17.73% Area B, and 22.77% Area C (Figure 2). In 1996, Ramallah was chosen as the temporary centre for the Palestinian National Authority. Since then, Ramallah has been through drastic transformations, establishing the setting for international organisations as well as governmental and commercial institutions.

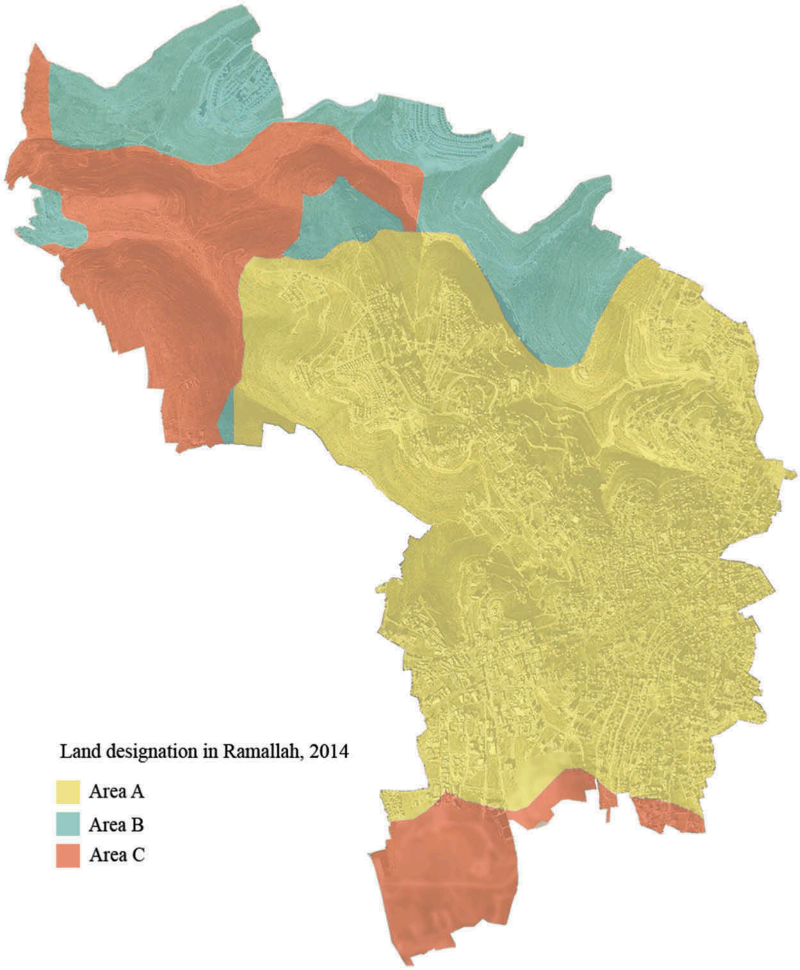

Figure 2. Ramallah Municipality map (2014), with A, B, and C area land designations.
Source: The Ministry of Local Government

This destabilised political foundation has led to a widespread economic crisis in Palestine. Since the occupation, and mainly after the first and second Palestinian Intifadas in 1987 and 2000 respectively, economic shocks such as rising unemployment, restrictions on economic, labour markets, and freedom of movement resulted in a widespread increase in both 'poverty' and 'deep poverty' levels in the region (Ajluni, 2003).

Study sources

Aerial photographs from 1994 and 2014 were used to trace different features of the landscape of Ramallah and the changes evident between these years (Figure 3(a) & 3(b)). These specific dates were chosen to provide a comprehensive study of the landscape change in Ramallah city after the Oslo II interim agreement and the introduction of the Palestinian National Authority. Documents and auxiliary data such as social, demographic, and economic data were collected, mainly from the Palestinian Central Bureau of Statistics (PCBS) and The Applied Research Institute—Jerusalem (ARIJ).

Figure 3(a). Aerial photo of Ramallah city border for the year 1994.
Source: The Ministry of Local Government

Figure 3(b). Aerial photo of Ramallah city border for the year 2014.
Source: The Geography Department, Birzeit University

The two orthorectified aerial photographs were retrieved from different archives in March 2015. The 1994 map was made available by the Geographic Information Centre of the Department of Geography at Birzeit University with the following specifications: cell size: 1.25*1.25 m, number of brands are 3, coloured. Its format is Enhanced Compression Wavelet (.ecw). Its Spatial Reference is: Israel_Tm_Grid, datum: D_Israel (Figure 3(a)). The map for the year 2014 was made available by the Ministry of Local Government with the following specifications: cell size: 0.25* 0.25 m, number of brands are 3, coloured. Its format is Enhanced Compression Wavelet (.ecw). Its spatial reference is: Israel_TM_Grid, datum: D_Israel (Figure 3(b)). It must be noted that due to the political situation and for security measures, Palestinians are forbidden from producing professional aerial photography. Therefore, according to A. Hjuj (personal communication, 21 September 2017)—the director of the Urban Planning and Architectural Organization Department in the Ministry of Local Government—the maps were bought from specialised private Israeli companies, which usually blur the important Israeli operated areas on the map, as seen at the southern end of the 2014 map in Figure 3(b).

Study method

This research assesses issues related to landscape transformation and development, addressing the physical change of tangible and measurable evidence. It traces the actual physical change in the landscapes to investigate development over time, and measures this development in terms of land cover and land-use, as demonstrated in changes on the maps (Figure 4). The landscape change was examined using GIS mapping and statistical analysis which produced an overview of the evident measurable changes. ArcMap 10.3 was used to analyse both photos using the manual digitization method (heads-up-on-screen) to identify different landscape classes in the area. Later, the maps were analysed using the spatial analysis programmes—FRAGSTATS—to quantify the landscape structure and the spatial distribution of patches within the study area.

In order to investigate the actual physical changes, the CORINE Classification System was adopted from the European Environmental Agency (EEA, 1999) to create a land-use database which provided information on the status of the landscape. The CORINE classification was customised to fit the nature of the study area by classifying land-uses into three levels: level 1, level 2, and level 3 categories, with increasing degrees of detail as shown in Table 1.

The area of each land-use class was calculated for both dates. Landscape composition was quantified by measuring the area covered by each land-use class for the two periods and calculating the losses and gains of each area. This provided a quantitative comparison of the changes in the landscape classes (Figure 5). The classification of 1994 was overlaid on that of 2014 and a matrix was derived. The matrix made it possible to identify land-use/cover dynamics over time and determine the spatial and temporal pattern of the landscape. Landscape structure was assessed using FRAGSTATS; the assessment focused on the landscape and classes metrics to quantitatively study the fragmentation and patterns by evaluating the number of patches, their size, density, and average size for each class of the 2 years. Later, interviews were conducted with various members of the Planning, Engineering, and GIS departments of Ramallah Municipality, and members of the Ministry of Local Government to discuss the study and evaluate the possible socio-political reasons behind the results.

Landscape analysis results

Landscape composition

Landscape composition was quantified by means of the area covered by each class. A transition matrix was generated to quantify the overall gains and losses of the area for the different land-use classes between the studied years. In the year 1994, the dominant class was the scrub area, within which patches of other land-use classes could be found. Accordingly, the changes of each landscape class in the area between 1994 and 2014 were calculated. Tables 2, 3, and 4 show the spatial and temporal changes in the land-use classes, presenting the change and the total losses and gains for each class in hectares and in percentages.

The matrix in Table 2 illustrates the gains and losses of the respective land-use classes. It also shows the amount each class had gained or lost, to which class the land had passed, and the area of each class that remained unchanged. The matrix also describes how the landscape composition was formulated. After looking at the main gains and losses for the land-use classes in Table 3, it was important to focus on four main classes that showed a considerable change during the 20 years

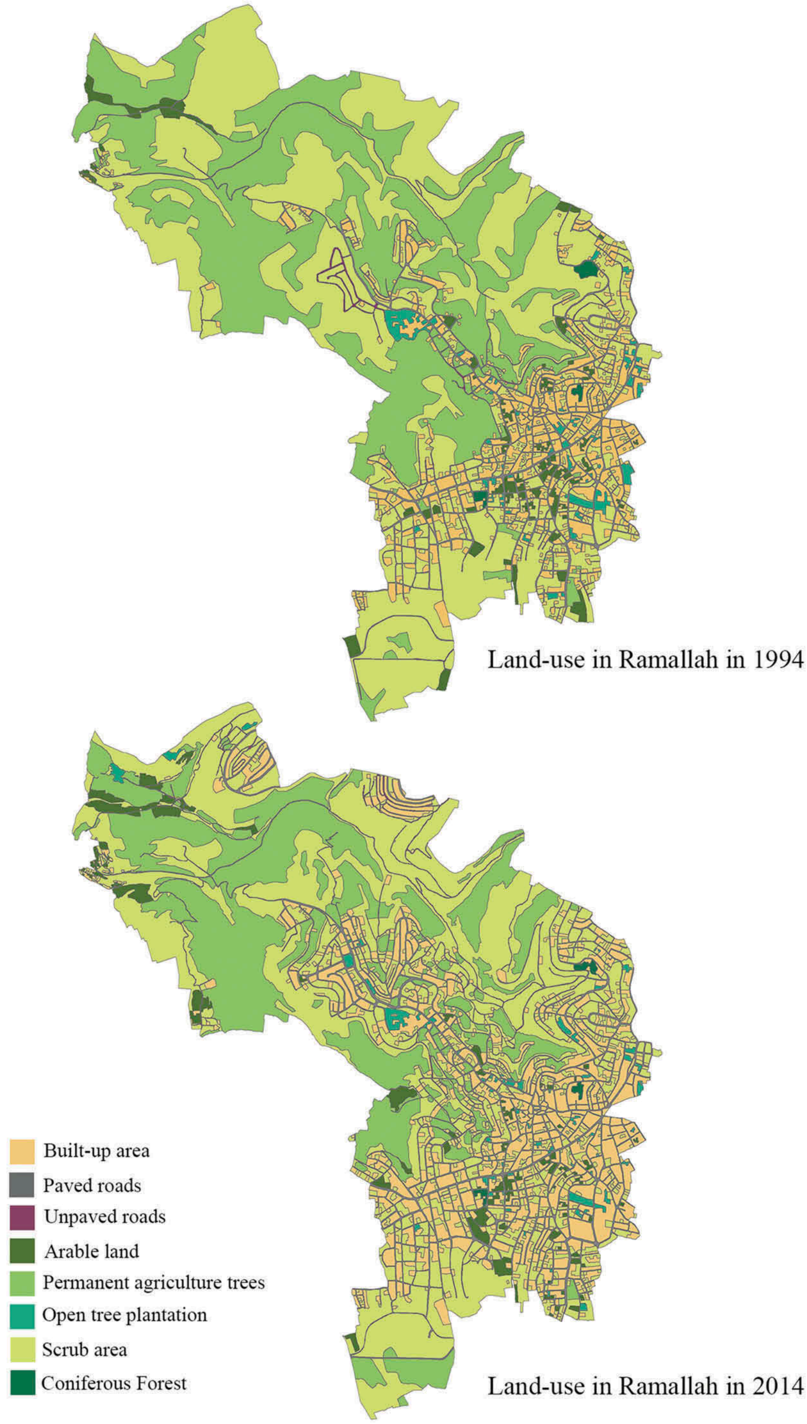

Figure 4. Landscape change between the years 1994 and 2014.

Source: Researchers. Please refer to Table 1 for land-use classes

Table 1. Land-use classes.

Land-use classes		
Land cover Level 1	Land-use Level 2	Land-use Level 3
1 Agricultural land	- Arable land (1) - Permanent agricultural trees (2)	
2 Forest - Coniferous cultivated forest - Open tree plantation	- Coniferous cultivated forest (recreation) (3) - Open tree plantation, broad-leaved (recreation) (4)	
3 Open land formation	- Scrub area (natural) (5)	
4 Built-up area	- Palestinian built-up area (6) - Roads	• Residential area, industry and commercial • Paved Roads (7) • Unpaved Roads (8)

Land-use classes:
(1) Arable land, including all areas that are cultivated with vegetables, wheat, or barley, and areas suitable for agriculture even if it is not all cultivated.
(2) Permanent agricultural trees, including areas with olive groves, vineyards, and stone fruit trees.
(3) Coniferous Cultivated forest, mainly Pinus and Cupressus species.
(4) Open tree plantations, forest consisting of bushes and scattered trees, mainly with broadleaved trees; Quercus, Ceratinia, Crataegus.
(5) Scrub area, consisting of small bushes less than 1 m in height, mainly Pittosporum spinosum with other wild woody herbs such as Thymus, Salvia species. They are of a greyish colour.
(6) Built-up area
(7) Paved roads
(8) Unpaved roads

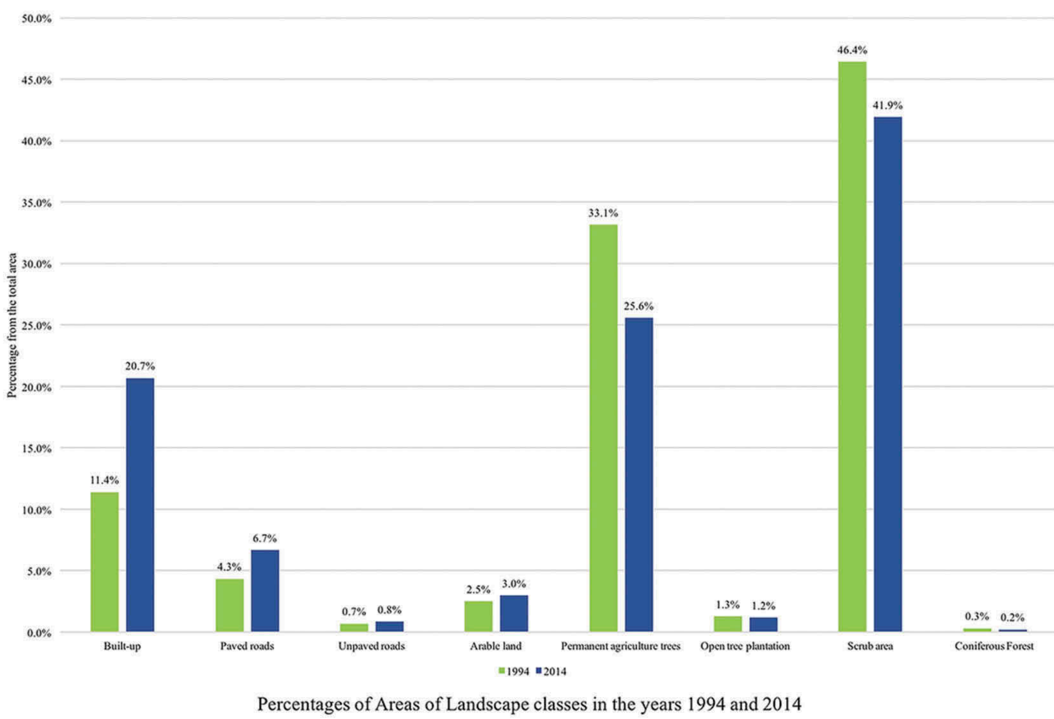

Figure 5. Landscape change between the years 1994 and 2014, percentages of landscape classes areas.
Source: Researchers

Table 2. Transition matrix shows areas in hectares of gains and losses for each landscape class between the years 1994 and 2014.

	Total Area 1994	1 Built-up	2 Paved roads	3 Unpaved roads	4 Arable land	5 Permanent agriculture trees	6 Open tree plantation	7 Scrub area	8 Coniferous Forest
1 Built-up	**219.50**	**216.15**	0.47	0.01	0.01	0.06	0.20	2.60	0.00
2 Paved roads	**83.17**	0.06	**81.74**	0.02	0.00	0.09	0.00	1.26	0.00
3 Unpaved roads	**13.08**	0.54	8.78	**1.87**	0.16	0.37	0.00	1.36	0.00
4 Arable land	**48.32**	8.75	0.52	0.29	**18.59**	2.99	1.61	15.58	0.00
5 Permanent agriculture trees	**639.11**	32.63	9.88	3.68	18.72	**407.45**	5.11	161.64	0.00
6 Open tree plantation	**24.40**	7.24	0.32	0.00	0.44	0.13	**12.88**	3.38	0.00
7 Scrub area	**895.11**	132.30	26.91	10.41	19.47	81.82	2.71	**621.45**	0.04
8 Coniferous Forest	**5.56**	0.61	0.14	0.00	0.00	0.00	0.00	0.77	**4.04**
Total area 2014	**1928.24**	**398.29**	**128.74**	**16.29**	**57.38**	**492.91**	**22.51**	**808.04**	**4.08**

In table 2, along columns shows the gain to landscape class in 2014 from other land-use classes, and indicates the changes happened to landscape classes in 2014 to/from other land-use classes. Along rows, illustrates the loss from 1994 landscape class area to 2014 other landscape class.

Table 3. Summary of the change between the years 1994 and 2014, showing areas in hectares and percentages of gains, losses, and change.

	Percentage of the area in 1994	Percentage of the area remained the same of each class	Loss (ha)	Percentage of loss	Gain (ha)	Percentage of gain	Percentage of the area 2014	Percentage of change
Built-up	11.38%	98.47%	**3.35**	1.53%	**182.14**	82.98%	20.66%	81.45%
Paved roads	4.31%	98.28%	**1.43**	1.72%	**47.01**	76.73%	6.68%	54.80%
Unpaved roads	0.68%	14.32%	**11.20**	85.68%	**14.42**	2.38%	0.84%	24.59%
Arable land	2.51%	38.46%	**29.74**	61.54%	**38.80**	8.11%	2.98%	18.74%
Permanent agriculture trees	33.14%	63.75%	**231.66**	36.25%	**85.46**	18.80%	25.56%	−22.88%
Open tree plantation	1.27%	52.81%	**11.51**	47.19%	**9.63**	4.52%	1.17%	−7.72%
Scrub area	46.42%	69.43%	**273.66**	30.57%	**186.58**	98.37%	41.91%	−9.73%
Coniferous Forest	0.29%	72.69%	**1.52**	27.31%	**0.04**	0.00%	0.21%	−26.62%

Table 4. Percentages of landscape change between the classes during the years 1994 and 2014.

	1 Built-up change	2 Paved roads change	3 Unpaved roads change	4 Arable land change	5 Permanent agriculture trees change	6 Open tree plantation change	7 Scrub area change	8 Coniferous Forest change
1 Built-up	0.0%	0.50%	−4.04%	−18.09%	−5.10%	−28.87%	−14.49%	−10.93%
2 Paved roads	−0.19%	0.0%	−66.99%	−1.07%	−1.53%	−1.30%	−2.87%	−2.47%
3 Unpaved roads	0.24%	10.53%	0.0%	−0.29%	−0.52%	−0.01%	−1.01%	0.00%
4 Arable land	3.98%	0.62%	1.06%	0.0%	−2.46%	4.77%	−0.44%	0.00%
5 Permanent agriculture trees	14.84%	11.76%	25.32%	32.54%	0.0%	20.44%	8.92%	0.00%
6 Open tree plantation	3.21%	0.38%	0.02%	−2.41%	−0.78%	0.0%	0.08%	0.00%
7 Scrub area	59.09%	30.84%	69.21%	8.06%	−12.49%	−2.76%	0.0%	−13.22%
8 Coniferous Forest	0.28%	0.16%	0.00%	0.00%	0.00%	0.00%	0.08%	0.0%
Total Change	81.45%	54.80%	24.59%	18.74%	−22.88%	−7.72%	−9.73%	−26.62%

researched. The four main classes that were analysed are: permanent agricultural trees area, scrub area, built-up area, and paved roads. It is important to note that although a considerable change occurred to the coniferous trees class, due to its small area (0.29% of the total area in 1994) it was not elaborated on through the following analysis.

By the year 2014, the main decrease in the areas was found in the permanent agriculture trees, while the main increase was in the built-up area. The permanent agriculture trees area decreased by 22.9%; changing from 33.1% of the total area in 1994 to 25.6% in 2014. Over the years, the area lost 12.5% to scrub area, 5.1% to built-up area, 2.5% and 1.5% to arable land and paved roads, respectively. Another noticeable decrease was in the scrub area, where it was reduced by 9.7%; from 46.4% of the total area in 1994 to 41.9% in 2014. Over the 20 years, the area's main change was a decrease of 14.5% to built-up area, 2.8% to paved roads, and 1% to unpaved roads. However, it gained 8.9% from the permanent agriculture trees.

The analysis showed a great increase in the built-up area by 81.5%. This is evident by the change from 11.4% of the total area in 1994 to 20.7% in 2014. The main change was a 59% gain from the scrub area, 14.8% from the permanent agriculture trees, 4% and 3.2% from arable land and open tree plantation, respectively.

The paved roads area also increased by 54.8%, since it was 4.3% of the total area in 1994, and became 6.7% in 2014. This increase was a result of gains from other classes, including 30.8% from scrub areas, 11.8% from permanent agriculture trees, and 10.5% from unpaved roads. Similarly, the unpaved roads area increased by 24.6%, from 0.7% of the total area in 1994 to 0.8% in 2014. The change was a remarkable gain from the scrub area (69.2%) and the permanent agriculture trees (25.3%), while there was a noticeable loss by 67% and 4% to the paved roads and the built-up area respectively. A summary of all gains, losses, change percentages in the two years 1994 and 2014 is shown in Tables 3 and 4.

The other land-use classes, on the other hand, did not reveal as much change as the classes above. Some of the areas registered an increase, such as the arable land which increased by 18.7%; from 2.5% of the total area in 1994 to 3% in 2014. However, other areas were diminishing, such as the open tree plantation area, which decreased by 7.7%; from 1.3% of the total area in 1994 to 1.2% in 2014, and the coniferous forest area, which decreased by 26.6%, from 0.3% of the total area in 1994 to 0.2% in 2014.

To sum up these results, the land cover classes were merged to form two main categories; the natural classes, and the man-made classes (Table 5). The natural classes were formed from natural and naturalness areas. According to Tveit et al. (2006, p. 244), naturalness areas are defined as 'the closeness to be conceived as natural'. Accordingly, the natural classes included permanent agriculture trees, scrub area, arable land, open tree plantation, and coniferous tree. On the other hand, the man-made classes included the built-up area, paved and unpaved roads. Considering this classification, the natural classes formed 83.6% of the total area in 1994, and decreased by 14.1% to form 71.8% of the area in 2014. On the other hand, the man-made classes increased by 72.1%, from 16.7% of the total area in 1994 to 28.2% in 2014.

Landscape structure

Studying the changes in the NP, PD, and MPS metrics (Table 6), in relation to the change of the areas between the studied years, show noticeable fragmentation in the permanent agriculture trees class; its NP increased by 77.6%, and the PD increased from 3.01 patch/ha in 1994 to 5.34 patch/ha in 2014, and its MPS decreased from 11.01 to 4.78 ha. Similarly, the NP of the scrub area increased by 66%, its PD increased from 18.31 to 30.3 patch/ha, and its MPS decreased from 2.54 to 1.38 ha.

On the other hand, the NP of the paved and unpaved roads decreased by 11.8% and 14.3% respectively, resulting in a decrease in their PD, and an increase in their MPS, indicating that the roads have become more connected. However, while the number of patches of the built-up area

Table 5. Area and percentages of areas and change between the man-made classes and the natural classes during the years 1994 and 2014.

	Area in 1994 (ha)	Percentage of the area in 1994	Area in 2014 (ha)	Percentage of the area in 2014	Percentage of change
Natural classes	1612.49	83.63%	1384.92	71.82%	**−14.11%**
Man-made classes	315.75	16.37%	543.32	28.18%	**72.08%**

Table 6. Class level metrics analysis during the years 1994 and 2014.

	Class Metrics							
	Class area (CA) (ha)		Number of patches (NP)		Patch Density (PD) (patch/ha)		Mean patch size (MPS) (ha)	
Class	1994	2014	1994	2014	1994	2014	1994	2014
Built-up	219.50	398.29	593	770	30.75	39.93	0.37	0.52
Paved roads	83.17	128.74	17	15	0.88	0.78	4.89	8.58
Unpaved roads	13.08	16.29	42	36	2.18	1.87	0.31	0.45
Arable land	48.32	57.38	63	82	3.27	4.25	0.77	0.70
Permanent agriculture trees	639.11	492.91	58	103	3.01	5.34	11.01	4.78
Open tree plantation	24.40	22.51	56	67	2.90	3.47	0.44	0.34
Scrub area	895.11	808.04	353	586	18.31	30.39	2.54	1.38
Coniferous Forest	5.56	4.08	3	3	0.16	0.16	1.85	1.36

increased by 29.9%, there was no significant change in its PD due to the increase of the class area (PD increased from 30.75 to 39.93 patch/ha in 2014), and there was an increase in the MPS from 0.37 to 0.52 ha. This implies compactness throughout the class. The arable land and open tree plantation area registered minor fragmentation due to a minor increase of their NP and PD, with a minor decrease occurred in MPS, while there was no fragmentation in the coniferous trees class (Figure 6).

Generally, studying the landscape metrics for the overall area (Table 7, Figure 7); the NP of the man-made classes increased by 26%, its PD increased from 33.8 to 42.6 patch/ha, while its MPS increased from 1.86 to 3.18 ha. However, the NP of the natural classes increased by 57.8%, its PD increased from 27.6 to 43.6 patch/ha, while its MPS decreased from 3.32 to 1.71 ha. These results revealed that while the man-made classes of the area have become

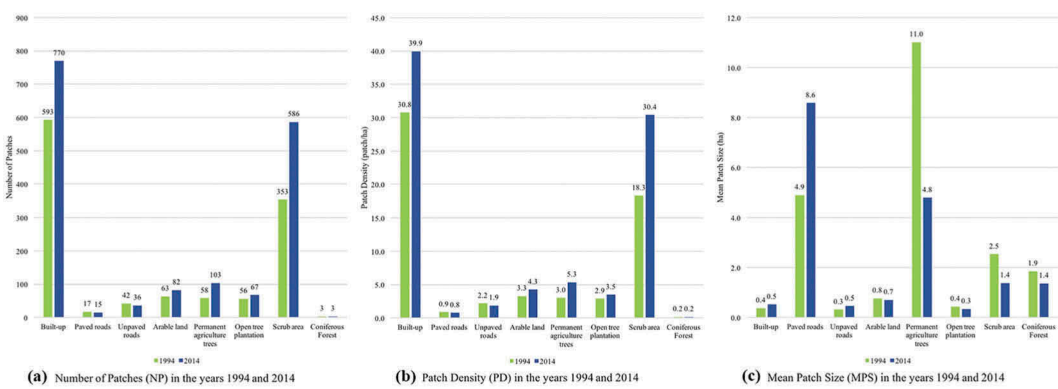

Figure 6. Change of class metrics between the different land use classes; (a) Number of patches, (b) Patch density, (c) Mean patch size.

Source: Researchers

Table 7. Summary of class level metrics analysis of the natural classes and man-made classes during the years 1994 and 2014.

	Class Metrics							
	Class area (CA) (ha)		Number of patches (NP)		Patch Density (PD) (patch/ha)		Mean patch size (MPS) (ha)	
Class	1994	2014	1994	2014	1994	2014	1994	2014
Natural Classes	1612.49	1384.92	533	841	27.64	43.61	3.32	1.71
Man-made classes	315.75	543.32	652	821	33.81	42.58	1.86	3.18

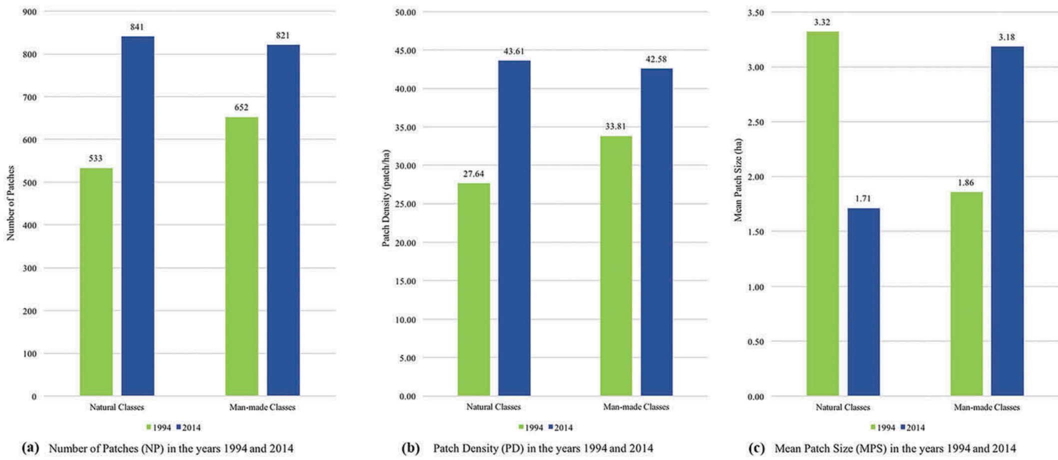

Figure 7. Change of class metrics between natural classes and man-made classes; (a) Number of patches, (b) Patch density, (c) Mean patch size.

Source: Researchers

more compacted and lacking surrounding open spaces, the natural areas have become smaller and more scattered.

Discussion

The most noticeable change was the decrease of the permanent agricultural trees area—mostly to scrub area, and the decrease in scrub area—mostly to built-up area. On the other hand, the most increase was in the built-up area and the paved roads. Other classes have changed, either by decreasing or increasing, by a small percentage of the total area. However, these changes are larger if measured individually for some of the classes. Linking these changes to the landscape metrics analysis, changes in the NP, PD, and MPS reveal new urban patterns in Ramallah, which in general became more fragmented and discontinuous. While the fragmentation was evident in the permanent agriculture trees and scrub area, the built-up area revealed a compacted structure. These changes can be considered as an alarming trend which poses a threat to additional losses of natural resources and biodiversity for further urbanisation.

Explanations behind the landscape change

The factors which led to the previously discussed land-use change are believed to include unplanned population growth and urbanisation, economic distress, and water scarcity. However, those, while strongly connected to the social, cultural, and economic demographics of Palestine in general, and Ramallah in particular, are directly affected by the occupation, and are a reaction explicit to the Israeli imposed policies. According to Khamaisi (2006), the planning process for Ramallah city is faced with dilemmas because of the unique political circumstance of the city. While the government and municipality council concentrate on developing the city into a core, the Israeli's outside control limits and restricts the possible development, accessibility, and mobilisation of the city (Khamaisi, 2006).

After the Oslo II agreement in 1995, Ramallah & Al-Bireh had to assume the role of the Palestinian Authority's new political headquarters, becoming the governmental, institutional, and economic capital of the area. The agreement also prompted an influx of Palestinian returnees who moved to Palestine in the hopes of improving the political and economic status of the country. During the same period, residents and villagers from the surrounding areas began migrating towards Ramallah looking for greater job opportunities and better living standards. This, with the natural population growth, has led to a 58.43% increase in the population of Ramallah and Al-Bireh Governorate, from 213,582 in 1997 to 338,382 in 2014 (PCBS, 1997, 2015b), which was reflected in the population density, increasing from 2.49 capita/ha in 1997 to 3.96 capita/ha in 2014 (PCBS, 2003, 2014). This unplanned population growth and the new assumed role of the city are main factors for the urbanisation of the city that caused an increase in the built-up area by 81.45%, which was gained from the scrub area, permanent agricultural trees area, arable land, and open tree plantation area (Table 4). This change is clear in Figure 4 through the urban development towards the North-West of the City Centre.

The increase in the population was faced with a decrease in the area which Palestinians are allowed to build on. As previously mentioned in the *Study Case* section, and as seen in Figure 2, ever since 1995, the area of Ramallah municipality which the Palestinians are permitted to build on decreased by 22.77% to include only areas A and B. According to Hamdeh, the director of the Planning Department at Ramallah Municipality, with much of the land under Israeli control, Ramallah municipality had to grant more permits to build on a smaller area within its municipal borders. This increase in the built-up area resulted in the destruction of a large amount of the natural areas in Ramallah, which the municipality could not protect since the regulations to protect natural areas were later introduced in 2011. While the municipal regulations were able to preserve the coniferous forest area, which, though limited, is protected by the municipality as a reserve, the deteriorating financial situation made it difficult to preserve much of the other green areas since they are privately owned (O. Hamdeh, personal communication, 20 September 2016).

The decrease in natural areas is also attributed to the erection of Israeli settlements on Palestinian lands, which contributed to the condensation of the built-up area in the city. A study conducted by ARIJ in 2014 concluded that from the year 2001 to 2012, around 7% (6,092.4 Ha) of the Governorate were confiscated. Moreover, the study noted that the erection of the segregation wall which extends along 89.4 km in Ramallah and Al-Bireh Governorate, and cuts through 19 Palestinian villages and towns, has led to severe damages to the Palestinian agricultural sector and farmers because of the constraints imposed on mobility and marketing (ARIJ, 2014a).

The shift from rural to urban also led to decrease in the interest in agricultural professions. In the Governorate, while the 'services and other branches' sector had the most working persons with around 38.3%, the 'construction' sector ranked third with 17.2%, and 'agriculture, hunting and fishing' came last with only 4.5% (PCBS, 2014a). One of the main factors for this change is the difference in wages; since in 2014 the average daily wage of all economic activities in Palestine was around $23.3, the average wage in agriculture sector was only $13.2 (PCBS, 2015a).

This disinterest in agricultural activities is also related to the shortage of water in Palestine, which makes maintaining agricultural areas more difficult. Israeli forces control groundwater resources and prevent Palestinians from drilling new wells and water networks or developing existing water infrastructure. In Ramallah and Al-Bireh Governorate, the Israeli water company —Mekorot—controls many deep wells which essentially serves the Israeli settlements with low water prices while selling Palestinians their own water at higher prices (ARIJ, 2014a). Hence, with the high price of the available water coupled with other job sectors proving to be more lucrative, many Palestinians have abandoned their agricultural land and practise for more profitable options, leading to a 22.88% decrease in permanent agricultural land, mostly to scrub and built up areas.

Conclusion

In summary, the current study provided an overview of the physical changes in Ramallah city. The generated transition matrix showed the gains and losses in each land-use. The analysis also showed the change in the number of patches, density, and size; studying the fragmentation of each class. Those changes correlate to the socio-political factors that are based on the imposed policies of the occupation, which have led to unplanned population growth, and caused more economic distress in the region in the form of agricultural malpractices, and the need for more places to develop. It is important to note that this study is not a single case in Palestine, but that similar findings have been documented by Alnather, 2008 in Artas valley in Palestine.

While this research achieved its objective, a more in-depth understanding of the landscape change could be possible through interviews and survey. Moreover, the research could be taken back to 1948 to give a long-term perspective on physical landscape change affected by the occupation. Finally, considering the urgency for planning policies to limit the haphazard urbanisation of the city, new legislations and strategies must be placed with the community's contribution as to increase the public awareness of the issue and create solutions for the environmental and economic issues at hand.

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Disclosure statement

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