Effect of land-use/land-cover change on the future of rainfed agriculture in the Jenin Governorate, Palestine

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Abstract: Land cover has been changed by humans throughout history. At the global level, population growth and socio-economic development have a significant impact on land resources. Recently, scholars added climate change as one of the major factors affecting land-cover transformation. In the West Bank of Palestine, the situation is more complicated, where geopolitical constraints due to the Israeli occupation and lack of control over land resources. In the West Bank, fertile land represents 16%, 87% of the cultivated land is rainfed, 11% is pastureland and 2% is irrigated. This paper focuses on the problems of agricultural land shrinkage by time and tries to reveal the major factors behind this change. The study area is Jenin, a major agricultural area in the West Bank, Palestine. Statistical data, aerial photos and related attribute data were analyzed by using GIS software. The study showed that urban growth is the major threat on agricultural lands.

Keywords: GIS; climate change; land cover; land use; rainfed agriculture; water resources.

Reference to this paper should be made as follows: Thawaba, S., Abu-Madi, M. and Özerol, G. (2017) 'Effect of land-use/land-cover change on the future of rainfed agriculture in the Jenin Governorate, Palestine', *Int. J. Global Environmental Issues*, Vol. 16, Nos. 1/2/3, pp.176–189.

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This paper is a revised and expanded version of a paper entitled 'Effect of land-use/land-cover change on the future of rainfed agriculture in the Jenin Governorate, Palestine' presented at the Second Conference of the Palestinian-Dutch Academic Cooperation Program on Water (PADUCO), The Hague, The Netherlands, 28 October 2015.

1 Introduction

In many countries, agricultural land resources face multi-dimensional challenges. Population growth, urbanisation and the absence of effective land management are the major factors threatening the agricultural land. At the global level, urbanisation encroaching into agricultural lands is expected to lead by 2050 to a loss of 5.7% of the lands that were classified as agricultural lands in 2000 (Azadi et al., 2011). One of the driving forces behind the conversion of the agricultural land into urbanised land includes the natural causes that affect agricultural productivity, namely rainfall and soil properties, while the extensive use of fertilisers and erratic rainfall patterns are impacting the agricultural yields and the consistency of incomes. Recent studies also add global warming and climate change to these factors (Chase et al., 2000; Kalnay and Cai, 2003; Mahmood et al., 2014). Furthermore, particularly in developing countries, the rural communities and farming systems are under a serious threat of rapid population growth and the transformation of agricultural land into urban areas (Jolly and Torrey, 1993;

Agoumi, 2003; Al-Bakri et al., 2013). Global urbanisation has dramatically increased during the past century from 10% in 1900 to expectedly reaching 84% in 2050 (United Nations, 2009). In the occupied Palestinian territories (OPT), which consists of the West Bank and the Gaza Strip, 73.9% of the total population was living in urban areas in 2009, and this is expected to reach 84.7% in 2050 (United Nations, 2009). Given the absence of appropriate land use policies and practices, it can be expected that population growth and urbanisation will add more pressure on natural resources, especially on agricultural land cover.

In the OPT, agricultural land is under the threat of instability due to the political situation, in addition to the mechanism of how land is allocated for urban uses, where most urban development is carried out by investors that typically implement profit-driven projects (Raddad et al., 2010). Based on the recent studies conducted in the OPT (Raddad et al., 2010; Abu Hammad and Tumeizi, 2012; Abu Kubi, 2005), main factors that influence agricultural land transformation can be categorised as follows:

- Political factors: land confiscation and control over water resources by the Israeli authorities.

- Socio-economic factors: farmers, especially smallholders, tend to sell their properties for immediate benefit of cash; daily earnings from working in the Israeli job market where numbers of workers allowed to get into the Israeli market depends on the political situation. There is a direct correlation between education and the trend of selling lands. People that receive higher education tend to have jobs with a monthly salary, which leads to abandon the agricultural land and in some cases lease or rent it and finally sell it for good price to be transformed to another function. The fragmentation of land between descendants (according to Islamic law) has its impact on land-use change.

- Population growth and urbanisation: the need for housing and services as a major pressure for transforming land into built-up areas rather than agriculture.

According to Land Research Centre, the dominant change in land use is the transformation of agricultural land into urbanised land (LRC, 2010). There are many reasons behind this land-use change, including lack of water, poverty, the need for reclamation, insufficient marketing for agricultural products, small plots, and the Israeli actions such as expropriation of land and control on peoples' movements and natural resources.

Despite the social and political relevance of land-use change and its potential impact on rainfed agriculture, to our knowledge there is no previous study that examines this topic in the context of the OPT. Studies that combine statistical and spatial data are particularly lacking. Thus, the objective of this paper is to investigate the causes of land-use change and its impact on rainfed agriculture. The empirical focus of the paper is on the Jenin Governorate, a predominantly agricultural zone located in the northern part of the West Bank. Based on the above list of factors that influence agricultural land transformation in the OPT, the paper aims to pinpoint the role of these factors, and to assess the resulting impact on rainfed agriculture by utilising both spatial and statistical data.

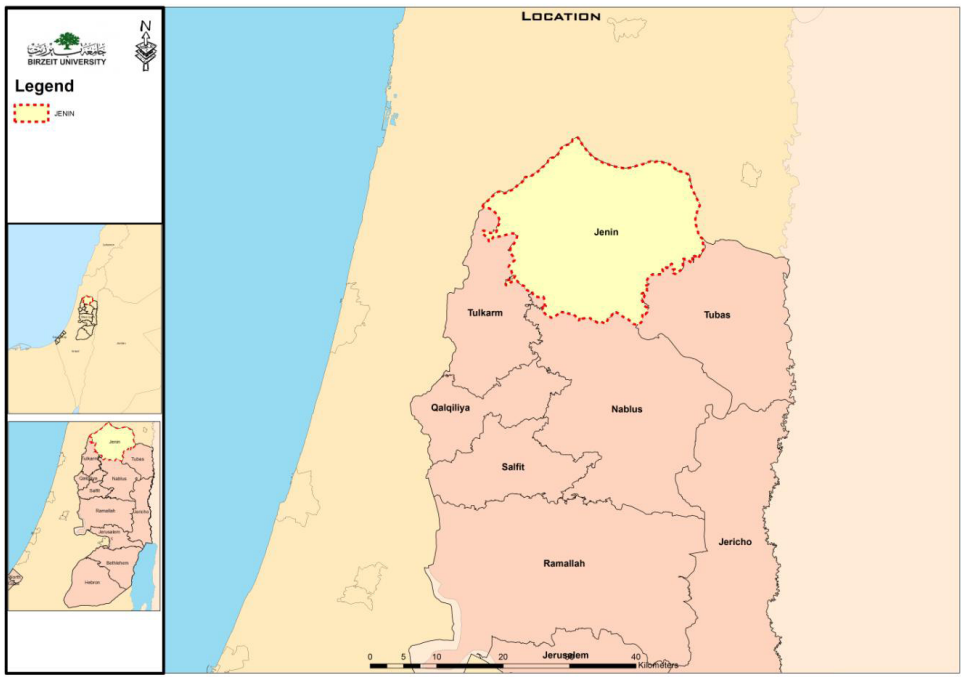
2 Materials and methods

2.1 Study site

In the past centuries Palestine has gone through different political regimes, namely the Ottoman rule, the British mandate, the Jordanian rule, the Israeli occupation and the Palestinian Authority. This complicated political and historical background impacted the land and people in the area.

In the West Bank, population density is 493 people/km² (PCBS, 2014), while most of the inhabitants are concentrated in poorly planned urban communities of 524 localities (PCBS, 2012). Urban population growth in the West Bank is 73.9%, whereas rural population growth is 16.7%. Jenin City as the governorate seat (major urban centre) has a density of 2,238 people/km^2 (PCBS, 2015). According to the Palestinian Central Bureau of Statistics (PCBS, 2015), annual population growth of the governorate is 3.8%.

Figure 1 Study site (see online version for colours)



Source: Birzeit University, GIS database

Jenin Governorate is located in the northern part of the West Bank, approximately 80 km north of Jerusalem (Figure 1). It has an area of 572 km^2. The terrain of the governorate extends between 90 and 750 metres above sea level. The governorate is bounded by Israel from the north and northern west sides, where most of the fertile land was confiscated in 1948. The eastern part is located in the Jordan Rift Valley, while the western part belongs to the coastal area of the Mediterranean Sea. The governorate has a mean annual rainfall of 528 mm for the period of 1953–1993 (PHG, 1995). Built-up area was 6.5 km^2 in 1989, which expanded to reach 13.2 km^2 in 2000, and the population grew

from 143,171 inhabitants in 1989 to 216,126 inhabitants in 2000 (ARIJ, 2004). In 1996, 61.7% of the people were living in rural areas, 6.3% in refugee camps, 27.6% in urban areas and 4.4% in semi-urban areas (PCBS, 2007). In 2015, the distribution of the population was 58% urban, 37% rural and 5% refugees (PCBS, 2015).

2.2 Data collection and analysis

In order to shed light on land-use change and its implications on rainfed agriculture, different types of data were collected and analysed in order to show if there is any correlation between these two variables. The collected data types and sources are explained below and summarised in Table 1.

Table 1 Data types and sources

	Data type	*Source*
1	Shape files	GIS Database of the Architectural Engineering Department, Birzeit University
2	Aerial photos	GIS Database Unit of the Ministry of Agriculture
		Ministry of Local Government
3	Land cover maps	Applied Research Institute (ARIJ)
		GIS Database Unit of the Ministry of Agriculture
4	Population statistics	Palestinian Central Bureau of Statistics (PCBS)

Spatial data was mainly collected from the aerial photos that were taken in during 2004, 2009 and 2014. These photos where digitised to produce the needed shape files for spatial land-use transformations. The produced shape files were as follows:

- built-up area during 2004, 2009 and 2014
- agricultural lands for the same period of time
- rainfed agriculture and irrigated lands.

Data that is related to demographic conditions and changes within the study area were collected from the published data sheets of the Palestinian Central Bureau of Statistics (PCBS).

Statistical and spatial data were linked in order to project, visualise and monitor the land-use change. Some GIS shape files were obtained from the GIS database unit of the Ministry of Agriculture and the Ministry of Local Government. Land-use/land-cover shape files were obtained from Birzeit University GIS Database/Architectural Engineering Department. By using the Arc Map GIS software, data were projected and land-use transformations were calculated after preparing the attribute data. Aerial photo for the study area was used in order to check different land uses.

3 Results and discussion

3.1 Land use types

Since 1967, the West Bank has been under Israeli control, and after the Oslo Agreement[1], which was signed in 1993 between the Palestinian Authority and Israel, some parts became under Palestinian control. Over 60% of the West Bank is still under Israeli control, which includes the Israeli settlements, Area C, water resources, major roads connecting the Israeli settlements, lands were confiscated to construct the separation wall and areas declared as military bases and military zones.

Since the Israeli occupation in 1948, political conflict impacted the population and land use dynamics. Agricultural lands were declared as forest land, military zone, and were confiscated for the establishment and expansion of Israeli settlements. Jenin hosts Palestinian refugees, who were forced to move out from their hometowns and villages and settled in what is called now the 'Jenin refugee camp'. In 2002, the construction of the Israeli segregation wall was started on the Palestinian lands, confiscating large areas from all the West Bank, while the agricultural lands in Jenin were impacted, too.

Israeli colonies occupy an area of 21.7 km^2, which represents 2.7% of the total governorate area. The built-up area of these colonies is 1.3 km^2. The separation wall annexed 3.1 km^2 of the governorate's land and isolates an area of 6.3 km^2 behind it (LRC, 2010).

Land uses according to the Ministry of Agriculture (2014) are classified as: arable land, forests, agricultural lands, Israeli settlements, mines, open spaces, Palestinian built-up area, permanent crops, greenhouses, and shrubs (Figure 2).

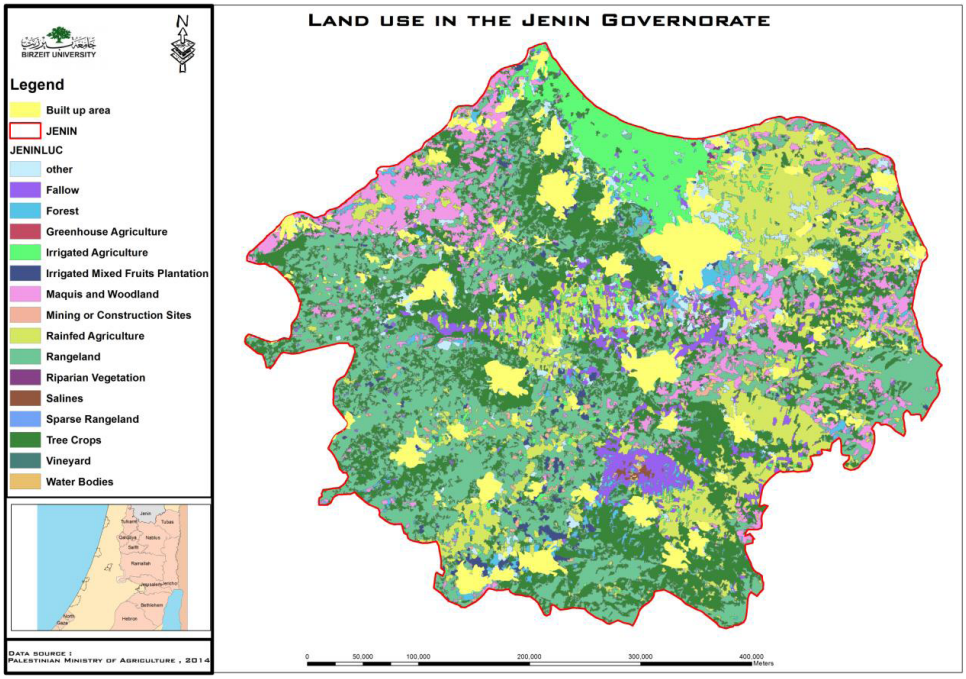
As also illustrated in Figure 2, Jenin Governorate can be considered as an agricultural area, where most of the rural areas depend on agriculture for living. The region is part of Marj Ibn Amer Valley, which has dark soils, heavy, deep and rich with organic material. The soils of this valley are very fertile and the area is famous for its agricultural practices (Abdullfatah, 2009).

Jenin Governorate produces a variety of agricultural products: fruit trees (olives, almonds, grape vines, figs, apricots and plums), field crops and forages, and vegetables, where rainfed vegetables occupies 85% of the total area for vegetable agriculture, and irrigated vegetables occupies 15% (ARIJ, 2004). The agricultural land in the Jenin Governorate that is planted with tree horticulture, vegetables, and field crops represents 19% of the total in the OPT (PCBS, 2010). According to PCBS (2010), 173 km^2 (20%) of Jenin land are cultivated with tree horticulture, vegetables and field crops.

The agricultural produce in the West Bank is classified into fruit trees (62.6%), field crops (27.6%) and vegetables (9.8%). Rainfed agriculture occupies 87% of the total cultivated land and contributes with 28.5% of the overall plant production, while irrigated land occupies 2% and the other 11% is arable land, built-up areas, roads and others (Spanish Cooperation, 2007).

According to an earlier study by ARIJ (2004), the analysis of land-use change shows that the area of agricultural land in the Jenin Governorate was 384.5 km^2 in 1989, 427.8 km^2 in 1997 and 400.1 km^2 in 2000. The same study pointed out that many factors resulted in this change which includes political instability and socio-economic factors.

Figure 2 Land use in the Jenin Governorate (see online version for colours)

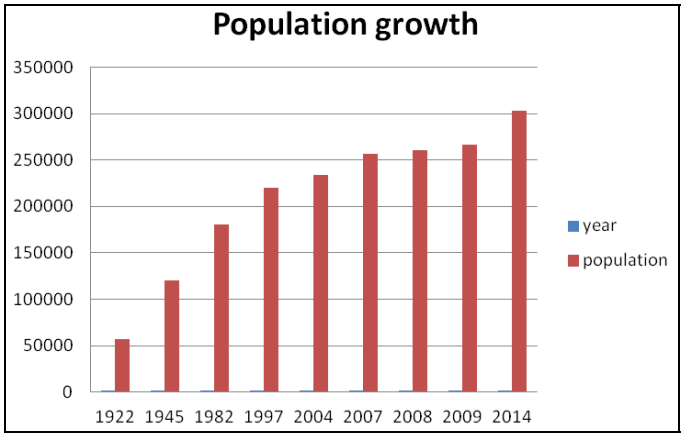


Source: Ministry of Agriculture (2014)

3.2 Population growth

Population growth is a major factor leading to land-use change in order to accommodate the new born and new comers. In the study area, increasing population is among the main pressures that can be associated with land-use transformation (Figure 3).

Figure 3 Population growth (see online version for colours)



Source: PCBS (2007) and ARIJ (1996)

In the Jenin Governorate, population growth has been affected by natural, manmade and political factors. Population density of the governorate in 2007 was 439 people/km^2 (PCBS, 2007).

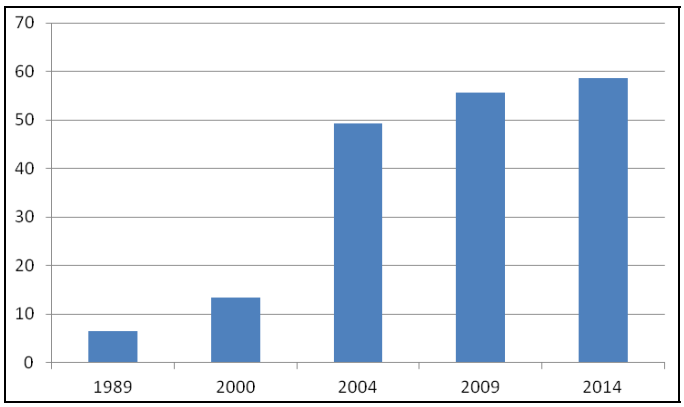
The workforce in agriculture was impacted by instable political situation in the OPT. Particularly, the first intifada in 1987, the second intifada in 2000 and the construction of the separation wall by Israel resulted in significant constraints regarding the mobility of Palestinians. In 1998, the workforce in agriculture was 21.1% of the total workforce and declined to reach 12.11% in 2004 (PCBS, 2010).

3.3 Urbanisation

In this paper, the major factor that is examined using spatial data is urbanisation, since uncontrolled urban expansion is threatening the environment and the agricultural land surrounding the urbanising communities. This pressure of urban development is challenging the limited natural resources both in irrigated and rainfed agricultural lands.

According to the Ministry of Planning and Local Government (2008), the governorate's population in 2007 was 256,619 with 42% living in urban areas, 54% in rural areas and 4% in the refugee camp. The governorate consists of 80 localities with Jenin City as the major urban centre.

Figure 4 Built-up area in the Jenin Governorate (see online version for colours)

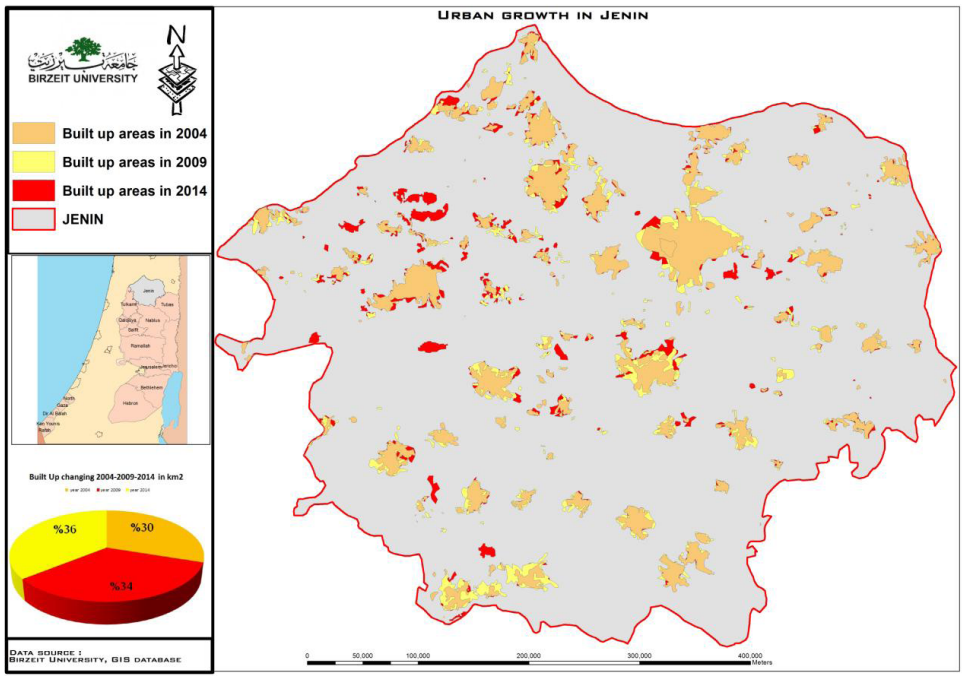


Source: Birzeit University, GIS database

Palestinian built-up area was 6.5 km^2 in 1998 and it expanded to reach 13.2 km^2 in the year 2000. The annual rate of growth in built-up area for the period of 1989–1995 was 0.479 km^2 per year, while in the period of 1995–2000 it was 0.754 km^2 per year (ARIJ, 2004). According to the data provided by the Ministry of Agriculture (2014), built-up area for the year 2004 was 49.2 km^2, for the year 2009 it was 55.6 km^2 and in the year 2014 it reached 58.6 km^2 (Figure 4).

Figure 5 shows the spatial distribution of the built-up area in the governorate. From the aerial photo, which was used to create the shape files, it is clear that localities were surrounded by agricultural land, and from 2004 until 2004, urban areas sprawled into the periphery areas.

Figure 5 Urban growth in Jenin (see online version for colours)



Source: Birzeit University, GIS database

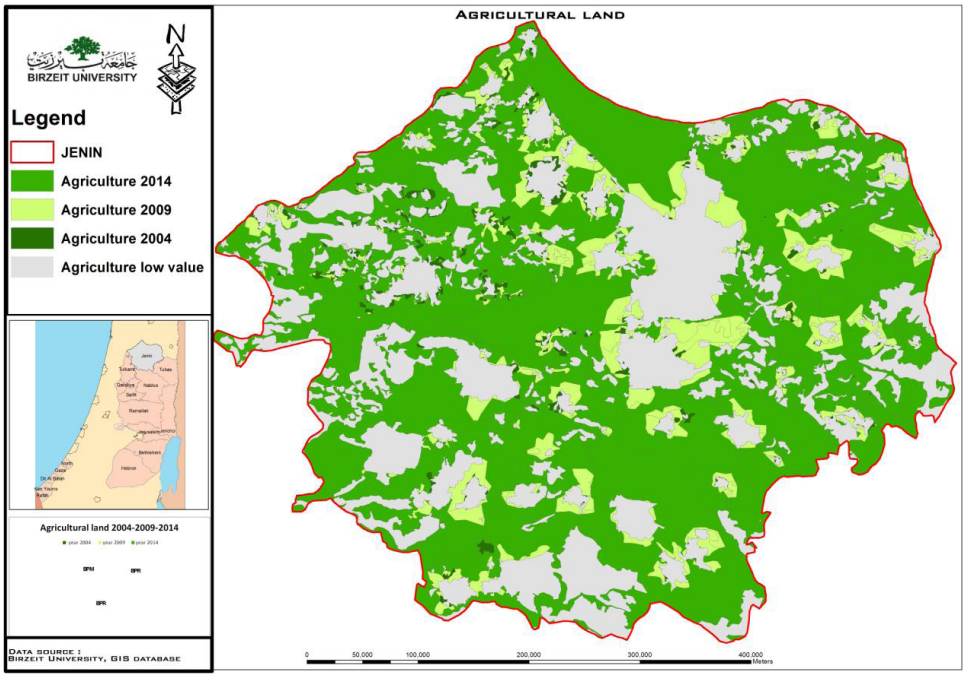
3.4 Shrinking agricultural lands

Figure 6 shows the shrinking agricultural lands in the governorate, and it is clear that there is a correlation between urban growth and the loss of agricultural land.

The examination of the agricultural land shows that the total agricultural area in 2004 was 411.67 km^2, while in 2014 it became 346.72 km^2, which means an approximate 6.5 km^2 loss in agricultural land per year.

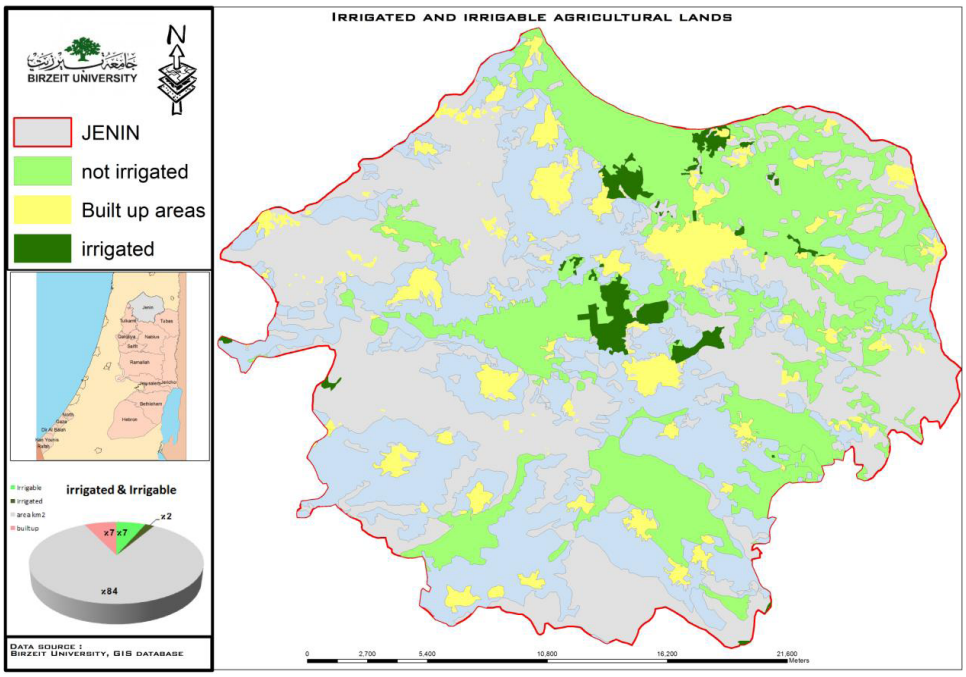
In the study area, agricultural lands are divided into two types: rainfed and irrigated[2]. The rainfed (irrigable) type is the most dominant type, while irrigated lands are occupying small areas around the Jenin City, where water wells are used. Figure 7 shows the location and the size of the rainfed agriculture, where olive trees are the dominant agriculture type.

Figure 6 Agricultural land (see online version for colours)



Source: Birzeit University, GIS database

Figure 7 Irrigated and irrigable agricultural lands (see online version for colours)



Source: Birzeit University, GIS database

The analysis shows that agricultural lands in the Jenin Governorate are under threats of mismanagement, which is related to urban growth and sprawl towards fertile lands due to inter-related factors. These factors include but are not limited to socio-economic factors such as poverty, inheritance and land tenure system, where descendants divide the land between them which leads to make farming a non-profitable skill, because the product is in small amounts and others end up by selling their shares. Another issue is related to land-use control and planning mechanisms. At the governance level, there is no master or regional plan for future development, and also there is no protection plan for sensitive and high-value areas. This finally led to the profound loss in the fertile agricultural lands. This land-use\cover transformation impacted the agricultural sector as it can be observed from the projected spatial data in Figures 3 and 4.

As mentioned before, many factors played a role in the spatial map of land-use change in the governorate: water availability, socio-economic factors, workforce and instability in political situation, inheritance system for land and lot size.

Figure 8 shows the landscape of the area, where urban development is taking place on the agricultural areas around the city and the surrounding villages in the study area. The figure shows that urban development is sprawling, whereas there exists no guidelines or regulations to manage this pattern.

Figure 8 Jenin area (Jenin municipality site) (see online version for colours)

4 Conclusions

This paper investigated the causes of land-use change in the Jenin Governorate and the impact of this change on agricultural land resources, with a particular focus on rainfed agriculture. Jenin Governorate is not a unique case in the OPT land-use change, since such changes are taking place in all governorates. Limited availability of land and the geo-political situation in the West Bank are impacting land-use\cover at the regional level.

In terms of land-use/cover, a major challenge facing both rainfed and irrigated agriculture in Jenin is urban growth and the associated expansion of built-up areas. In the

study site, built-up area was monitored for ten years, from 2004 until 2014. The analysis of the spatial data showed that urban growth is found to be one of the major pressures on agricultural land. Built-up area expansion in Jenin City is taking place on the fertile irrigated agricultural lands, while it is encroaching into the rainfed agricultural lands in the other localities in the governorate. If urban growth would continue in the same rate of 6 km^2 per year, the governorate will face a significant problem regarding agricultural production and food security.

The Jenin case is a typical example of land-use transformation that impacts agricultural land resources. If the existing urban development is not monitored adequately and guidelines are not formulated for future urban development, natural resources, and particularly agricultural land resources, are likely to be depleted rapidly and even lost irreversibly. Under these alarming conditions, public and policy attention should focus on the development and implementation of mechanisms for the protection of agricultural land resources. Finally, there is an urgent need to prepare a master plan that will demonstrate how and where to absorb urban growth with minimal negative impact on natural resources.

Acknowledgements

This work was performed within the framework of the Palestinian-Dutch Academic Cooperation Program on Water (PADUCO), funded by the Netherlands Representative Office (NRO) in Ramallah, Palestine. The financial support is gratefully acknowledged.

References

Abdullfatah, K. (2009) 'Marj Ibn Amer', *This Week in Palestine*, No. 139 [online] http://archive.thisweekinpalestine.com/details.php?id=2924&ed=175&edid=175 (accessed September 2015).

Abu Hammad, A. and Tumeizi, A. (2012) 'Land degradation: socioeconomic and environmental causes and consequences in the Eastern Mediterranean', *Land Degradation and Development*, Vol. 23, No. 3, pp.216–226.

Abu Kubi, M. (2005) 'Detection and mapping of the land use/land cover (LULC) changes in the 'Jordan Valley' using LANDSAT imageries', *Environmental Monitoring in the South-Eastern Mediterranean Region using RS/GIS Techniques, Option Méditerraéennes – Séerie B*, No. 46, p.16.

Agoumi, A. (2003) *Vulnerability Studies on Three North Africa Countries (Algeria, Morocco and Tunisia) with Respect to Climatic Changes*, Final report of UNEP-GEF Project RAB94G31, The International Institute for Sustainable Development, Manitoba, Canada.

Al-Bakri, J., Salahat, M., Suleiman, A., Suifan, M., Hamdan, M.R., Khresat S. and Kandakji, T. (2013) 'Impact of climate and land use changes on water and food security in Jordan', Special Issue: Tragedy or Transcendence: Reflections on 'The Tragedy of the Commons, *Sustainability*, Vol. 5, pp.724–748.

ARIJ (1996) *Environmental Profile for the West Bank*, Vol. 7, Jenin District, Jerusalem.

ARIJ (2004) *Impact of Urbanization on Land Use and Local Communities in the West Bank*, Technical report, Jerusalem.

Azadi, H., Ho, P. and Hasfiati, L. (2011) 'Agricultural land conversion drivers: a comparison between less developed, developing and developed countries', *Land Degradation and Development*, Vol. 22, No. 6, pp.596–604.

Chase, T.N., Pielke Sr., R.A., Kittel, T.G.F., Nemani, R.R. and Running, S.W. (2000) 'Simulated impacts of historical land cover changes on global climate in northern winter', *Climate Dynamics*, Vol. 16, Nos. 2–3, pp.93–105.

Jolly, C.L. and Torrey, B.B. (1993) 'Population and land use in developing countries', *Report of a Workshop*, Committee on Population, Commission on Behavioural and Social Sciences and Education, National Research Council, National Academy Press, Washington, DC.

Kalnay, E. and Cai, M. (2003) 'Impact of urbanization and land use on climate change', *Nature*, Vol. 423, No. 6939, pp.528–531.

Land Research Center (LRC) (2010) *Land Suitability for Reclamation and Development in the West Bank*, Halhul, Hebron, Palestine.

Mahmood, R., Pielke, R.A., Hubbard, K.G., Niyogi, D., Dirmeyer, P.A., McAlpine, C., Carleton, A.M., Hale, R., Gameda, S., Beltrán-Przekurat, A. and Baker, B. (2014) 'Land cover changes and their biogeophysical effects on climate', *International Journal of Climatology*, Vol. 34, No. 4, pp.929–953.

Ministry of Agriculture (2014) *GIS Unit Database*, Ramallah.

Ministry of Planning and Local Government (2008) *Jenin District Strategic Development Plan* [online] http://www.molg.pna.ps/studies/SummaryJDSDPEnglish.pdf (accessed 29 August 2015).

Palestinian Central Bureau of Statistics (PCBS) (2007) *Estimated Population n the Palestinian Territory Mid-Year by Governorate, 1997–2016* [online] http://www.pcbs.gov.ps/Portals/_Rainbow/Documents/gover_e.htm (accessed October 2015).

Palestinian Central Bureau of Statistics (PCBS) (2010) *Final Results for the First Agricultural Census in the Palestinian Territory*.

Palestinian Central Bureau of Statistics (PCBS) (2012) *Statistical Year Book of Palestine 2012*, PCBS, Ramallah.

Palestinian Central Bureau of Statistics (PCBS) (2014) *Palestinian Population Brief* [online] http://www.pcbs.gov.ps/site/512/default.aspx?tabID=512&lang=ar&ItemID=1166&mid=3265&wversion=Staging (accessed March 2015).

Palestinian Central Bureau of Statistics (PCBS) (2015) *Population Estimates of the Communities in Jenin Governorate: 2007–2016*.

Palestinian Hydrology Group (PHG) (1995) *Analysis of Secondary Source Rainfall Data from North West Bank*, Jerusalem.

Raddad, S., Salleh, A.G. and Samat, N. (2010) 'Determinants of agriculture land use change in Palestinian urban environment: urban planners at local governments' perspective', *American-Eurasian Journal of Sustainable Agriculture*, Vol. 4, No. 1, pp.30–38.

Spanish Cooperation (2007) *A Review of the Palestinian Agricultural Sector*, Jerusalem, ISBN 978-9950-304-03-1.

United Nations (2009) *Urban and Rural Areas* [online] http://www.un.org./en/development/desa/population/publications/pdf/urbanization/urbanization-wallchart2009.pdf (accessed 25 August 2015).

Notes

1 The outcome of the Oslo Accords is land division of the West Bank into three categories: Area A, is under full Palestinian control, it is mainly consists of Palestinian urban areas, Area B, is the area that Palestinian control civil affairs and Israeli military forces control security, Area C, is the rural lands and this area is under full Israeli control, this area is over 60% of the West Bank

2 In this paper irrigated agricultural land is defined as the land that depends on pumped water for agricultural production and it is located nearby the localities where the only source for

water is the water pumped from the surrounding wells, which is used for both domestic and agricultural purposes.

Irrigable/rainfed agricultural land is defined as the land that depends mainly on rainfall and it is located on the periphery of the localities (typical crops are olive, almond, lentil), some kinds might use tank water (eggplant, cabbage).