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Impact of Population Growth on Land Use Changes in Wadi Ziqlab of Jordan between 1952 and 2008

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Abstract Three sets of remotely sensed data were used to measures the land use/land cover changes in Wadi Ziqlab catchment during the period 1953-2008. Its population increased from 11162 in 1952 to 63970 in 2004. The population growth have resulted into changing the land use/land cover of 4414 ha (42%) of the catchment area. The main changes show that orchard trees and urban areas increased by 22.4% and 6.2% into field crops, forest and rangeland areas. The ownership data indicates the presence of 44843 plots in the catchment, 68.9% of these have the area of less than 1 ha.

Keywords Spatial analysis, Remote sensing, Land fragmentation, Land use/land cover, Wadi Ziqlab

1. Introduction

Global land use has significantly changed during the past decades. Historically, the driving force for most of land use changes is population growth [26]. Population growth is often used as a proxy for land use change [11], but at lower scales, a set of complex drivers are important too [12]. Increasing demand on food as a result of population growth has created more pressure on land resources [1].

Objectives for land use change differ between the developed and developing countries. In developed countries, land use change is based on economic reasons such as large scale farming or urban development and an increasing need to conserve biodiversity and environmental quality for current and future generations [3], whereas in the developing countries, rapid population growth, poverty and the economic situation are the main driving forces [13, 17, 26].

The Mediterranean region has been affected by anthropic disturbance for thousands of years, and is, nowadays, one of the most significantly altered hotspots in the world [9].

Wadi Ziqlab catchment is part of the Northwest Jordanian mountains. In an evaluation of the woodland and range in Wadi Zeqlab it was found that the natural vegetation cover decreased between 1953 to 2000, due to deforestation, overgrazing, and expansion of agriculture and urban areas. The cultivated areas (olives and field crops) are concentrated near urban areas [25].

Deforestation in Wadi Ziqlab catchment and is considered as the main cause of land degradation [10]. During the last two decades, less than 60 thousands forest trees were removed and replaced with fruit trees, houses, or buildings [20].

Fragmentation is also considered as a major problem, which prevents land development. Multiple ownership of single plot is also dominant and hinders proper farming. Thus, land left unused and exposed to degradation.

The analysis of the study area on a territorial basis involves the use of Geographical Information System (GIS), for the management, analysis and representation of the real world. Satellite remote sensing allows a retrospective, synoptic viewing of large regions, thus providing the potential for a geographically and temporally detailed assessment of land-use/ land cover changes in estuarine watersheds [29, 22]. Remote sensing (RS) provides information about the various spatial criteria/ factors under consideration, can provide us the information like land use/land cover, drainage density, topography etc. RS in combination with GIS are powerful tools to integrate and interpret data. The integrated GIS and RS technology apart from saving time and yielding good data quality have the ability to locate potential new cropland sites [14].

The general objective of this study was to evaluate the extent of land use/land cover changes within Wadi Ziqlab catchment and to investigate the impact of population growth and land tenure on these changes.

The specific objectives were to:

- Assess temporal land use/ land cover change and land ownership in the study area.
- Identify possible factors that governed land use/land cover changes and the distribution of different land utilizations during specific period of time.

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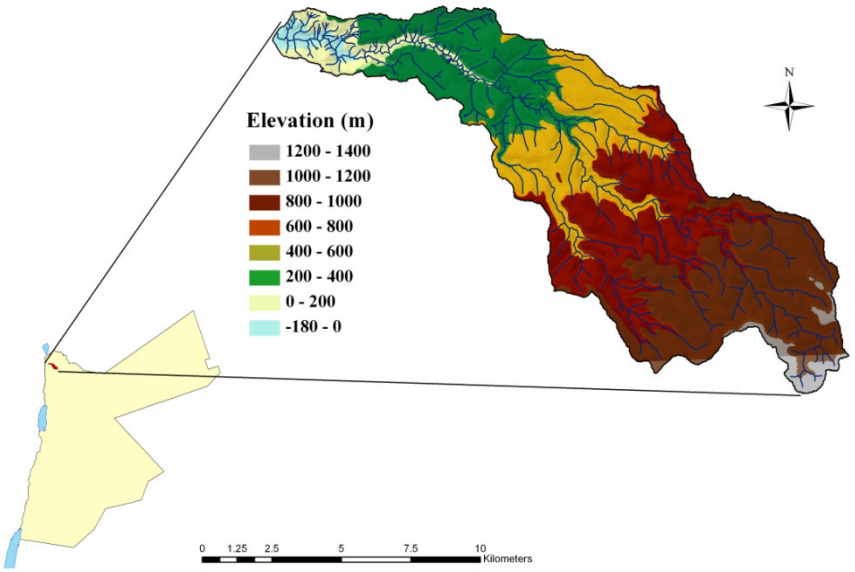

Figure 1. Location of study area, showing the boundary of Wadi Ziqlab catchment

2. Study Area

Wadi Ziqlab catchment is located within an area that extends from the Highlands of Northern Jordan, to Eastern mountains bordering Jordan Valley. The study area is located between 32°23"- 32°34" North to 35°33"- 35°50" East. The catchment is 24 km long, 8 km wide, and covers about 105 km² (Figure 1).

Wadi Ziqlab occupies one of the steep areas located in the east bank of Jordan Valley. It extends from the western part of the plateau around Irbid into the Valley floor. The elevation within the catchment is highly variable. It falls from 1075 m above sea level, at the upper South-East portion of the catchment, to about 200 m below sea level, at the confluence of the Wadi Ziqlab with the main stream of the Jordan Valley in the West [10]. The general direction of drainage area is to the West-Northwest.

Rainfall at Wadi Ziqlab catchment varies according to elevation, rainfall records indicated variations in rainfall distribution within the catchment as well as variation in the annual rainfall. The Eastern parts receive an annual average of 528 mm/year, whereas the Western parts receive only 375 mm/year.

Air temperature at Wadi Ziqlab catchment changes according to elevation. Mean annual maximum air temperature was 29.9°C and 29.2°C at Baqura and DeirAlla stations, respectively for the Western part of the catchment, while the mean annual maximum temperature was 23.1°C, and 18.5°C, at Irbid and Ras Muneef stations, respectively, for the Eastern part of the catchment. The mean annual minimum air temperature was 17.9°C and 15.7°C at Baqura and DeirAlla, respectively for Western part of the catchment. While the mean annual minimum air temperature was 12.7°C, and 10.1°C, at Irbid, and Ras Muneef stations, respectively, for Eastern part of the catchment.

3. Methods

GIS software was used as a platform for data analyses and management of products. The following maps and data were used in this study:

- Topographic maps at scale of 1:25000 -produced by Royal Jordanian Geographic Center (RJGC) in 1997- was used to produce the contour lines and Digital Elevation Model (DEM) map.
- Different land cover maps were produced, using aerial photos at scale 1:10,000 obtained from (RJGC) for year 1953 and 1978. Satellite image Quick Bird, resolution (60 cm) prepared by (RJGC) 2008.
- Ownership and land size distribution map was produced, using cadastral maps at scale 1:10000 obtained from (Land and Survey Department-Jordan, 2004).
- The polygon boundaries were digitized by on-screen digitizing, for topographic maps, aerial photo for years 1953 and 1978, and satellite image for year 2008.

Satellite image (2008) and aerial photos (1953 and 1978) were analyzed and classified to investigate land covers and land cover changes during the period from 1953-2008.

Aerial photos were scanned, geo-referenced to the coordinate system (WGS84, projection: UTM zone 36) using a topographic map which was produced in 1978 at a scale of 1:25000 by RJGC. An image-to-image registration technique in the ERDAS imagine 9.3 software was used to geo-reference and mosaic of the 24 aerial photos for 1953, and 1978. The satellite images and other maps used in this study were projected to a common coordinate system and resampled to the same spatial resolution (60 cm).

Visual interpretation of aerial photos and satellite images was enhanced to draw the land covers maps for 1953, 1978 and 2008 with ArcGIS 9.1 software.

Field visits were carried out to validate the results of land

cover interpretation and for description of the characteristics of each land cover class and land use. Selective sampling technique was used for this purpose.

Cadastral maps that cover the study area were obtained in digital format from the Land and Survey Department (LSD), and were transformed and reclassified according to ownerships and parcel size using GIS. Land ownership was classified for each plot according to the type of ownership (Government or private land). The cadastral maps were classified according to parcel size according to the following categories: ≤0.10 ha, 0.11-0.20 ha, 0.21-0.40 ha, 0.41-1.0 ha, 1.1-2.0 ha, 2.1-3.0 ha, 3.1-5.0 ha, and >5 ha. The cadastral map (for selected villages) was overlaid with different land covers at various dates to evaluate effect of plot size on land use/land cover change.

4. Results and Discussion

4.1. Land Use/ Land Cover in 1953

The land use/land cover analyses of 1953 showed that 9975 ha (95% of the catchment area) was under range use, forest and field crops (Table 1). Steep, shallow, and rocky land covered about 7329 ha (70%) was not cultivated, and was covered with forest and range.

Field crops were mainly cultivated on flat areas. Production of wheat, barley, and vegetables was sufficient to satisfy the need of people and the animal. Family labour and farm animals (Oxen and Horses) were used to plow the land and sow the seeds.

Small areas were planted with olive trees 399 ha (3.8%). Mostly, at stream-sides protected with soil conservation measure where danger of erosion is minimum. Olive tree has long been observed as sacred, and has major agriculture importance as source of daily food and olive oil. Urban areas covered only 118 ha (1.1%).

Table 1. Land use/land cover pattern during different years (Area in hectare)

Land use/land cover classes	1953	1978	2008	% change (1953-2008)
Field crop	2646	2249	1301	-12.8
Orchard (olive)	399	855	2745	+22.4
Forest	3412	3487	3081	-3.2
Range	3917	3539	2489	-13.6
Irrigated	2	32	43	+0.4
Urban	118	308	767	+6.2
Dam		25	25	+0.2
Quarries	0	0	35	+0.3
Animal farm	0	0	10	+0.1
Total	10495	10495	10495	

4.2. Dynamics of Land Use/Cover Change during the 1953-2008 Period

Figure 2 and Table 1 show the distribution of different land use/land covers during the periods of 1953-1978, and 1978-2008.

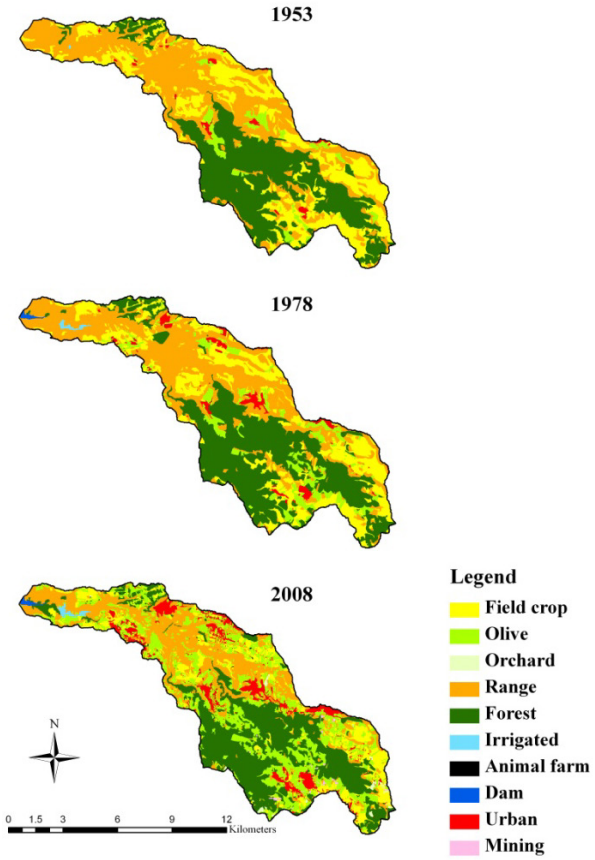

Figure 2. Land use/land cover in 1953, 1978, and 2008

During the period from 1953 to 2008, about 4414 ha (42%) was changed from one land use/cover to another, while 6081 ha (58%) of the land use was never changed since 1953.

Changes during 1953-1978 period revealed that the area covered with olives and urban has increased from 517 ha to 1163 ha. Orchards were concentrated, mostly, around villages.

The increase in urban and olive trees areas was on the expense of field crops and range areas (-7.4%) (Figure 3). Meanwhile, Forest areas increased because of the afforestation project carried out by Ministry of Agriculture [18].

Land use/cover changes by 2008 show more expansion of olive and urban areas (Figure 3). Orchards and olive trees cultivation expanded on a steep, rocky, and stony area, which was not suitable for field crops covering 2745 ha (26.2%) in 2008. This expansion also generated better income than field crops.

Soil conservation measures were implemented by different projects of Ministry of Agriculture such as Zarqa river basin project and Yarmouk river basin project. These measures were taken to reduce the effect of run-off, control erosion, and discourage the growth of gullies [28, 5], and reduce the silt deposition at downstream [24]. This eventually made cultivating areas under these conservation schemes possible [28, 24].

High resolution satellite image for 2008 identified that the forest area decreased by 331 ha (-3.1%) due to deforestation; these changes were mainly within the private forests. The development of road network and availability of machineries provided the farmers with better access and facility to clear and cultivate their privately owned forest or replace it with olives trees or other orchard trees.

Urban area expanded to cultivated lands covering 767 ha (7.3% of the area). It was uniformly expanded around the old villages, and on farms far from the villages.

Rangeland, forest and field crops covered only about 6871 ha (65.5%) in 2008.

4.3. Population Growth

Among the 21 villages located within the catchment, 64% of areas allocated to these villages fall within Wadi Ziqlab catchment (Figure 4).

Population of Wadi Ziqlab catchment and the area bordering the catchment was only 11162 people in 1952. It increased to 29719 and 63970 capita in 1979 and 2004 respectively. Table 2 shows the population and the population density for each village at different periods.

The population density in catchment varied from 87 to 154 person/km^2 in 1952, and increased to 389 to 943 person/km^2 in 2008 (Table 2).

Tebneh village had the highest population density (214 capita/km^2) in 1952, which increased to (1379 capita/km^2) in 2004. Samad village had low population density, which was (49 capita/km^2) in 1952, and increased to 89 capita/km^2 in 2004.

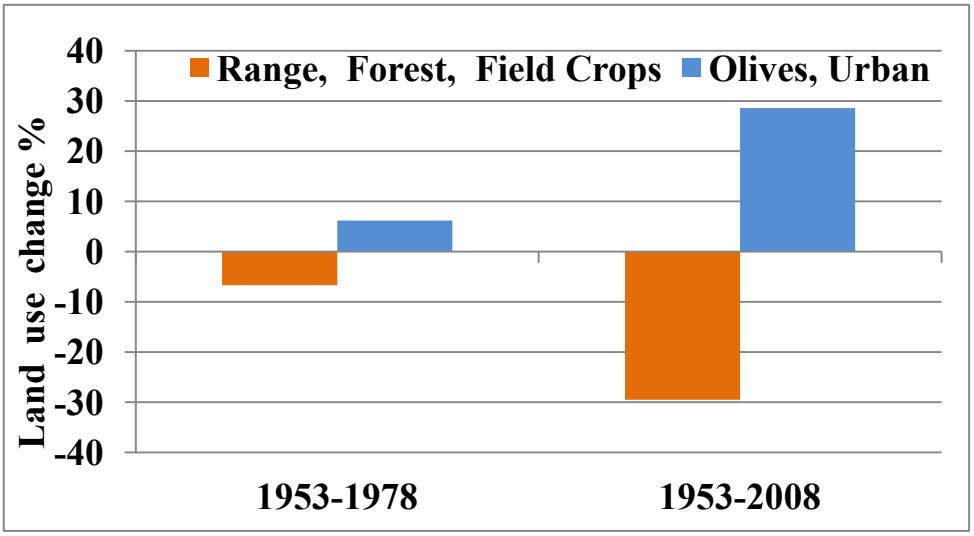

Figure 3. Land use/land cover % change in 1953-1978, and 1978-2008

Table 2. Distribution of population and population density for each village at different periods from 1952-2004

Village name	Registered village area (ha)	Population			Density person/km^2		
		1952	1979	2004	1952	1979	2004
Deir Abo Saeed	1208	1587	4780	14145	131	396	1171
Enbeh	1372	1198	2655	6662	87	194	486
Jenien Essafa	721	801	1688	3752	111	234	521
Kofor Kiefia	213	147	384	618	69	181	291
Mazar Shamaliyyeh	1597	2442	6642	12422	153	416	778
Merehba	227	238	699	*	105	308	*
Irhaba	954	1120	3250	7655	117	341	802
Rkhayyem	623	0	27	129	0	4	21
Samad	1214	599	1128	1086	49	93	89
Sammo	518	796	2529	6213	154	488	1199
Samt	158	204	785	*	129	497	*
Sowwan	475	0	8	12	0	2	3
Tebneh	421	900	2161	5805	214	513	1379
Zmal	466	700	1602	3028	150	344	650
Zoobya	437	430	1381	2860	98	316	655
Total	10600	11162	29719	64387	105	280	607

Source: Department of Statistics, reports: 1952, 1978, and 2004.
* These village are currently part of Deir Abo Saeed.

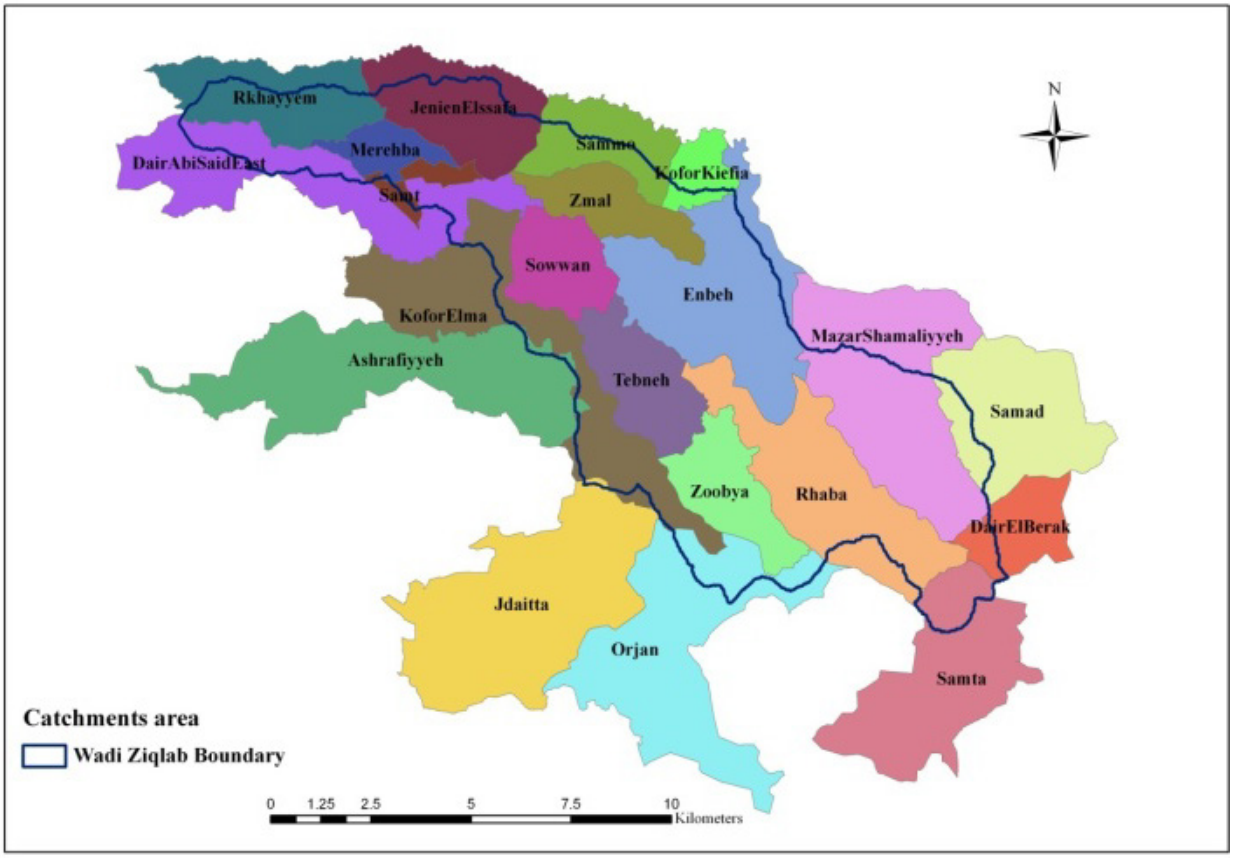

Figure 4. Villages boundary located within WadiZiqlab catchment

4.4. Fragmentation and Plot Size

Generally, in Jordan, land fragmentation occurred on private land. Area of private land within the catchment is 7506 ha, or 71.5% of total area (Table 3). According to the cadastral map of 2004, private lands were classified into eight classes based on plot size.

The analyses of plot sizes indicated that private land suffers from severe fragmentation. Data documented the presence of more than 44843 plots.

The largest area (1874 ha, 25%) occurs within 1-2 ha category, followed by 1604 ha (21%), which occurs within 0.4-1 ha category.

According to plot number, 11262 plots (25%) occurred within less 0.1 ha category, followed by 0.4-1 ha category, which included 10125 plots (22.6%).

Most of the plots near or around the villages land occur on lands with <0.1 ha category, while the other blocks are those far from the village usually divided by families not individuals (Figure 5).

Dynamics of different land use/ land cover in plot size classes indicate that olive grew to be cultivated mostly within 0.4-1 ha, and 1-2 ha categories far from residential areas into forest and rangeland areas (Figure 6).

Meanwhile, most of the reduction in the area cultivated with field crops occurred within plots of <0.4 ha. Cultivation of field crops was reduced with smaller plots size due to lower returns.

Urban areas developed on small plots. Maximum area used for urban area was less than 0.1 ha.

Table 3. Distribution of private land according to plot size in 2004 (Area in hectare)

Land ownership	Plot size	Area	%	Number of plot	%
Private	=<0.1	293	3.9	11262	25.1
	0.1-0.2	282	3.8	4865	10.9
	0.2-0.4	440	5.9	4632	10.3
	0.4-1	1604	21.4	10125	22.6
	1-2	1874	25.0	7720	17.2
	2-3	964	12.8	2697	6.0
	3-5	1000	13.3	2139	4.8
	=>5	1050	14.0	1403	3.1
Total		7506	100.0	44843	100.0
Government		2601	100.0	1625	100.0
Roads		390	100.0	7740	100.0
Grand total		10496	100.0	54208	100.0

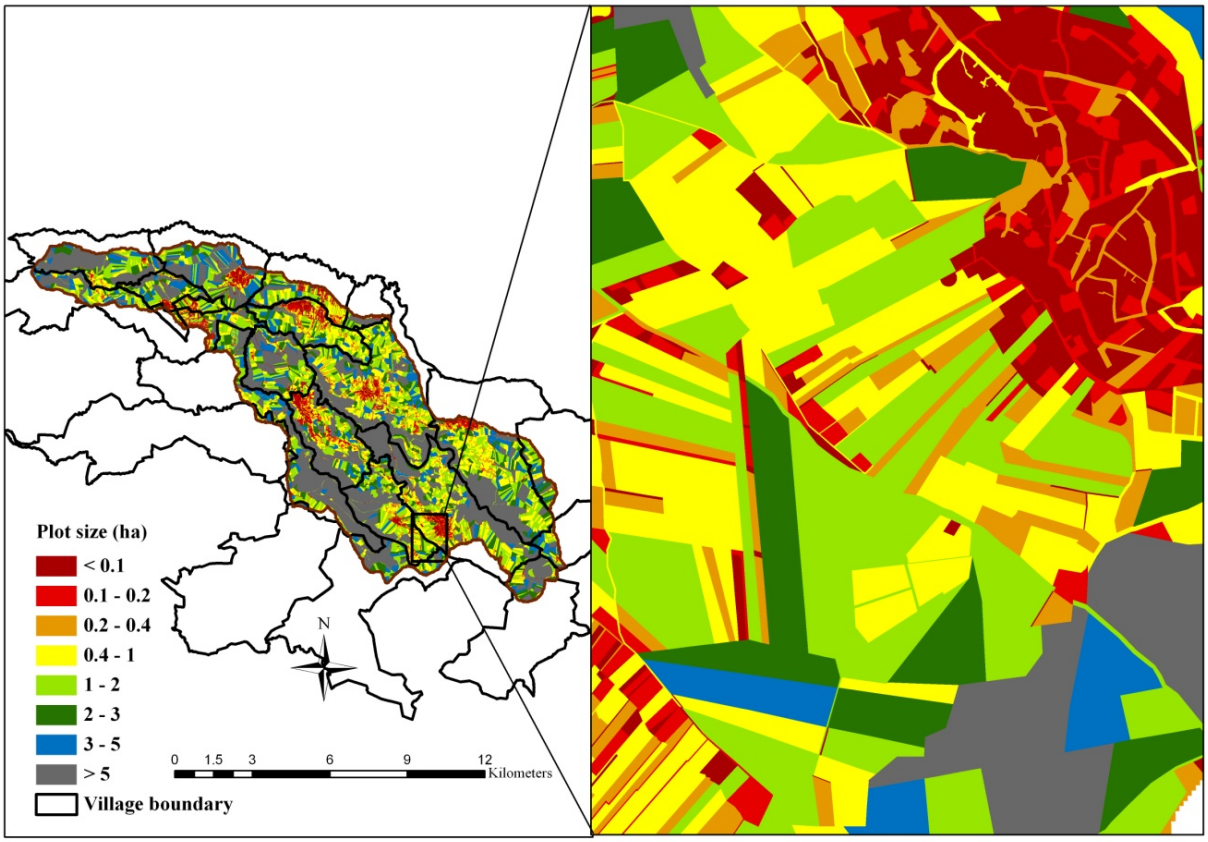

Figure 5. Distribution of land by plot size categories (Area in hectare)

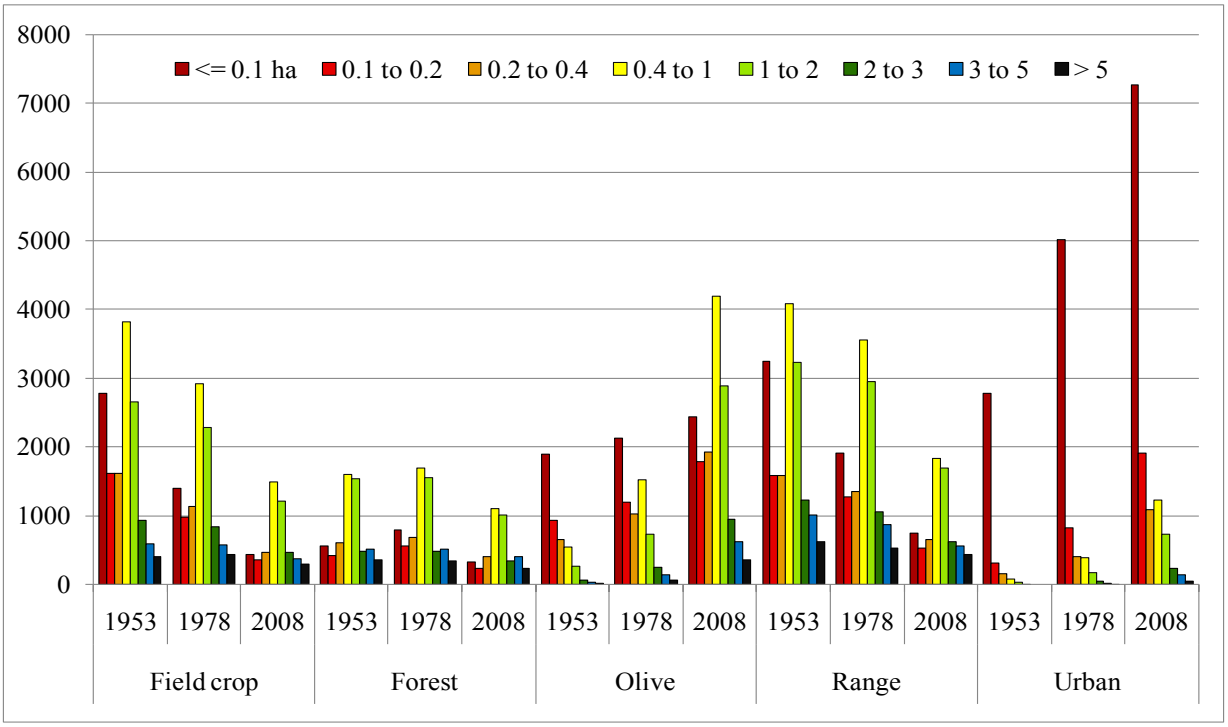

Figure 6. Distribution of different land use/land cover with time

5. Conclusions

This geographical analysis between 1953 and 2008 provides a comprehensive view of land use/land cover changes, population dynamics, and land fragmentation trends in Wadi Ziqlab catchment. Major changes in land use/ land cover during this period influenced by population density show an increase in olive and urban areas on the expense of forest, rangeland and field crop cultivation. The impact of land use/land cover on land fragmentation varies according to land use situation, human needs and poor planning. Olive farms required larger plot size while urban areas expanded around villages on small plot sizes.

The distressing features are that deforestation, cultivation on slope area, and land fragmentation are all leading to increased land degradation.

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