

Land Use Changes in Two Mediterranean Coastal Regions: Do Urban Areas Matter?

L. Salvati, D. Smiraglia, S. Bajocco, M. Munafò

Abstract—This paper focuses on Land Use and Land Cover Changes (LULCC) occurred in the urban coastal regions of the Mediterranean basin in the last thirty years. LULCC were assessed diachronically (1975-2006) in two urban areas, Rome (Italy) and Athens (Greece), by using CORINE land cover maps. In strictly coastal territories a persistent growth of built-up areas at the expenses of both agricultural and forest land uses was found. On the contrary, a different pattern was observed in the surrounding inland areas, where a high conversion rate of the agricultural land uses to both urban and forest land uses was recorded. The impact of city growth on the complex pattern of coastal LULCC is finally discussed.

Keywords—Land use changes, coastal region, Rome, Attica, southern Europe.

I. INTRODUCTION

SEVERAL Mediterranean cities underwent a rapid transition from the traditional ‘compact’ model to various phases of a more ‘dispersed’ form characterised by an impressive sprawl around the urban area [1]. In the ‘compact’ spatial organisation phase, land use conversion mainly involved cultivated and residual semi-natural areas at the urban fringe. During this phase, a few agricultural and forest land was converted to built-up settlements by clearcutting and fire, or indirectly by land fragmentation due to infrastructure development [2]. In the most recent ‘dispersed’ phase, an impressively growing surface of peri-urban lands was subjected to land use changes. A landscape formed by dense urban settlements, and fragmented peri-urban settlements, dispersed villages, clusters of isolated (although not rural) buildings, merged within (and intermixed with) a plethora of commercial units, industrial districts, and even tourism resorts, all linked with a more and more dense road network is now typical of several coastal peri-urban Mediterranean urban regions [3].

In Southern Europe, high-quality and biodiversity-rich rural landscapes surrounding the main cities are progressively eroded by dispersed urbanization [4]. In the Mediterranean basin, actually one of the world hotspots for urban sprawl due

to unplanned (or poorly regulated) settlement expansion [3], the ecological fragility of fringe landscapes was attributed to the high and increasing human pressure coupled with important transformations in soil, climate and vegetation observed at both local and regional scales [2].

In these regions Land Use and Land Cover Changes (LULCCs) are the result of a complex socioeconomic system and depend on a multifaceted stratification of causes involving several interacting agents. Local stakeholders and urban planners have determined a spontaneous fast urban growth followed by a slower expansion due to both planning and planning ‘deregulation’. In such a context, the urban expansion is one of the most dynamic drivers of environmental degradation.

Permanently monitoring land use changes within and outside the metropolitan regions, as well as their consequences (e.g. depletion of cultivated and natural lands, landscape fragmentation, loss of ecological diversity) are crucial tasks in the analysis of natural resources [4].

The European Environmental Agency [5] published a well-known report focusing on LULCCs in the Mediterranean region. According to this study, population density on coastal areas is on average 10% higher than inland, reaching a peak of 50% in some countries. Even more worrying is the conversion rate of natural coastal areas into artificial ones, being faster than population increase [2].

Restraining land use changes and mitigating the effects of land consumption thus represent an important matter of concern for regional and local planning, and need to be considered when developing strategies for the sustainable development of the Mediterranean urban areas [6], [7].

The sensitivity of coastal areas to urbanization and its interrelations with the socio-economic and ecological systems have been relatively poorly studied. The aim of this paper is thus to explore changes in LULCCs during 1975-2006 along two coastal urban regions in the Mediterranean basin. These case studies can be regarded as ‘laboratories of LULCCs’ due to the stratification of immediate and underlying factors determining land conversion.

In particular, the two study cases are taken as paradigmatic examples of a compact mono-centric (Athens) and poly-nucleated (Rome) urban form, with the high quality wooded areas (Athens) and agricultural lands (Rome) preserved along the urban fringe and in the rural countryside which were both subjected to a rapid urbanisation process [8]. Results are analysed in order to quantify diachronically the land cover distribution within the investigated coastal areas.

The implications such dynamics have on planning strategies

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aimed at preserving traditional landscapes and their quality in demographically growing or stable urban contexts were discussed.

II. STUDY AREA

The Greek investigated area covers a large part of Nuts-2 region of Attica including the urban conurbation of Athens. The area within a distance of ten kilometres from the coastal line was considered for a total surface of about 2,500 km² covering the entire city region. Although placed along the Mediterranean coast, the investigated region mostly consists of mountains. They all border the urban area of Athens which occupies a relatively flat coastal territory with some scattered uplands below 300 m a.s.l. The most representative examples of these hills are the 'Tourkovounià', located in the municipalities of Athens, Galatsi and Psihikò, and the 'Likavitòs' placed in the centre of Athens. They are completely surrounded by built-up areas, partly covered by coniferous woods and actually managed as urban parks. Three coastal plains are located in the Attica region outside the strictly urban area: the Messoghia plain, the Marathon plain, and the Thriasio plain. The first two are mainly specialised in agriculture, the third one was designated to hold industrial settlements.

The Italian investigated area covers the coastal territory of Nuts-3 province of Rome within a distance of ten kilometres from the coastal line for a total surface area amounting to nearly 1,000 km². The coastal territory of the municipality of Rome was included in the analysis. As far as elevation is concerned, the study area prevalently consists of lowlands.

A complex demographic pattern was observed during the study period in the two investigated regions. In the 1950s, 1960s and 1970s, the population grew by nearly 3% (per year) in both Athens and Rome. In 1961, the population living in Attica and Rome province amounted to nearly 2 million people and 2.8 million people, respectively. Since the 1980s, both cities started a process of urban de-concentration with the consequent spill-over of population in the surrounding zones. In 2001, although the overall population increased up to more than 3.7 million people in both cities, population growth rate (per year) fell up to 1% in Athens and 0.5% in Rome.

III. DATA AND METHODS

Land uses were assessed for the two study areas in 1975, 1990, and 2006 at the same spatial scale (1:100,000) by using the land cover maps obtained from the LACOST (LAnd cover changes in COASTal zones) (1975) and CORINE (CoORDinated INformation on the European Environment) Land Cover (1990, 2006) projects.

LACOST (LC) is a research project aimed at quantifying LULCCs in a 10 km land strip from the coastline during 1975–1990. LC is based on Landsat satellite images from 1970s and uses CORINE Land Cover (CLC) 1990 as its reference dataset. It uses CLC hierarchical classification (three-level hierarchical nomenclature with 44 categories at the third classification level) at 1:100,000 scale [5]. This

project was carried out in the mid 1990s by the Agricultural Information Systems Unit (AIS) of the Space Applications Institute (SAI) based at the Joint Research Centre (JRC), Ispra (Italy).

The CLC project was aimed at providing land cover maps at various times for the whole of Europe and was coordinated by the European Environment Agency (EEA). It contributes to the knowledge of the land cover and its changes in 26 European countries between 1990 and 2006 [4], providing two CLC databases (CLC1990 and CLC2006) with comparable technical features.

The CLC inventory is based on Landsat satellite images as primary information source. The choice of scale (1:100.000), minimum mapping unit (MMU) (25 ha), and minimum width of the polygons (100 m) represents a trade-off between production costs and land cover information details. The geometrical accuracy is 100 m, which means that there are no shifts higher than 100 m between the Landsat images and the CLC polygon edges. These basic variables are the same for CLC1990 and CLC2006. The standard CLC nomenclature includes 44 land cover classes and it is standardized for all of Europe which makes comparison and aggregation at the European level easier. The classes are grouped in a three-level hierarchy. The five main (level-one) categories are: (i) artificial surfaces, (ii) agricultural areas, (iii) forests and semi-natural areas, (iv) wetlands, and (v) water bodies.

In this study, three main standard categories of CORINE land cover were adopted: urban, agricultural, and semi-natural areas. Independent sources were used in order to verify the soundness of the land cover estimates, including the censuses of Agriculture (number of farms, main cultivations, crop surface by municipality), Buildings (number and surface of buildings by year of construction and municipality or building block), and Population (resident and usual population occurring in each municipality).

Land use composition was calculated as the percent surface of each land use category on the total investigated area. A change detection analysis between the different land uses (1975-1990 and 1990-2006) was performed by using the Geographic Information System tools made available with ArcGIS software.

IV. RESULTS

In 1975, at the beginning of the observation period considered in this study, the distribution of the different land cover types considered here was rather different in Athens and Rome. The landscape of the coastal belt of Rome province was mainly represented by agricultural areas, especially arable lands (Table I). Semi-natural and built-up areas covered only 21% and 13% of the investigated areas, respectively. In Athens, the semi-natural classes were the most frequent (50%) land use category, with the predominance of coniferous forests (Table II). Urban and agricultural lands covered 15% and 34% of the investigated area.

The rapid growth of the built-up areas was observed in both cities: after about thirty years, this class increased by 2.1% in Rome and 3.8% in Athens (Fig. 1). On the contrary, the

dynamics of the agricultural and semi-natural land use categories differed in the two study areas. In Rome the loss of cultivated surfaces (-3.8%) was marked in both periods (1975-1990 and 1990-2006) whereas the semi-natural areas showed a slight increase (1.7%) in the same period. The reverse pattern was observed in Athens: semi-natural areas fell by 4.2% whereas agricultural lands slightly increased (0.5%).

These dynamics are partially due to the different landscape composition in the two cities (forested in Athens, agricultural in Rome), and to the more moderate dominance of built-up areas in Rome compared to Athens. The spatial organization of the two cities was different as well: Athens represents a clear example of a mono-centric compact city, Rome can be depicted as a poly-nucleated city with a relatively compact city centre and dispersed peri-urban settlements.

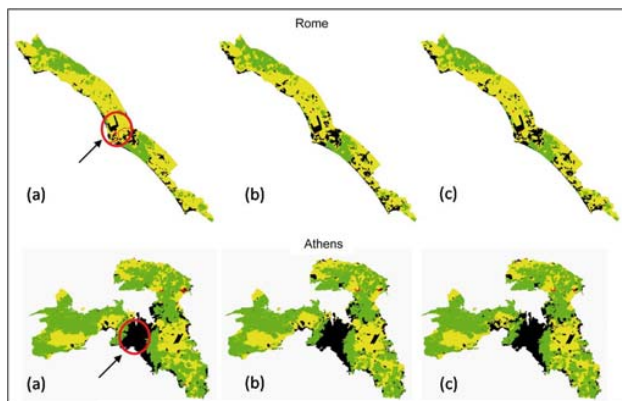


Fig. 1 Mapping of the built-up areas increase in Rome and Athens from 1975 (a) to 1990 (b) and 2006 (c)

TABLE I
LAND USE DISTRIBUTION (1975-2006) IN ROME

Land use	ha 1975	ha 1990	ha 2006	change % 1975- 1990	change % 1990- 2006	change % 1975- 2006
Urban areas	13707	15498	15903	1.7	0.4	2.1
Agriculture	70020	66384	65979	-3.4	-0.4	-3.8
Semi-natural	22419	24264	24264	1.7	0	1.7

TABLE II
LAND USE DISTRIBUTION (1975-2006) IN ATHENS

Land use	ha 1975	ha 1990	ha 2006	change % 1975- 1990	change % 1990- 2006	change % 1975- 2006
Urban areas	39672	43416	49374	1.5	2.3	3.8
Agriculture	87111	92979	88281	2.3	-1.8	0.5
Semi-natural	126675	117315	116100	-3.7	-0.5	-4.2

V. DISCUSSION

In the present study, the land use changes observed in Mediterranean coastal urban and peri-urban lands were disentangled in two paradigmatic case studies (Attica and Rome province). Results indicated that both the region of Attica and the province of Rome were subjected to a number of land cover changes due to urban sprawl, littoralisation and tourism development, forest fires, as well as depopulation of

marginal wooded and mountain lands (Athens), and even forestation in restricted peri-urban areas (Rome).

As far as the semi-natural land uses are concerned, the woodland cover was only partially destroyed by the urban growth in both cities. In Athens, despite strongly degraded by numerous fires and by the exceptional human pressure due to the closeness to the City, the original forest vegetation (mainly *Pinus halepensis* woods) is relatively well conserved in several stands especially in the most remote lands of Parnitha, Pendeli, and Imitos mountains. The relict forest patches on Egaleo and Pikilo hills are extremely important from the ecological point of view, as they are located at the urban fringe close to the most populated districts of Athens and Piraeus. Unfortunately, they are permanently at risk due to summer fire, clearcutting for spontaneous settlements, road construction, and illegal landfill. In Rome too, the original forest vegetation (i.e. the deciduous wood mainly composed of *Quercus* trees) is well conserved in limited broadleaved stands (e.g. Castelporziano coastal flat oakwood) where human-derived disturbance is relatively low. The causes of disturbance are similar to those observed in Athens and include planned sprawl, infrastructure development and, at a lesser extent, second-home 'littoralisation', summer fires, illegal landfill, and spontaneous urbanisation.

On the contrary, an important part of the agricultural mosaic landscape has been compromised either directly or indirectly in both cities. This process implies a dramatic loss in both the natural elements and the 'cultural' (i.e. traditional) dimension of the landscape. Unfortunately, this point was generally demised by the political action. Urban sprawl, although with different characteristics compared to the past, continues threatening the agricultural landscape around the two urban regions. Notably, the traditional rural landscapes in Athens and Rome, actually subjected to a rapid urban spillover, represent invaluable heritages for the entire world with important archaeological monuments (sometimes not exploited), typical cultivations, and traditional (even unique) landscapes needing stringent conservation measures.

As noted in other Mediterranean regions [9], land use conversion has important environmental implications affecting land quality and triggering land degradation, as was recently observed [10].

The most severe environmental effects of urbanisation and demographic concentration processes on the agricultural and semi-natural areas around the major coastal cities of southern Europe include (i) consumption and degradation of soils with high agricultural potential, (ii) impoverishment of groundwater resources due to overexploitation, and (iii) the abandonment of land in the neighbourhood of built-up areas with a consequent increase in marginal and unproductive land [3]. Increasing fire severity and the concentration of tourism and industrial activities in coastal areas further enhance such environmental impact [9]. Finally, urban sprawl-induced land fragmentation reduces connectivity among natural patches and represents another underlying factor of environmental degradation [11].

Both the ecological and socio-economic factors contributed

to this process, with a leading role played by those factors (e.g. spontaneous settlements, inflating house speculation, 'laissez faire' policies, city master plan deregulation, and limited effectiveness of the regional planning tools) impacting not only on land use conversion (and thus determining soil sealing, contamination, compaction, and salinisation), but also on agricultural extensification and woodland afforestation due to the uneven marginalisation of peripheral places leading to soil erosion.

VI. CONCLUSIONS

Identifying the causes of land cover changes requires understanding how people make land-use decisions (decision-making processes) and how specific environmental and social factors interact to influence these decisions (decision-making context) [12]. Hence, assessing the decision-making context represents a major concern when analyzing the mutual relationship between land management and land quality status. Through the analysis of such changes, negative effects strongly linked to land degradation could be highlighted, and the spatial pattern of the degradation processes could be evaluated.

The problem of land use conversion and soil sealing in large Mediterranean urban regions is becoming central in both research and policy agenda in the most recent years [5]. Furthermore, many researchers, environmental associations, and local groups started divulging the negative impact of these processes on the peri-urban coastal landscape. Unfortunately, the limited effectiveness of urban and regional plans coupled with a relatively poor control against land appropriation, land conversion, and illegal housing were especially impressive in the two investigated cities, especially up to 1990s in Athens and up to 1980s in Rome [13].

The evolving LULCCs towards anthropic uses reflect a sort of 'landscape homologation' in the Mediterranean city regions [14]. As a matter of fact, high diversity landscapes, observed up to the 1970s along the coast-inland gradient, underwent dispersed urbanization and are progressively evolving into a low-diversity landscape, invaded by scattered human settlements in lowlands and dominated by low-quality woodlands in marginal areas [14]. This means that the traditionally-complex series of land cover types distributed along the urban-rural gradient (with cropland, pastures, and fallow land intermixing compact urban areas and woodlands) is likely to be replaced by a simplified and polarized urban-forest gradient strictly associated with elevation.

These transformations create an 'anthropogenic' landscape with relict cultivated fields and pastures undergoing future low-density urbanization, and with mountain areas facing the forestation process as a consequence of socioeconomic marginalization [6].

In order to contain the sprawl-derived 'landscape homologation', an effective planning strategy should promote specific conservation measures according to the environmental quality of the different land cover classes found along the coastal-inland gradient.

Regional (and urban) planning should therefore promote

multi-scale measures aimed at protecting the sensitive landscape elements as hot spots for containing land use conversion and depolarising the urban spill-over across defined land use types. Such measures should be designed within a sustainable development strategy with the final goal of mitigating the ecological, social, and economic disparities. Otherwise, the risk could be that rapid LULCCs in suburban areas may alter the residents' perception of environmental vulnerability and natural resource depletion, while public officials are adhering to a traditional sectoral and structural interpretation of land conservation as a strictly agricultural (and forest) problem [2].

This study will hopefully stimulate the debate on the possible tools to monitor low-density urban expansion and LULCCs and may inform policies promoting the sustainable urban growth, the containment of soil sealing, and the protection of land from fragmentation in the Mediterranean region [15]. In particular, because of the lack of homogeneous, diachronic and high-resolution land-use maps at the regional and local scales in the Mediterranean basin, research should improve landscape monitoring tools evaluating changes in biophysical and socioeconomic drivers.

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