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THE CAUSES OF DEATH IN THE PROVINCE OF ROME BETWEEN 1981 AND 2007: A GEOGRAPHICAL ANALYSIS

ABSTRACT. In this paper we provide an overview of the main causes of death in the province of Rome in 1981 and 2007, showing the most relevant variations which have been recorded over time. Using ArcGIS 9.2 software, we have drawn up several medical-geographical thematic maps and specific land use maps which corroborate the temporal and spatial analysis, and which provide suggestions about the relation between causes of death and certain risk factors. Particular attention is given to the diseases of the circulatory system and neoplasms which caused, respectively, 38.4% and 32.6% of deaths in 2007 and which followed substantially different trends. Then, we focus on the city of Rome, where we examine the evolution of land use between 1980 and 2001 in order to investigate, by means of detailed screening, the changes recorded in a city where, in 2007, 67% of the inhabitants of Rome province lived.

KEY WORDS: causes of death, circulatory system, neoplasms, medical-geographical thematic maps, land use maps, risk factors, GIS.

INTRODUCTION

For some years experts in health research "have been successful in re-establishing interest in the role of place in shaping health and health inequalities". Experts in epidemiology, sociology and geography consider this role of space significant, because they recognise "that there is a mutually reinforcing and reciprocal relationship between people and place". These academics "argue that these approaches to understanding how place relates to health are important in order to deliver effective, 'contextually sensitive' policy interventions" [Cummins et al., 2007, p. 1825].

In a more recent paper Rainham et al. [2010, p. 668] introduce "the need to move beyond conventional place-based perspectives in health research, and invoke the theoretical contributions of time geography and spatial ecology as opportunities to integrate human agency into contextual models of health". They also introduce the concept of *healthscape* "as an approach to operationalizing context as expressed by the spatial and temporal activities of individuals".

In a previous paper other researchers explored the links between (perceived) environmental risk and community (re)action in a urban industrial neighbourhood in Hamilton, Ontario, Canada. The analyses "were conducted with residents of an area with a documented history of adverse air quality, in order to determine the relative

influence of *social capital* (networks, norms, and social trust) and *place attachment* (sense of belonging in a neighbourhood) in deciding to take civic action around this particular environmental issue" [Wakefield et al., 2001, p. 163].

The above papers present some interesting approaches for our international project *Medical and geographical analysis of urban agglomerations in different natural and socioeconomic conditions,* whose main goal is to establish the role both of space and time in the distribution of the diseases in two different areas of Europe, i.e. the province of Rome and the oblast of Moscow.

For this purpose, we evaluate:

- the relationship between people, health and space;
- the importance of time geography and spatial ecology;
- the effective "contextually sensitive" policy intervention;
- the contextual models of health;
- health in the industrialized areas;
- health in green areas close to and in cities and towns;
- the influence of immigration on health.

As far as regards methods and tools used, we have employed ArcGIS 9.2 software in order to draw up and analyse various maps, which show the distribution of some diseases in relation to selected particulars of municipalities in the province of Rome. Recently, in our book *La salute nel mondo. Geografia medica e qualità della vita,* we have already explored the possibility of introducing GIS in our researches on medical geography, discussed many practical applications and showed the added value of analysis at different scales [Palagiano, Pesaresi, 2011, pp. 315–318]; here we have used GIS to organise a wide database which can be progressively updated and upgraded and can produce a number of superimposed layers. For the purposes of our project and thanks to the characteristics of GIS, the maps and the problems shown for the province of Rome [Pesaresi, Marta, in press] will be comparable with those of the oblast of Moscow produced by colleagues of the Faculty of Geography, Lomonosov Moscow State University, Russia [Malkhazova et al., 2007], for the same project. In this way, we provide input for communal reflections and analysis.

In the geographic literature, however, this kind of comparative study has already been carried out. For example, in 1963, Ortolani (in collaboration with Mounfield) made a comparison between two industrial regions, Lombardy in Italy and Lancashire, in the UK. Likewise, in 2004, Cristaldi and Darden analysed the demographic structures and social networks among Filipino immigrants in Rome and Toronto. We intend to refer to these projects to show the differences and similarities of the relationship between the health situation in two different areas of Europe, the province of Rome and the oblast of Moscow.

THE MAIN PHASES AND AIMS OF THE RESEARCH

"Empowerment" is a process of social activity which allows people, communities and local administrations to acquire information and competences in order to change and improve the features of their environment and of their quality of life [Italian Ministry of Health, 2010, p. 14]. One of the key components in the acquisition of this information is knowing the main causes of death and the related risk factors on a large scale. With the aim of encouraging a similar process, and the development of adequate socio-sanitary facilities, besides a continual reflection on the techniques of planning [Morelli, 1983, p. 510], in this paper we evaluate the changes which have been recorded between 1981 and 2007 regarding the main causes of

death in the municipalities of the province of Rome; subsequently, we indicate which are the axes and the macro-areas currently showing the highest values for: diseases of the circulatory system; neoplasms; diseases of the respiratory system; injury, poisoning and certain other consequences of external causes; endocrine, nutritional and metabolic diseases. On the other hand, many years ago the relevance of recording the provincial and municipal mortality data over time was demonstrated, such as the importance of making analysis and follow-up studies involving local communities which are exposed to particular risk factors [Rubino et al., 1983, p. 78].

In practice, using GIS we created many medical-geographical maps which facilitate temporal and spatial analyses and help to investigate the potential risk factors. In this way, through map making, we can encourage "map *thinking*, the method by which assumptions embedded in an analytic process are understood and employed in the researcher's response to a problem" [Koch, Denike, 2007, p. 76]. Moreover, after defining general frameworks at the scale of the municipality and showing the effective land use by employing a specific legend, we focus our attention on the city of Rome, for which we analyse the evolution of land use between 1980 and 2001 in order to examine the eventual relation between causes of death and proximity to certain activities or pollution sources; this surgical screening allows us to evaluate the most important changes which could have contributed to the increase or decrease in mortality due to particular diseases.

Therefore, the digital cartographic elaborations produced form a cognitive basis useful for:

- discovering anomalous or notable modifications recorded over time;
- identifying the areas which present the highest values for specific causes of death;
- observing in which municipalities there is a relation between causes of death and some risk factors (industries, mining activities, waste, etc.) and the municipalities where this relation is not very strong;
- drawing an analytic framework of the potential dangerous elements which are present in the city of Rome, deriving this qualitative data from a re-elaboration *ad hoc* of the official land use maps;
- avoiding program faults during the planning phases, above all in areas with high population density.

THE MAIN CAUSES OF DEATH IN 1981 AND 2007

In 2007 – the last year for which the National Institute of Statistics (ISTAT) provided the data for municipalities – 35,849 deaths were recorded in the province of Rome.

Diseases of the circulatory system were the primary cause of death (13,758 deaths) and neoplasms were the second (11,684), as was the case in 1981 (Fig. 1). Nevertheless, comparing the data of 2007 with that of 1981, we can observe a significant reduction in the distance between them, because the trend of neoplasms shows a marked and regular increase [Pesaresi, Marta, in press]. In third place we continue to find diseases of the respiratory system, while diseases of the digestive system have moved from fourth to sixth place and injury, poisoning and certain other consequences of external causes[1] have passed from sixth to fourth position. Endocrine, nutritional and metabolic diseases are always in fifth place, while symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, are no longer found in the first ten places. Presently in seventh place we find diseases of the

[1] We would point out that the ISTAT code (V01-Y89) for injury, poisoning and certain other consequences of external causes is different from that of the International Statistical Classification of Diseases and Related Health Problems 10th Revision Version for 2007 (S00-T98). See http://apps.who.int/classifications/apps/icd/icd10online.

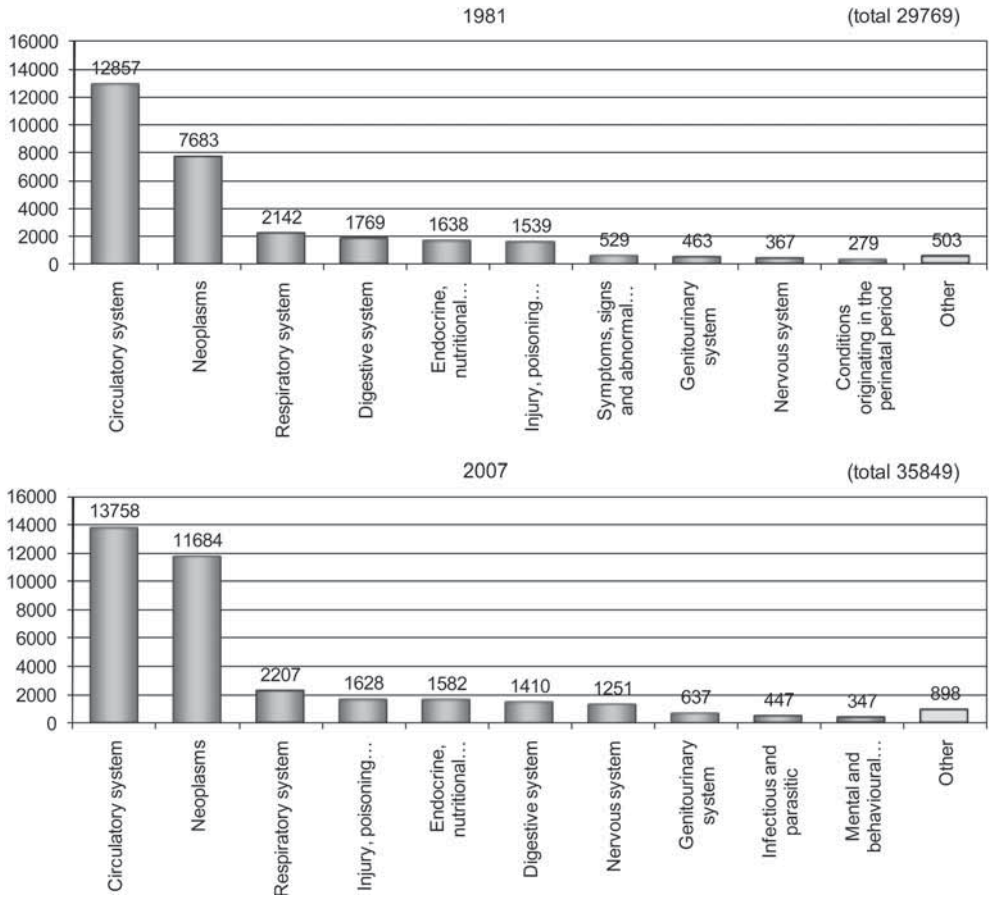

Fig. 1. The mortality due to the different causes of death, in 1981 and 2007, in the province of Rome.

Source: elaboration on data ISTAT

nervous system[2], which were in ninth place in 1981. The diseases of the genitourinary system continue to be in eighth position, while conditions originating in the perinatal period are no longer in the first ten places because important progresses have been made in this field (as confirmed also by the zero deaths due to pregnancy, childbirth and the puerperium). In ninth and tenth positions we find respectively infectious and parasitic diseases, which can be also related to the substantial increase in immigrants living in Rome city and in nearby municipalities, and mental and behavioural disorders, to which have to be added an increase in diseases of the nervous system caused by stress, traffic and other day to day tense conditions.

Regarding the percentage of mortality due to the main six causes of death, we can affirm the following (Fig. 2):

- the relevance of diseases of the circulatory system decreased by almost five percentage points (from 43.2% to 38.4%), while the relevance of neoplasms increased by almost seven percentage points (from 25.8% to 32.6%). Consequently, the gap which amounted to 17.4 percentage points in 1981 is now reduced to 5.8 percentage points and it suggests a possible closer convergence within the next 30 years [Pesaresi, Marta, in press];

[2] The ISTAT code (G00-H95) for diseases of the nervous system is different from that of the International Statistical Classification of Diseases and Related Health Problems 10th Revision Version for 2007 (G00-G99). See http://apps.who.int/classifications/apps/icd/icd10online.

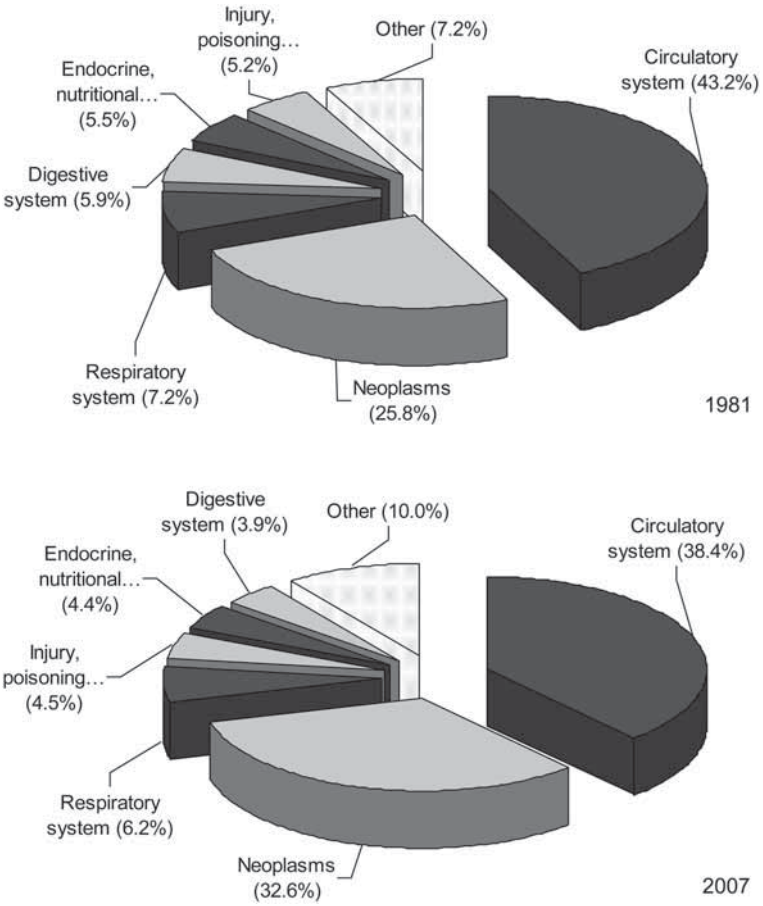

Fig. 2. The percentage of mortality due to the main six causes of death, in 1981 and 2007, in the province of Rome.

Source: elaboration on data ISTAT

- the relevance of diseases of the respiratory system decreased by one percentage point, the relevance of diseases of the digestive system decreased of two percentage points, endocrine, nutritional and metabolic diseases decreased by 1.1 percentage points and injury, poisoning and certain other consequences of external causes decreased by 0.7 percentage points;

- the dynamic of the main causes of death in the province shows, on percentage, a general reduction, with the exception of neoplasms which appear to be becoming the most problematic disease of the 21st century.

THE MAIN CAUSES OF DEATH IN 1981 AND 2007 PER MUNICIPALITY

For the five main causes of death, we have drawn up a map for the percentage data of 1981[3] and another for 2007, in order to illustrate which municipalities have recorded the principal changes. Thus, we have drawn up several specific thematic maps adopting a standard scheme. We have always considered five classes and the central one has been thought to include the provincial values of 1981 and 2007. For each cause of death, the five classes are the same for 1981 and 2007, in order to facilitate the comparisons and to see immediately which modifications are the most relevant.

[3] In the maps of 1981 the municipality of Rome includes the present municipality of Fiumicino.

Diseases of the circulatory system

The comparison between the thematic map of 1981 and that of 2007 shows an overall marked decrease in the percentage of mortality due to diseases of the circulatory system (Figs. 3–4). In fact, in 1981 the diseases of the circulatory system caused more than 45% of deaths in 62 municipalities while in 2007 they caused more than 45% of deaths in 26 municipalities. At the same time, in 1981 the diseases of the circulatory system provoked more than 55% of deaths in 26 municipalities while in 2007 the number of municipalities with such a high value fell to 11, mostly in the east of the province (Fig. 5), with the addition of Allumiere (65.9%) in the north-west. The maximum values are recorded in Marano Equo (80.0%), Affile, San Gregorio da Sassola, and Vallepietra (66.7%).

In order to show more clearly the amount of difference between the percentage data of 1981 and 2007 (Fig. 6), we have elaborated another map to indicate which municipalities have shown: a large reduction (values less than –20 percentage points), a fair reduction (between –20 and –3.1 percentage points), a not appraisable variation (conventionally between –3 and 3 percentage points), a fair increase (between 3.1 and 20 percentage points), and a large increase (more than 20 percentage points). The main results are the following: 81 municipalities recorded a substantial decrease (17 municipalities are in the class with values less than –20 percentage points, and 64 between –20 and –3.1 percentage points), 14 municipalities recorded a not appraisable variation and 23 a substantial increase (15 between 3.1 and 20 percentage points, and 8 more than 20 percentage points).

The maximum decreases were in: Sambuci (–56.1 percentage points), Vallinfreda (–50.0), Roviano (–49.4), Filacciano (–46.4), San Polo dei Cavalieri (–42.6), Gorga (–38.3), Civitella

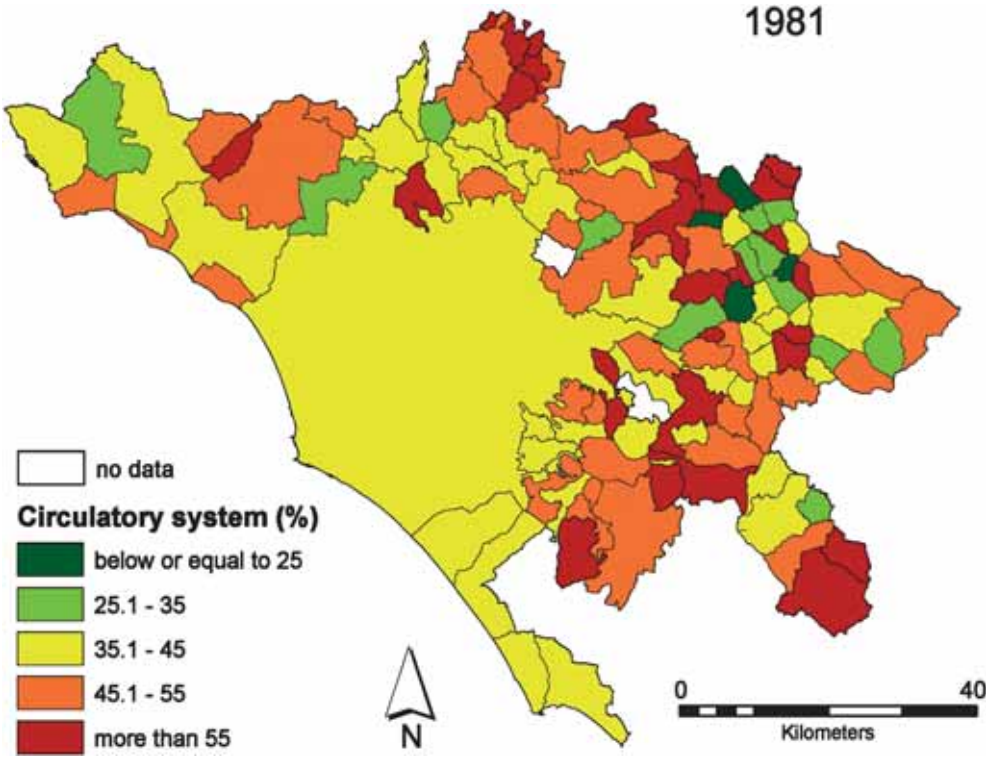

Fig. 3. The percentage of mortality due to diseases of the circulatory system, in 1981, in the municipalities of the province of Rome.

Source: elaboration on data ISTAT

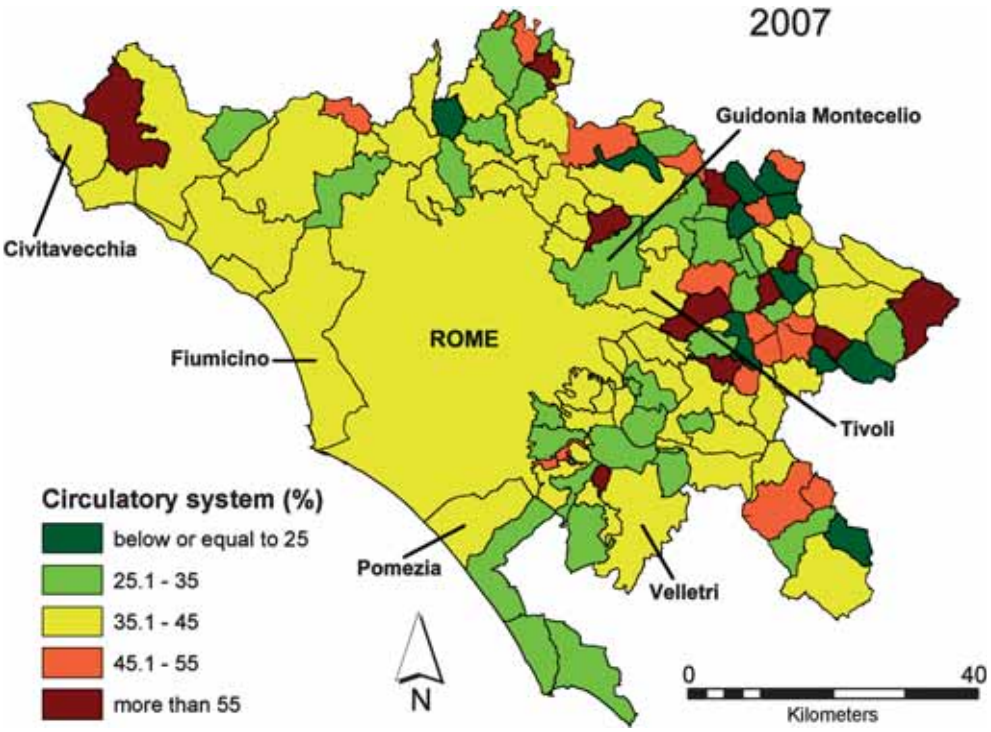

Fig. 4. The percentage of mortality due to diseases of the circulatory system, in 2007, in the municipalities of the province of Rome. The municipalities with more than 40,000 inhabitants (on the basis of the Census data of 2001) are indicated in the map to provide some geographical information.

Source: elaboration on data ISTAT

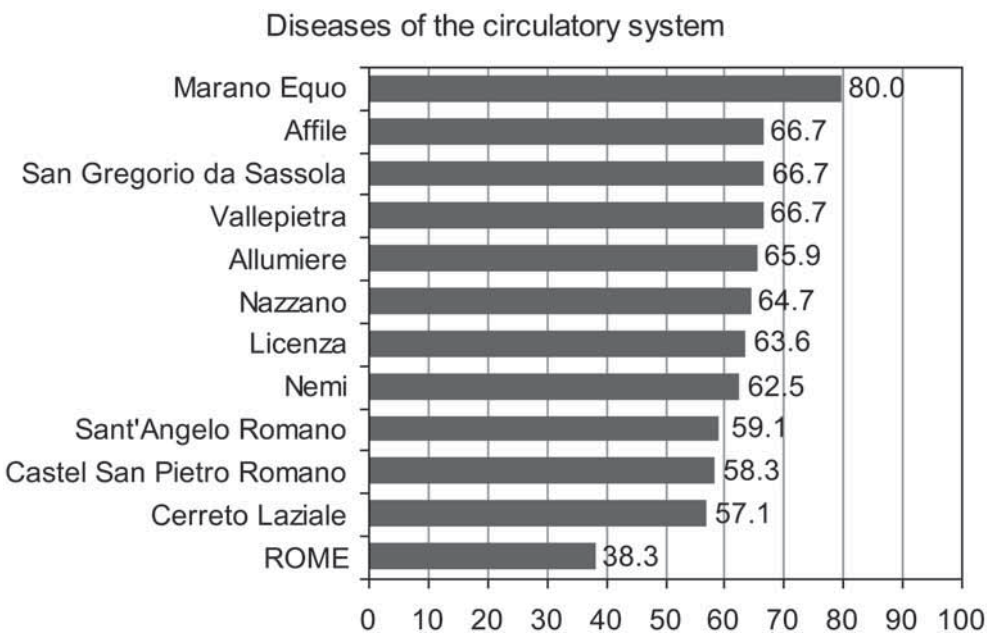

Fig. 5. The municipalities of the province of Rome with the highest percentage of mortality due to diseases of the circulatory system, in 2007, with the addition of Rome city.

Source: elaboration on data ISTAT

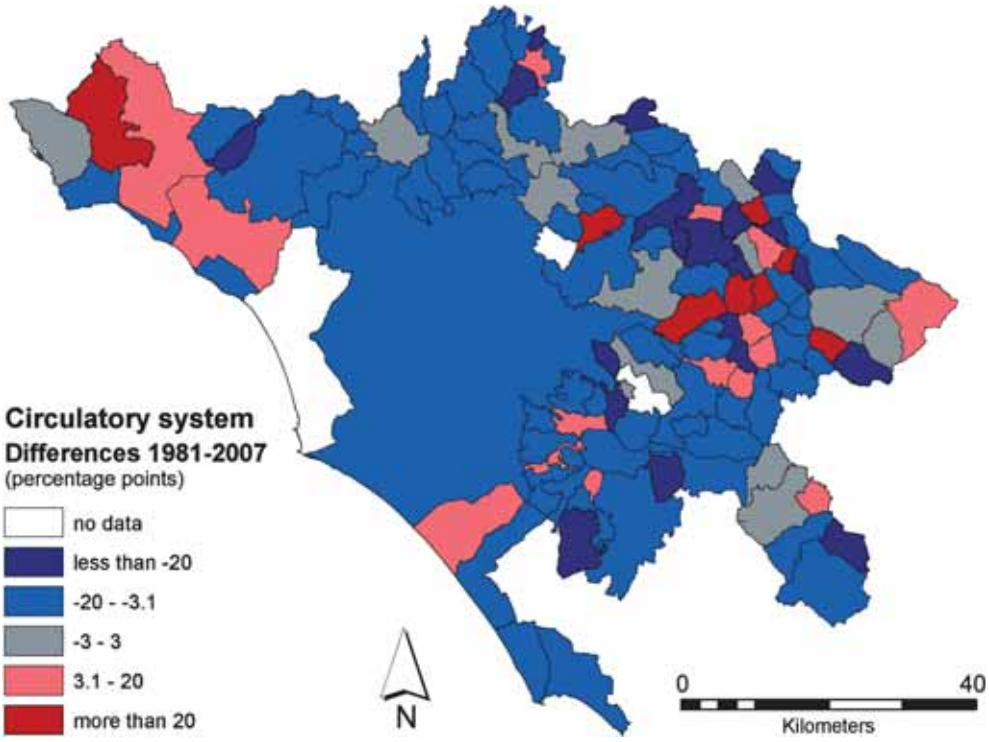

Fig. 6. The differences between the data of 1981 and 2007 for the percentage of mortality due to diseases of the circulatory system in the municipalities of the province of Rome (percentage points).

Source: elaboration on data ISTAT

San Paolo (–37.7), Agosta (–32.2). Instead, the most worrying increases have been recorded in: Marano Equo (55.0 percentage points), San Gregorio da Sassola (39.4), Allumiere (35.1), Affile (32.2), and Sant'Angelo Romano (31.8).

As for the city of Rome, the data shows that mortality due to diseases of the circulatory system has decreased from 42.5% to 38.3%, denoting a reduction slightly smaller with respect to the province. Thus mortality due to diseases of the circulatory system evaluated in percentages in Rome city and in its province is practically the same.

Neoplasms

Unlike the situation for diseases of the circulatory system, the comparison between the thematic map of 1981 and that of 2007 shows a generally remarkable increase in the percentage of mortality due to neoplasms (Figs. 7–8). Particularly, in 1981 neoplasms caused more than 35% of deaths in 10 municipalities while in 2007 neoplasms caused more than 35% of deaths in 47 municipalities. Contemporarily, in 1981 neoplasms were the cause of more than 45% of deaths only in 2 municipalities while in 2007 the number of municipalities with such a high value had increased to 11, all distributed in the east, where a longitudinal axis can be traced with various municipalities aligned along it. The maximum values (Fig. 9) are recorded by Mandela, Roccagiovine, and Vallinfreda (66.7%).

In the same way as for the diseases of the circulatory system, we have created a map of the differences between the percentage data of 1981 and 2007 (Fig. 10), and the main results are the following: 14 municipalities recorded a substantial decrease (4 municipalities are in the class with values less than –20 percentage points, and 10 between –20 and –3.1 percentage points), 11 municipalities

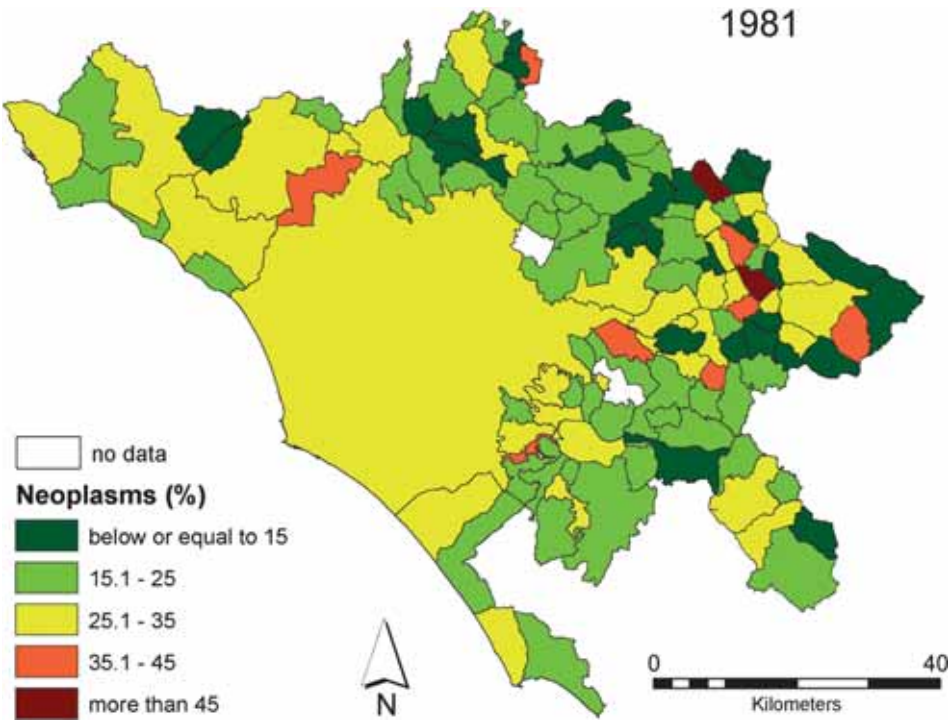

Fig. 7. The percentage of mortality due to neoplasms, in 1981, in the municipalities of the province of Rome.

Source: elaboration on data ISTAT

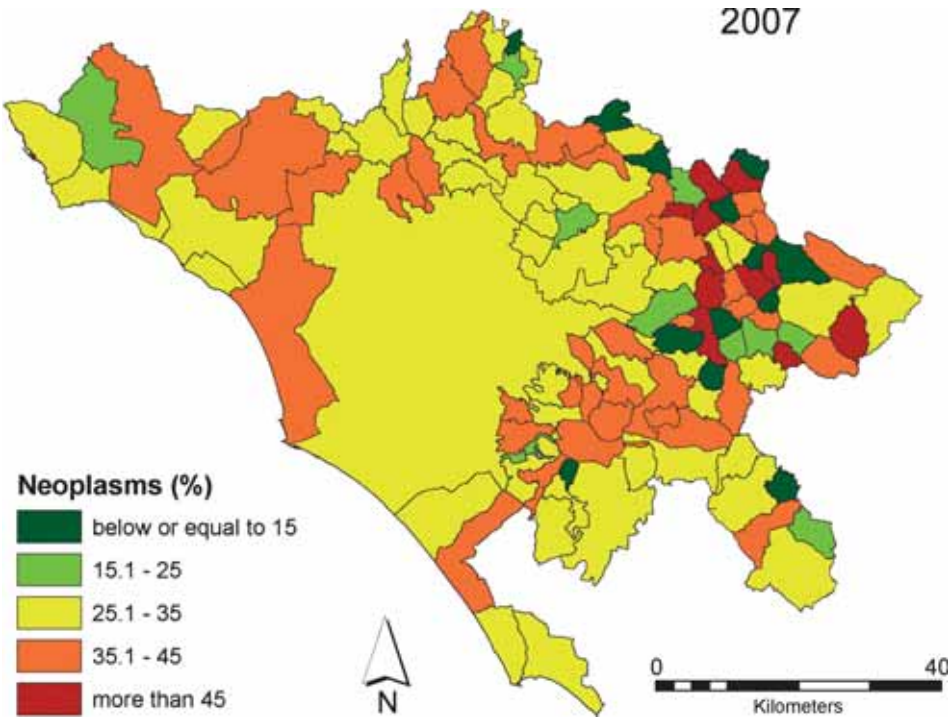

Fig. 8. The percentage of mortality due to neoplasms, in 2007, in the municipalities of the province of Rome.

Source: elaboration on data ISTAT

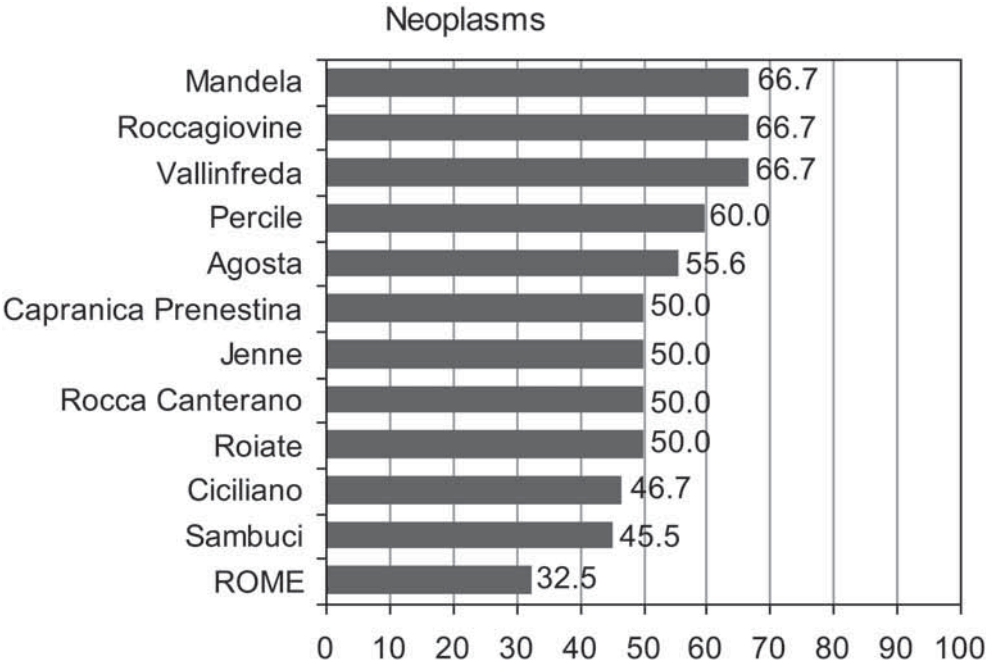

Fig. 9. The municipalities of the province of Rome with the highest percentage of mortality due to neoplasms, in 2007, with the addition of Rome city.

Source: elaboration on data ISTAT

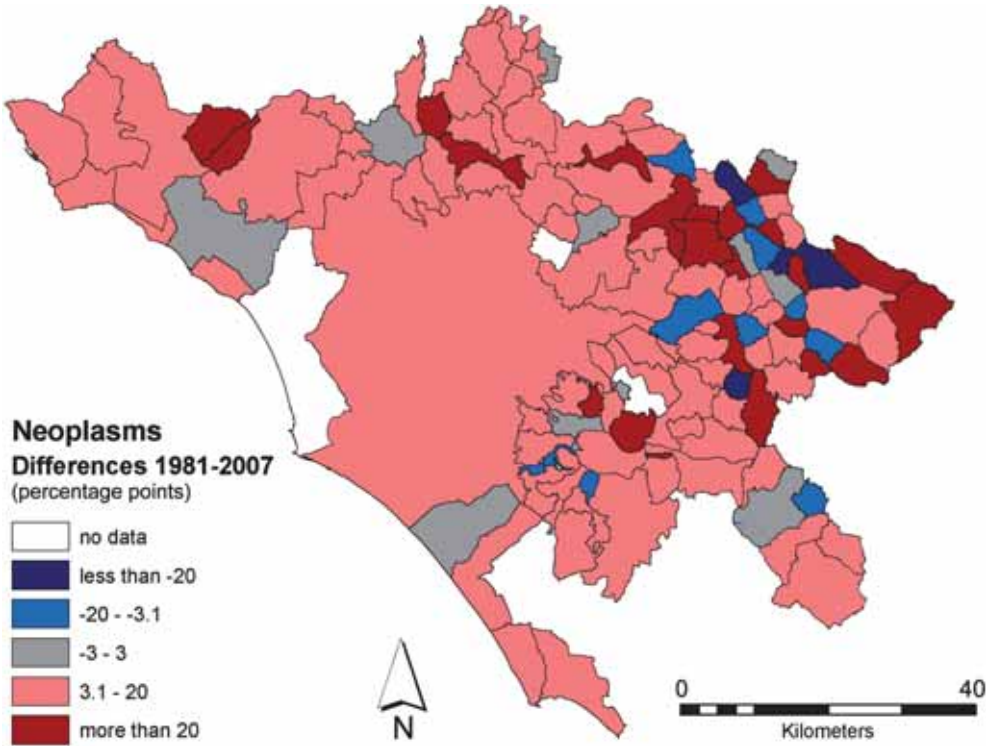

Fig. 10. The differences between the data of 1981 and 2007 for the percentage of mortality due to neoplasms in the municipalities of the province of Rome (percentage points).

Source: elaboration on data ISTAT

recorded a not appraisable variation and 93 a substantial increase (71 between 3.1 and 20 percentage points, and 22 more than 20 percentage points). The municipalities with the most appreciable decreases were: Percile and Rocca di Cave (–40.0 percentage points), Cervara di Roma (–33.3), Marano Equo (–25.0). The municipalities with the most relevant increases were: Vallinfreda (55.6 percentage points), Roccagiovine (46.7), Sambuci (45.5), San Polo dei Cavalieri (44.4), and Agosta (40.6).

In practice, the maps of the differences between the data of 1981 and 2007, for diseases of the circulatory system and neoplasms, show two opposing conditions and in some aspects one can seem the "negative" of the other.

In the case of Rome city, the mortality due to neoplasms increased from 26.5% to 32.5%, just a few less than in the province and also the percentage of mortality caused by this disease is nearly the same in the city of Rome and in its province.

Diseases of the respiratory system, injury, poisoning and certain other consequences of external causes, and endocrine, nutritional and metabolic diseases

A comparative analysis of the percentage data of 1981 and 2007 for diseases of the respiratory system (Figs. 11–12) shows several municipalities with important decreases. In fact, 60 municipalities recorded a decrease in values (at least –1.1 percentage points) and many of them showed significant diminution, especially: Vallepietra (–50.0 percentage points), Saracinesco (–33.3), Ciciliano (–30.0), Marano Equo (–25.0), Nazzano (–24.1), Torrita Tiberina (–18.2), Rocca Canterano (–16.7), Cineto Romano (–16.4) and San Vito Romano (–15.8) plus another six municipalities with values less than –10 percentage points. A few more than half (35) were the municipalities

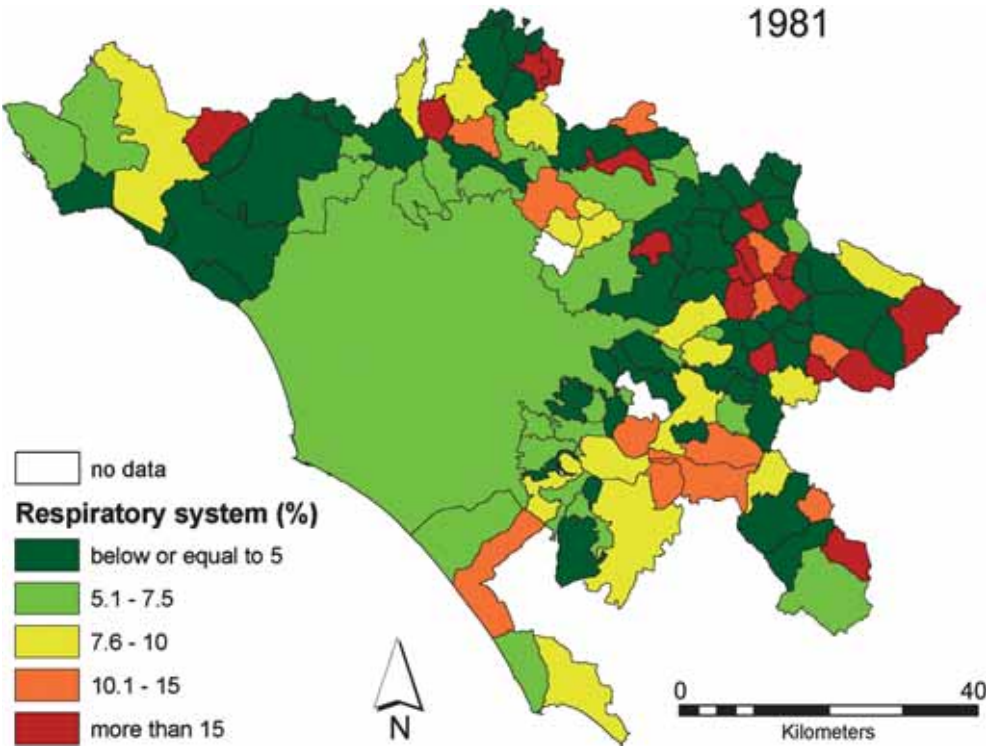

Fig. 11. The percentage of mortality due to diseases of the respiratory system, in 1981, in the municipalities of the province of Rome.

Source: elaboration on data ISTAT

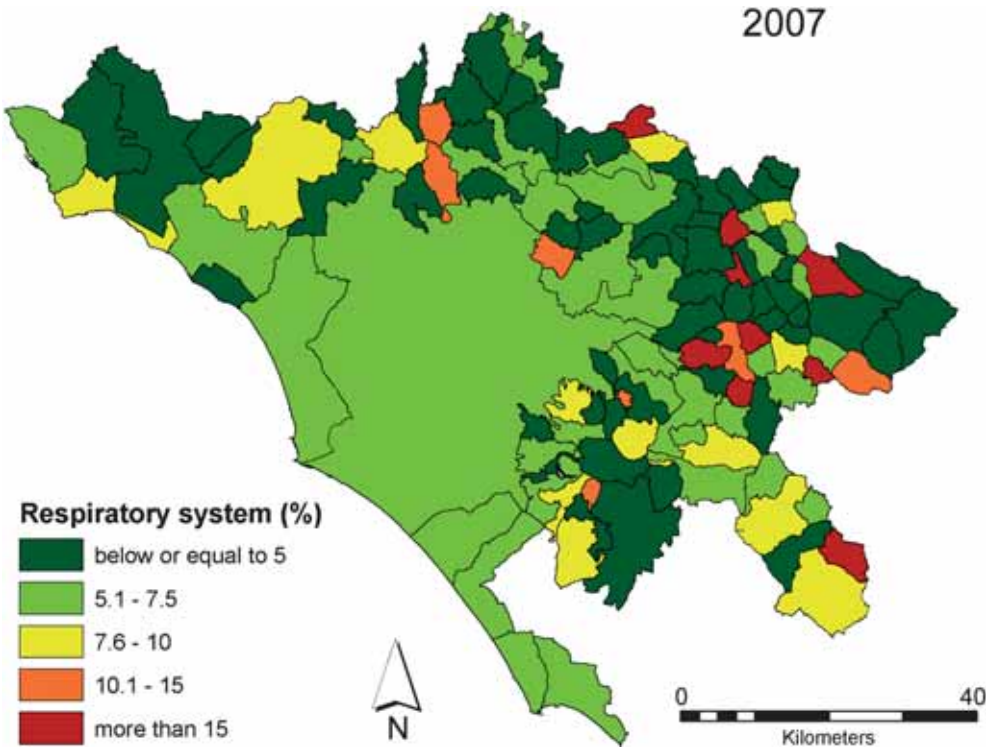

Fig. 12. The percentage of mortality due to diseases of the respiratory system, in 2007, in the municipalities of the province of Rome.

Source: elaboration on data ISTAT

with increases in values (at least 1.1 percentage points), and the most significant values have been recorded in: Rocca di Cave (50.0 percentage points), Cervara di Roma and Pisoniano (20.0), Mandela (16.7), Capranica Prenestina and Nemi (12.5). Finally, there were 23 municipalities with very slight changes (conventionally between –1 and 1 percentage points).

The general picture of 2007 shows a situation of mainly low (below or equal to 5%) and medium-low (between 5.1% and 7.5%) values. The coastal zone especially includes municipalities with medium-low values, while the east of the province has a considerable number of municipalities with low or medium-low values but also some municipalities with high (more than 15%) or medium-high values (between 10.1% and 15%).

In the city of Rome, mortality caused by diseases of the respiratory system decreased from 7.3% to 6.3%, and the values continue to be strictly aligned with those of the province.

As regards injury, poisoning and certain other consequences of external causes (Figs. 13–14), a comparison between the percentage data of 1981 and that of 2007 indicates that 45 municipalities showed a decrease in values (at least –1.1 percentage points), 34 recorded increases (at least 1.1 percentage points) and 39 showed very little change (between –1 and 1 percentage points). The municipalities with the most significant variations were: for decreases, Vivaro Romano (–20.0 percentage points), Mazzano Romano (–18.8), Nemi (–15.4), Castel San Pietro Romano (–14.3), Colonna (–12.1), Fiano Romano (–11.7) and Poli (–11.1), and, for increases, Filacciano (42.9), Percile (20.0), Torrita Tiberina (16.7), Ciciliano (13.3), Canterano (12.5) and Gorga (11.7). Therefore, in comparison with diseases

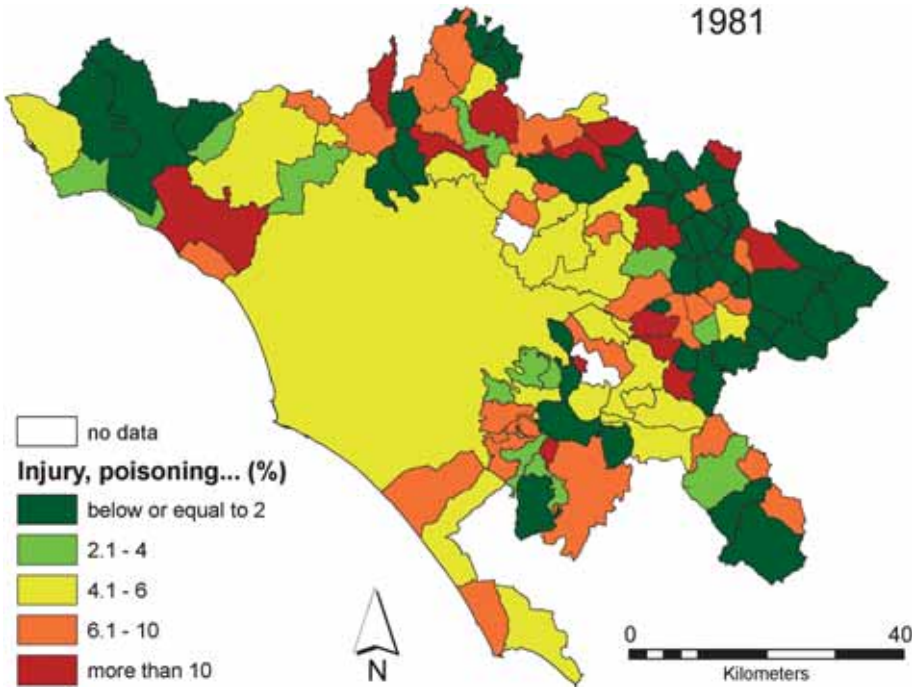

Fig. 13. The percentage of mortality due to injury, poisoning and certain other consequences of external causes, in 1981, in the municipalities of the province of Rome.

Source: elaboration on data ISTAT

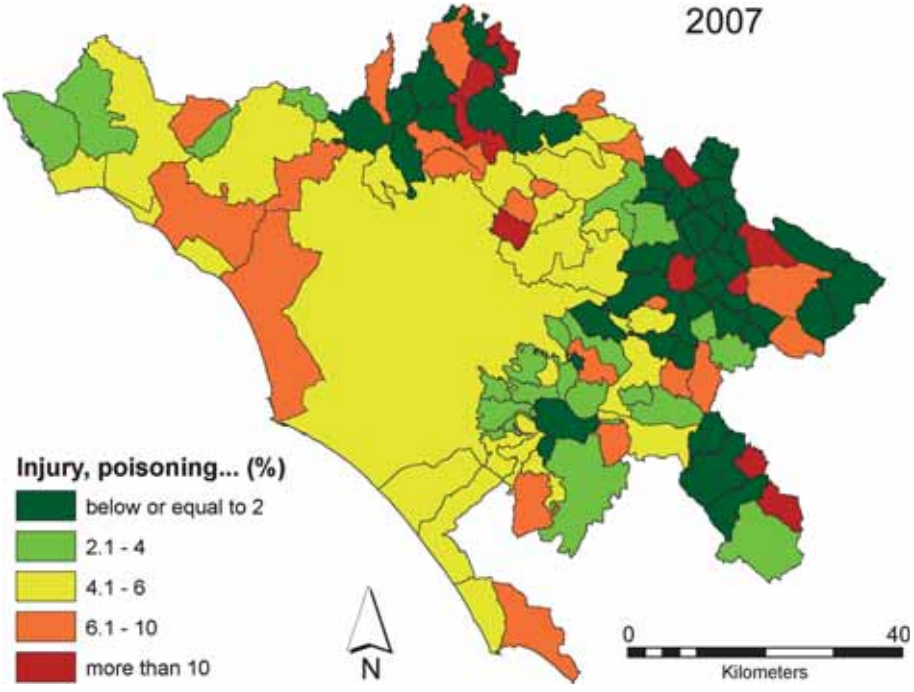

Fig. 14. The percentage of mortality due to injury, poisoning and certain other consequences of external causes, in 2007, in the municipalities of the province of Rome.

Source: elaboration on data ISTAT

of the respiratory system, the number of municipalities with high variations (values more than 10 percentage points and less than –10 percentage points) is smaller and the amount of these changes is generally less remarkable.

The map for 2007 shows a more variegated situation compared to that of diseases of the respiratory system. The municipalities of the coastal zone show almost exclusively medium (between 4.1% and 6%) or medium-high (between 6.1% and 10%) values, while all the most divergent cases were recorded in the eastern part of the province, where aggregations of municipalities with low (below or equal to 2%) values were interspersed with municipalities with high (more than 10%) or medium-high values.

In the city of Rome, the mortality due to injury, poisoning and certain other consequences of external causes decreased from 5.2% to 4.4%, in close parallel with the values of the province.

As regards the percentage of mortality due to endocrine, nutritional and metabolic diseases (Figs. 15–16), the thematic maps of 1981 and 2007 show a situation which in some aspects is the opposite to that of injury, poisoning and certain other consequences of external causes. In fact, a similar high number of municipalities, that is to say 40, continued to record values close to those of the past. Then, 35 municipalities showed a decrease in values (at least –1.1 percentage points) and 43 municipalities showed an increase (at least 1.1 percentage points), that more or less is the opposite of the previous situation. As particular cases, we indicate: for decreases, Roccagiovine (–40.0 percentage points), Roiate (–25.0), Castelnuovo di Porto (–18.4), Camerata Nuova (–18.2), Mandela (–14.3) and Riofreddo (–13.3); for increases, Monteflavio (25.0 percentage points),

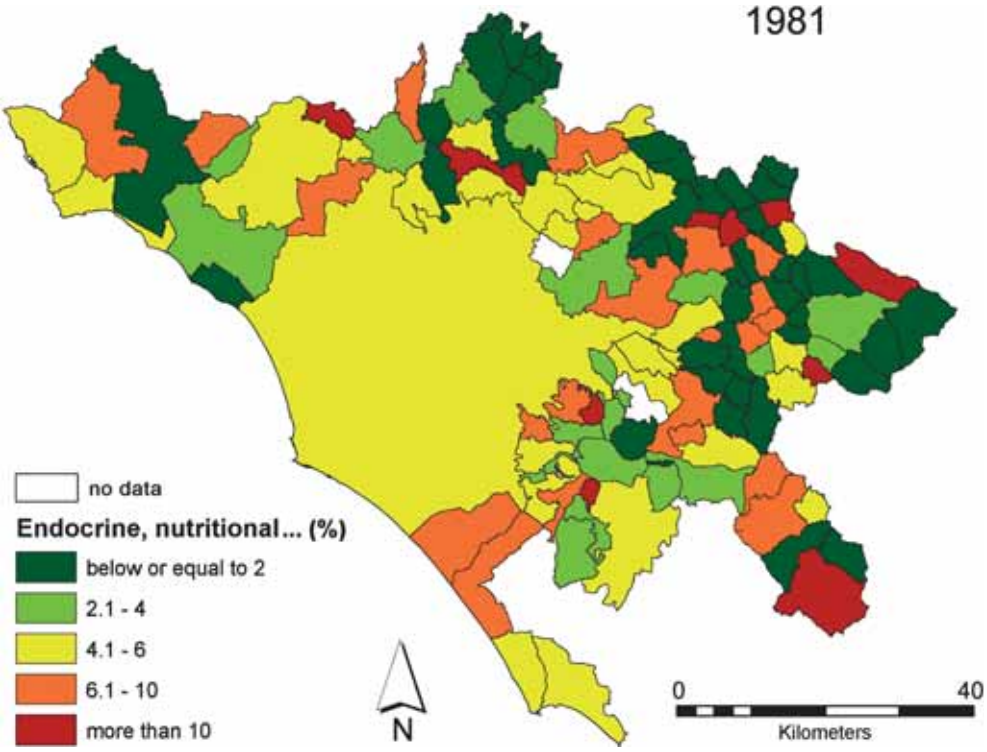

Fig. 15. The percentage of mortality due to endocrine, nutritional and metabolic diseases, in 1981, in the municipalities of the province of Rome.

Source: elaboration on data ISTAT

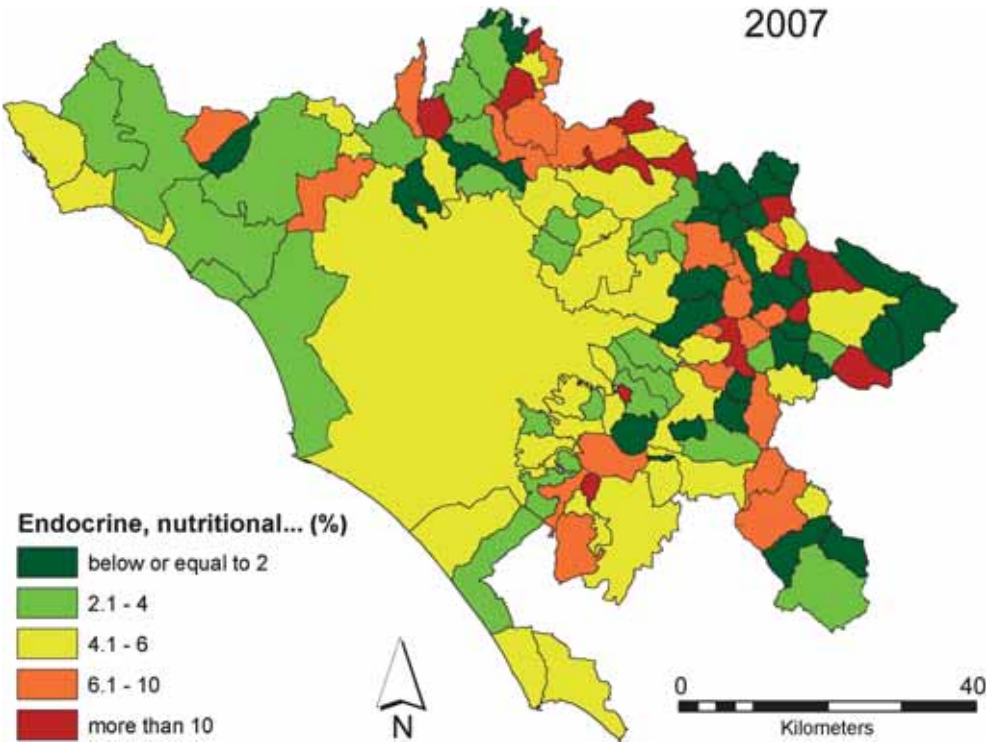

Fig. 16. The percentage of mortality due to endocrine, nutritional and metabolic diseases, in 2007, in the municipalities of the province of Rome.

Source: elaboration on data ISTAT

Cervara di Roma and Marano Equo (20.0), Arcinazzo Romano and Filacciano (14.3), Civitella San Paolo (13.6) and other five municipalities with values more than 10 percentage points.

The map for 2007 shows a variegated situation, but the coastal zone featured only medium (between 4.1% and 6%) and medium-low values (between 2.1% and 4%), while all the different cases were recorded in the east, where a certain number of municipalities with medium-high (between 6.1% and 10%) or high (more than 10%) values were to be seen, also in close proximity to municipalities with low (below or equal to 2%) values.

In the city of Rome, the mortality due to endocrine, nutritional and metabolic diseases decreased from 5.7% to 4.3%, showing once again values very near to those of the province.

All in all, the continuing similarity between the values of the city of Rome and its province lead us to the conclusion that the data of Rome city strongly influences the provincial data as an effect of the "giant" role played by the city (both in surface area and above all for number of inhabitants). Consequently, to carry out a screening on the city of Rome, and in particular on the land use and its evolution over time, a knowledge of the peculiar features, the risk factors and the location of pollution sources or noxious economic activities in a city where, in 2007, 67% of the inhabitants of its province lived, would be of primary importance.

HEALTH THREATS AND ENVIRONMENTAL RISKS IN URBAN AREAS: THE CASE OF ROME PROVINCE

Health is one of the fundamental prerequisites for a sustainable lifestyle in cities. Nowadays cities house more than half

of the world population but the amount of urban population will continue to increase in the future [UN-Habitat, 2006]. This is the reason why urban areas have an important role in promoting better conditions for their inhabitants (from an economic, social and environmental point of view) and healthy ways of living. The recent rate of urban growth, especially in the developing world, is unprecedented, with vast implications for human well-being and the environment [WHO, 2007].

Among industrialized nations, city dwellers already account for nearly three-quarters of the population. Cities of the developing world, on the other hand, will absorb roughly 95 percent of the total population growth expected worldwide in the next two decades, a result of rural to urban migration, the transformation of rural settlements into urban places, and natural population increases. Megacities, those with more than ten million inhabitants, will continue to grow in size and number.

However where cities pose environmental problems they are expected also to offer solutions. The aim of a healthy city is not only about minimizing adverse factors such as traffic, the pollution of air, soil, water, or social problems. It is about actively creating certain conditions that promote the health, safety and well-being of people in the city.

Different types of hazard affect the city and the province of Rome including biological pathogens, chemical pollutants (air pollution, water pollution, hazardous wastes), physical hazards (traffic hazards, natural and human accidents because of inadequate attention to prevention and mitigation), heat island effects and thermal inversions, resource degradation (soil erosion; deforestation; water pollution; ecological damage from acid precipitation and ozone plumes); land or water pollution from waste dumping; loss of biodiversity; loss of non-renewable resources, greenhouse gas emissions, stratospheric ozone-depleting chemicals. One of the more urgent issue in Rome, as in many other vast urban areas, is air pollution. Rome experience severe forms of air pollution as the result of the increased private transport.

Apart from the different forms of pollution affecting the city, the problem of Rome is the lack of effective and cross-cutting goals and policies to protect the environment and prevent its degradation. Many cities all round the world are experimenting environmental best practices through the initiative of Local Agenda 21. This is also the case of Rome. The main issues addressed by the Local Agenda 21 of Rome province and municipality are: innovations in building construction, improve of energy efficiency and waste management, increase of public transportation. With proper planning and long-term vision Rome, as other dense settlement patterns, can offer economies of scale to reduce pressures on natural resources from population growth and make life in city mores sustainable.

The effort needed for Rome in the future is to include environmental concerns in all the other policies in order to make environment a concrete priority. This effort is necessary to increase the health and life quality of Rome citizens and to protect the landscape of Rome, one of the most important resources of the city.

LAND USE CHANGE AND ENVIRONMENTAL QUALITY: THE CASE OF ROME PROVINCE

Land use and land cover change is gaining recognition as a key driver of environmental change [Dale, 1997; Turner, 1994]. With the awareness of the importance of land-use change on global change, the study of land use and land cover change has become the focus of much scientific endeavour and international organizations. Human activities are altering the land use at an unprecedented rate and scale. Changes in land use affect

environmental quality because of the different implications of land use practices on environment. Changes in land cover have important consequences for natural resources through their impacts on soil and water quality, ecosystem processes and functions, and global climatic systems [Meyer, Turner, 1991]. The modification and conversion of land use and land cover are directed by the interaction in space and time between environment and human activities. In particular there is a growing concern on the sprawl affecting urban areas all over the world and the progressive conversion of rural and natural areas into built-up areas.

The analysis of land use can, indeed, be a useful tool to study the environmental quality of urban areas while the analysis of land cover change can help in investigating whether the environmental quality has decreased or increased.

Since we want to analyse the relationship between health and city and since environmental quality is a key element in promoting human well-being in urban areas, we decided to study the land cover of Rome province, which is our case study, to try to evaluate the environmental quality of Rome as a result of land cover analysis.

As a second step we analysed the evolution of land use in the city of Rome between 1980 and 2001 to find out if the environmental conditions of the city are becoming better or worse. We focused the attention on the city of Rome because human pressures and human activities are much stronger in this area and can have a greater effect on the health of inhabitants.

Today artificial land use covers 14.37% of the total surface of Rome province while rural areas cover 50.46% and natural areas 35.17%. In comparison with other metropolitan areas the amount of built-up areas is not particularly high (Tab. 1, Fig. 17). In addition it is worth noting that more than half of the total surface is covered by agricultural areas. The most critical areas are the coastal zones, in the western part of the area, the city of Rome and the south-east area of the province, the area of the Alban Hills. During the last few decades these areas have been affected by urban sprawl determining an unprecedented growth of built-up areas and commercial areas, an increase in traffic flows, the fragmentation and loss of rural and natural areas, often resulting in marginal areas, and the increase of human pressure on the physical environment.

Table 1. The main land use types of Rome province

Land cover classes	%
Continuous urban fabric	4.49
Discontinuous urban fabric	4.39
Non irrigated arable land	26.05
Permanently irrigated land	5.46
Olive trees	7.74
Deciduous forest	23.48
Coniferous forest	5.13
Total surface	76.64

Some parts of the Rome province, especially in the city area of Rome, host sites for activities with high pressure on human health, such as industrial units, dump sites, mineral extraction areas (Fig. 18). The environmental impacts of these activities are not sufficiently taken into account in land planning and management. The consequence of this lack of planning is often a concentration of health risks in some areas.

On the other hand, a significant amount of natural areas, often included in protected areas, have an important role in preserving a high level of environmental quality in Rome province (Fig. 19). It is worth noting that the area features a high percentage of forests which lessen air pollution and mitigate the effects of climate change.

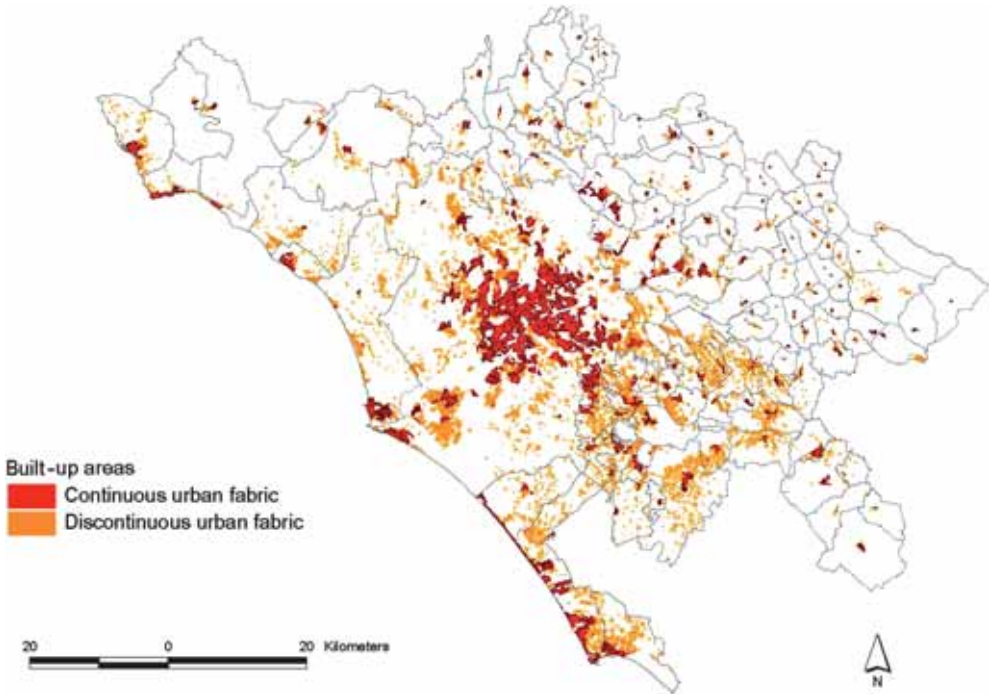

Fig. 17. Built-up areas of Rome province.

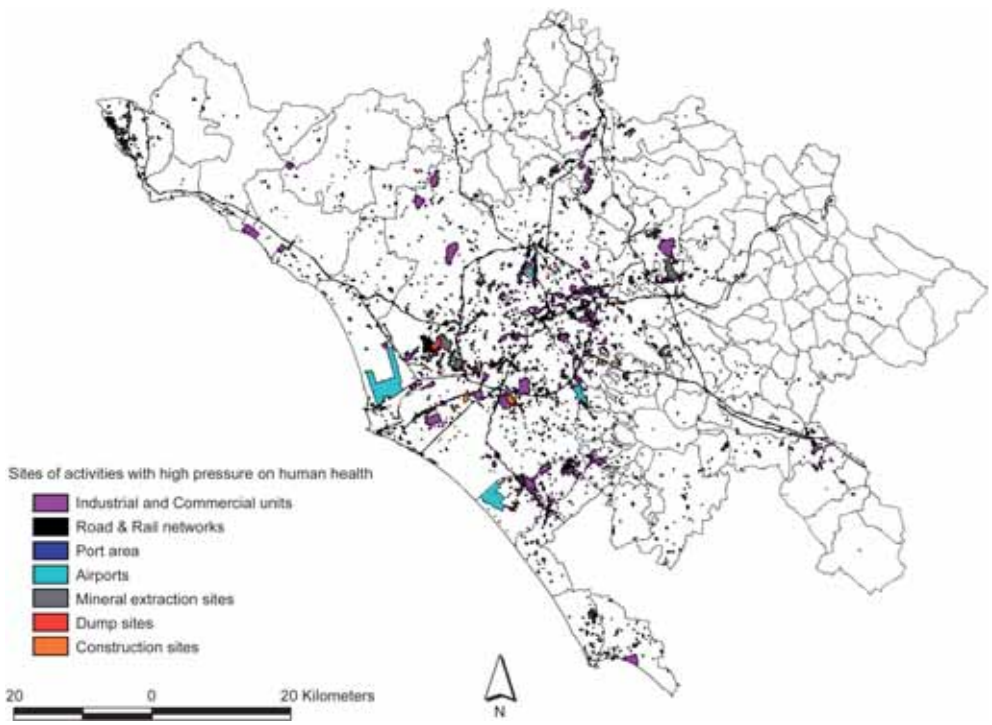

Fig. 18. Sites of activities with high pressure on human health.

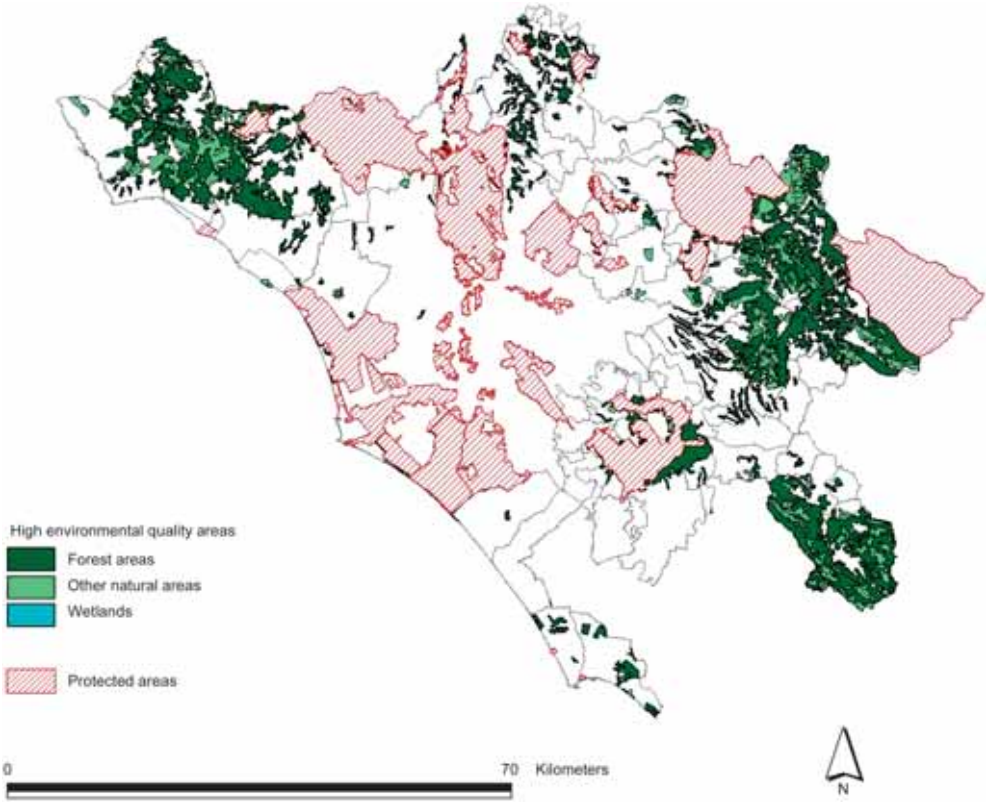

Fig. 19. High environmental quality areas.

Table 2. Different land use types in 1980 and 2001 and % variation (80-01) in the city of Rome

Land use classes	hectars 1980	hectars 2001	% var. 80-01
Road and rail networks	8865.24	10884.70	23
Continuous urban fabric	11539.66	14672.43	27
Discontinuous urban fabric	9912.28	12635.97	27
Green areas	1178.12	1405.33	19
Sports and leisure facilities	696.97	1386.77	99
Cemeteries	200.08	251.90	26
Non irrigated arable land	71669.76	61557.24	–14
Permanently irrigated arable land	2658.36	3253,.31	22
Complex cultivation patterns	5514.86	3771.46	–32
Sparsely vegetated areas	119.59	100.41	–16
Reforestation areas	2400.71	2964.84	23
Transitional woodland shrubs	1185.99	1853.89	56
Sclerophyllus vegetation	1235.51	1296.75	5
Coniferous forest	2361.33	2457.96	4
Broad-leaved forest	7522.65	8543.76	14
Hygrophilous forest	680.24	707.44	4
Inland waters	43.19	20.20	–53
Water bodies	833.91	859.26	3

Land cover change in Rome city between 1980 and 2001

The situation of environmental quality in the city of Rome is today very similar to other metropolitan areas of the developed world. The city is affected by air, land and water pollution, hazardous wastes, traffic hazards, heat island effect, resource degradation, loss of biodiversity, loss of non-renewable resources, greenhouse gas emissions. In comparison with other European cities (www.urbanaudit.org) the city presents higher levels of traffic and resources consumption (water, energy). On the other hand, Rome has a significant amount of protected areas, representing almost one third of the whole municipality, and a relevant coverage of green areas (15%) and agricultural lands (50%). The environmental quality of the city is today compromised by the development of new residential and commercial areas, both sprawling processes accelerated by the approval of the New Master Plan (2005). Building and tourist activities are, in fact, the main economies of the city.

The land use change occurring in the city of Rome is determining the progressive conversion of agricultural lands into built-up areas. Non irrigated arable lands decreased, between 1980 and 2001, by 14%, while complex cultivation patterns decreased by 32% (Tab. 2). In the same period, artificial lands showed a growth of 77%. However, it is worth noting that some vegetation types are also increasing in terms of surface area (Figs. 20–21).

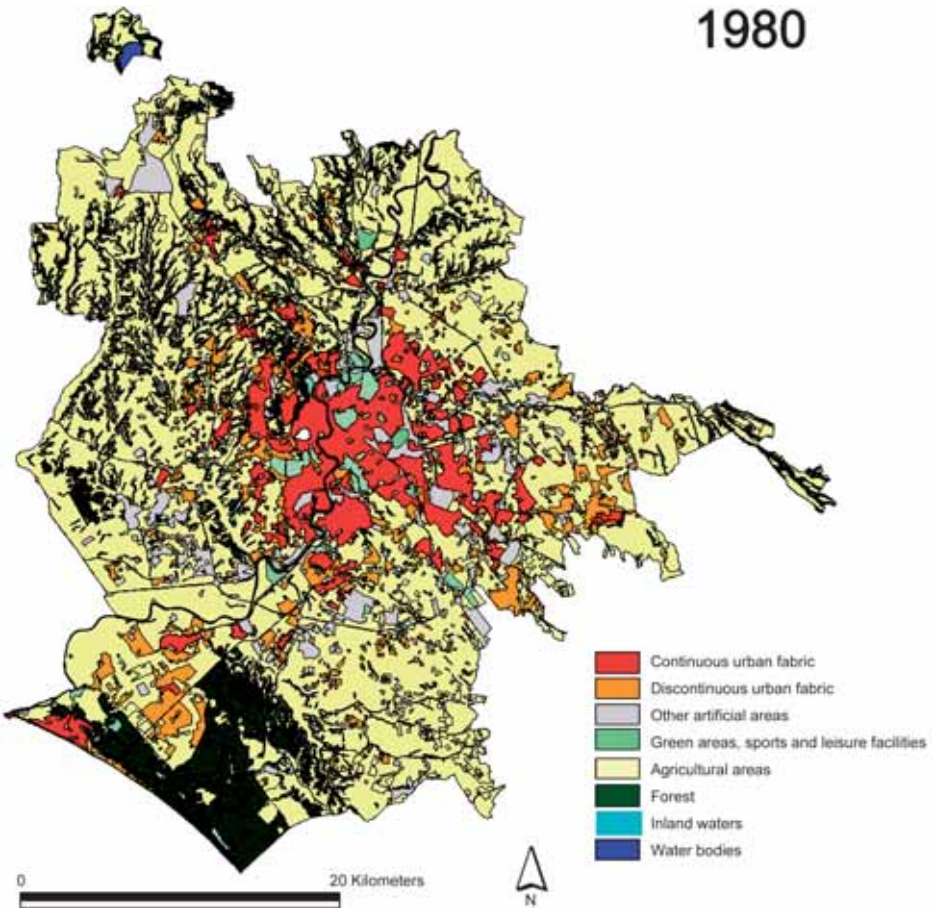

Fig. 20. Land cover in Rome in 1980.

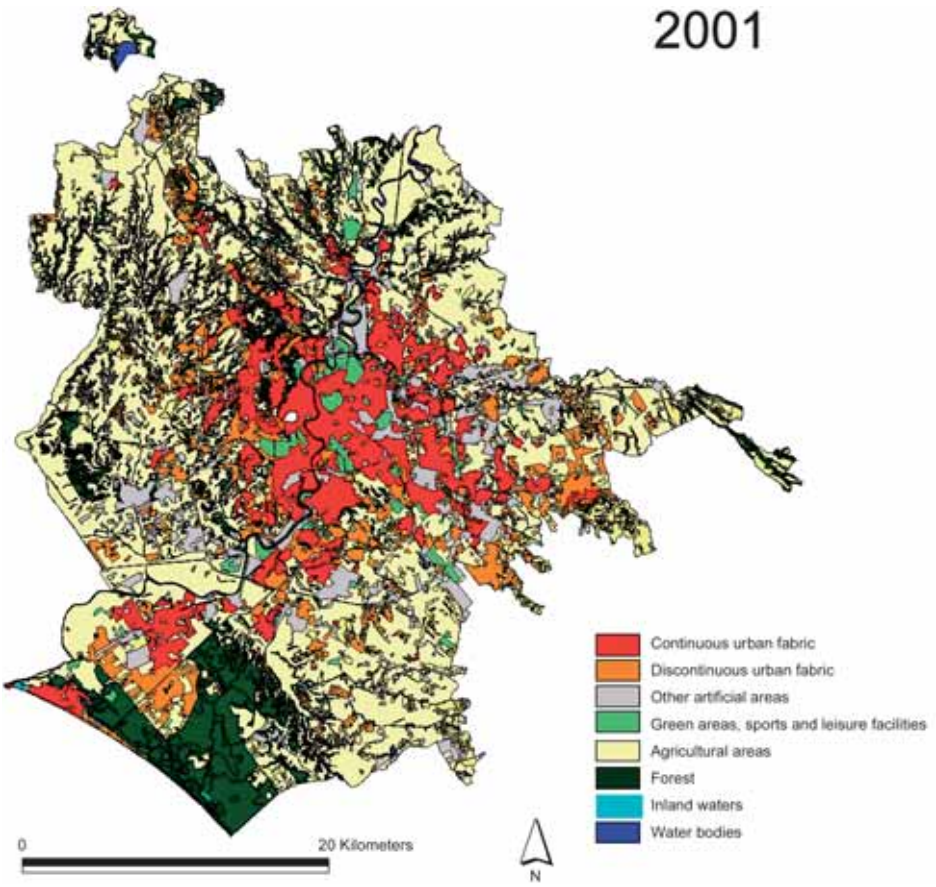

Fig. 21. Land cover in Rome in 2001.

The significant amount of green and forest areas of the city of Rome has an important rule in improving the environmental quality of the urban area. However it is necessary to make an effort to increase the safeguarding and restoration of natural and agricultural areas, in order to offset the negative effects of urban sprawl.

The improvement of urban sustainability has to become the main goal of future land use and city planning in order to offer better living conditions for city dwellers and healthier ways of living.

CONCLUSIONS

The analysis of quantitative data regarding the main five causes of death in the province of Rome allows us to produce detailed spatial and temporal frameworks, which may be useful for:

- sanitary and geo-medical purposes, since these frameworks show the local and provincial characteristics and induce to search the possible risk factors;
- social purposes, in order to improve the environment and to increase the quality of life of the city inhabitants and the level of services for sick person;
- future planning of economic activities, in order to decrease risks for human health and their impacts on other local problems.

For what it concerns the diseases of the circulatory system and neoplasms, which are respectively the first and the second causes

of death in Rome province and in Italy too, we observed two very different trends. First of all, the relevance of diseases of the circulatory system decreased from 43.2%, in 1981, to 38.4%, in 2007, while the relevance of neoplasms in the same years increased from 25.8% to 32.6%. Therefore, the gap between the relevance of diseases of the circulatory system and neoplasms recorded an important reduction. Then, through various medical-geographical thematic maps, we showed the distribution and evolution of the data at the scale of the municipality; for example the results derived by the maps regarding the amount of difference between the percentage data of 1981 and 2007 are synthetically the following:

– for the diseases of the circulatory system, 81 municipalities recorded a substantial decrease, 14 municipalities recorded a not appraisable variation and 23 a substantial increase;

– for neoplasms, 14 municipalities recorded a substantial decrease, 11 municipalities recorded a not appraisable variation and 93 a substantial increase.

In the next step, we produced some maps derived from a re-elaboration *ad hoc* of the legend of the official land use maps. Our maps were elaborated to show:

– the spread of built-up areas, with the most critical areas represented by the coastal zones, the city of Rome and the area of the Alban Hills;

– the location of sites of activities with high pressure on human health;

– the high environmental quality areas (above all forest, other natural areas and protected areas), which characterise a large part of the Rome province.

In fact, these are elements which can threaten or preserve the integrity of ecosystem and have an influence on human health.

Finally, we focused the attention on the land cover change in Rome city between 1980 and 2001 to provide an exemplification of analysis at very large scale in a context where important increases are recorded both in built-up areas, i.e. along the axe between Via Portuense and Via Cristoforo Colombo (in the southwest part of the city, near the River Tiber), and some vegetation types. These changes above all if analysed for several municipalities and progressively updated may provide neuralgic inputs to investigate the variations recorded in the causes of death and to conduct interdisciplinary researches where geography and medicine may advantageously collaborate.

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