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QUALITY OF LIFE ASSESSMENT IN URBAN ENVIRONMENT USING A GEOGRAPHICAL INFORMATIONAL SYSTEM MODEL. CASE STUDY: BRĂILA CITY

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ABSTRACT – The study on the quality of life (QoL) in urban areas is gaining interest from a variety of disciplines such as planning, geography, sociology, economics, psychology, political science, marketing, and is becoming an important tool for urban planning and management. At present, there is a great deal of ambiguity and controversy on the concept of QoL, its elements and indicators. Thus, the present paper focuses on the development of a methodology for assessing quality of life in urban environment implementing a geographical informational system model that includes data from different areas of analysis, as follows: geographical data, Urban Audit socio-economic data, Urban Atlas data, satellite image data, survey data and indicators. The Geographic Information model derived from correlating the data mentioned above is used for evaluating the quality of life in Brăila, a 200,000 people city, situated in eastern Romania and port on the Danube River.

Keywords: satellite data, Urban Audit, indicator, Urban Atlas

INTRODUCTION

Quality of life concept refers to factors that make a life better to live. It represents more than private "living standards" and represents all needs and requirements of the conditions of human beings. We often use this concept to measure and evaluate people's well-being, satisfaction and happiness.

Quality of life demands, among other things, available and accessible social and public infrastructure to satisfy the needs of those concerned in it and affected by it as well as an environment free of serious deterioration or pollution. Such conditions are not generally met in our cities, since a large part of the inhabitants live in dwellings and neighbourhoods lacking basic facilities and services.

From the sociologic point of view, quality of life reflects both objective and subjective elements (Stathoupoulou et all, 2009). For example, employment is an objective criterion, while how satisfied people are about their work is clearly subjective. An economic analysis regarding quality of life takes into account the living standard as being the general level of prosperity, comfort, of material goods and of needs available to a certain socio-economic class from a certain socio-economic domain in a specific geographical area.

For defining quality of life, a number of indicators are commonly used representing the most important aspects in the life of a person, such as education, employment or the state of the physical environment.

STATE OF THE ART

Wallace (1971) stated that quality of life includes the psychological and sociological dimensions of adequate housing, the enjoyment of cultural, recreational and leisure time activities (Weng, Q., 2010). Smith (1973) suggested that adequate income, decent housing, good quality education and health services, as well as good physical environment, are important aspects of social

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well-being (Smith, D.M, 1973). Liu (1976) believed that quality of life was based on economic, political, environmental, health, education and social factors. Bederman and Hartshorn (1984) used weighted socioeconomic variables at the county level extracted from census data as a primary source in ranking the quality of life in Georgia (Weng, Q., 2010).

The socioeconomic variables extracted from census data do not always reflect the environmental reality. That is the reason why satellite images facilitate the evaluation of an improved quality of life analysis. The aim of Lo and Faber (1996) research was to explore the integration of environmental data extractable from satellite images with the socio-economic data from the census in order to assess the quality of life by using a computer – assisted remote sensing geographical information system approach. This concept was initiated by Chombart de Lauwe, a French sociologist interested in the use of aerial photography, who developed the concept of "l'espace social" in 1952 (Lo, C.P., Faber, B.J., 1997). Social space, considered as the total environment in which people live, is determined by two dimensions: the morphological environment and socio-cultural environment.

Lo and Faber created a quality of life map for Athens – Clarke County, Georgia, by combining environmental factors, including land use/cover, surface temperature, and vegetation index derived from Landsat Thematic Mapper (TM), with census variables, including population density, per capita income, median home value, and percentage of college graduates using both principal component analysis and GIS overlay methods.

Pacione (2003) addressed urban environmental quality and human wellbeing from a social geographical perspective and presented a five dimensional model for the study of the quality of life, and examined the major theoretical and methodological issues which quality of life research are confronted with (Pacione, M., 2003).

In their study, Li and Weng (2006) focus on the development of a methodology for integrating Landsat Enhanced Thematic Mapper (ETM+) with the 2000 Census in a GIS framework, and applies the methodology to assess the quality of life in the city of Indianapolis, Indiana. Thus, vegetation fraction, impervious surface fraction and land surface temperature are derived from Landsat ETM + image as environmental indicators, while income, education level, unemployment rate, poverty, house characteristics, crowdedness, and other variables are extracted from the Census as socioeconomic indicators. These two types of data were integrated in a GIS environment for further analyses (Li, G., Weng, Q, 2006).

THEORY AND METHODOLOGY

Different conceptual views of geographical information systems

GIS is one of many information technologies that have transformed the ways geographers conduct research and contribute to society (Foote, K., Lynch, M., 1995). In geography, many innovations in the application of information technologies began in the late 1950s, 1960s and early 1970s. Methods of sophisticated mathematical and statistical modelling were developed and the first remote sensing data became available. Researchers began also to envision the development to geographic information systems. The mid 1970s to early 1990s was a period of contagion. The first commercially available software for GIS became available in the late 1970s and spurred many experiments, as did the development of the microcomputers in the early 1980s.

A Geographical Informational System is a set of subsystems made for the collection, processing, absorption, store, extraction and delivery of geographical data (Niţu, C. et al., 2002). It is used by many disciplines as a tool for spatial data handling in a geographic environment. Basic elements of GIS consist of hardware, software, data and liveware. GIS is considered one of the important tools for decision making in problem solving environment dealing with geo-information.

There is a variety of definitions within this research field. No matter what kind of emphases on various aspects is distinguished in a definition, all includes features of spatial references and data analysis. Spatial information is related to geographical space, for example large – scale space. This is the space that represents the surrounding geographic world, which is topographic space, land use/land cover, climatic, cadastral, and other features of the geographical world. Geographical information

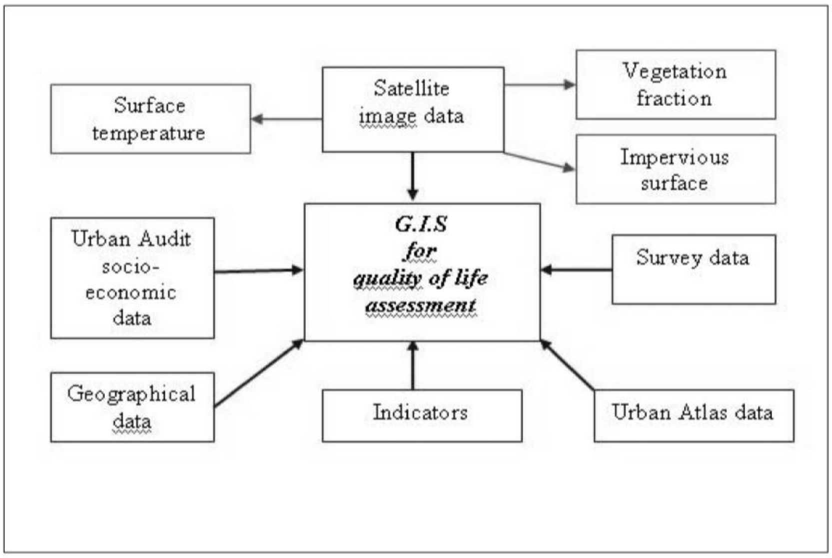


Figure 1. *GIS model for quality of life assessment*

system technology is used to manipulate objects in the geographical space, and to acquire knowledge from spatial facts (Raju, P.L.N, 2005).

From my point of view, a truthful imagery of quality of life representation stands in using and correlating the elements derived from the geographical informational model scheme (Figure 1). Geographic Information System for QOL can be considered a tool that allows both analysis and visual representation of spatially referenced data. It also provides information about additional data that can be integrated into spatial information approach, thus enhancing the possibility for a wide quality of life assessment.

The regular availability of satellite image data will allow the evaluation of environmental quality to be updated frequently to reveal more realistically QOL, than the one based just on socioeconomic variables from the static census data.

STUDY AREA AND METHODOLOGY

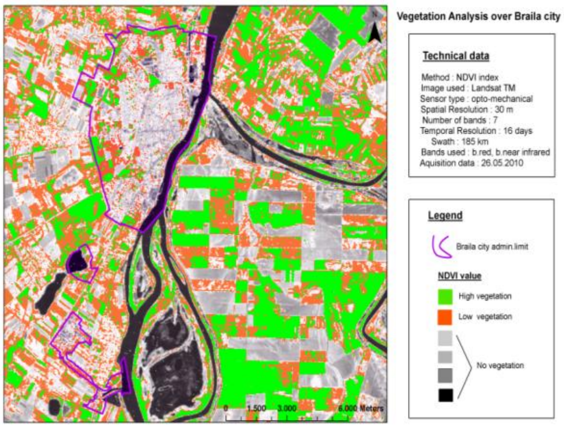
Brăila city, 45º16´09.1″N, 27 º57´26.9″E, the administrative capital of Brăila County, South – East Region of Romania, spreads over an area of 43.7 km², and has a population of 216,292 inhabitants. The city is located on the Danube River and is the country’s second largest port. Accessible to small and medium-sized sea-going ships, the economy of Brăila is centred on trade, manufacturing, construction, transport, storage and services.

Satellite image data

Remote sensing has been recognized worldwide as an effective technology for monitoring urban and environmental changes. One of the advantage of satellite remote sensing is its repetitive and synoptic coverage that is useful for urban areas (Rajeshwari, 2006). It helps to create information based on land use, land cover distribution, urban change detection, monitoring urban growth and urban environmental impact assessment, which lead the way for quality of life assessment.

The study uses the Landsat TM image dated 26.05.2007. Atmospheric conditions were clear at the time of image acquisition, the image being acquired through the United States Geological Survey (USGS) Earth Resources Observation System Data Center.

As greenness relates to vegetation, it will be measured using vegetation indices such as NDVI (normalized difference vegetation index). NDVI was developed by Rouse et.al (1974) and currently is one of the most common used band indices for detection of vegetated areas (Rouse, J.W., 1974). The NDVI is calculated as: (NIR-R)/(NIR+R), where: NIR = Near Infrared; R= visible Red band. High and low vegetation, as presented in Figure 2, can be explained on land use categories, using Corine Land Cover, European nomenclature for land use-land cover, as shown in Figure 3.



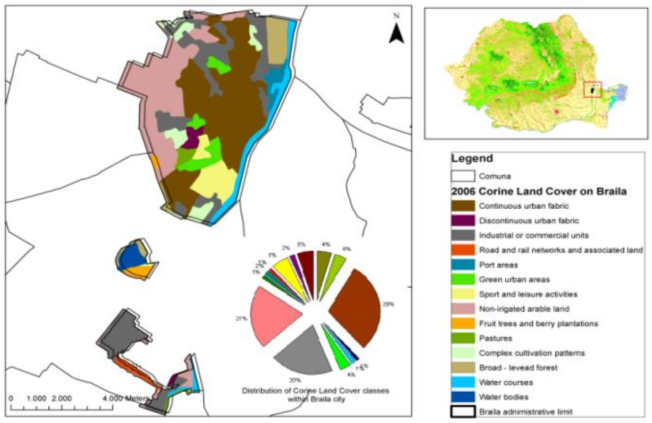


Figure 2. *NDVI Brăila map* **Figure 3.** *Brăila Corine Land Cover*

Land surface temperature can provide important information about the physical properties and climate which plays an important role in many environmental processes and, at the same time, is an important factor affecting human comfort. High surface temperature is considered undesirable by most people, therefore it can be used as an indicator of environmental quality (Li, G., Weng, Q., 2006).

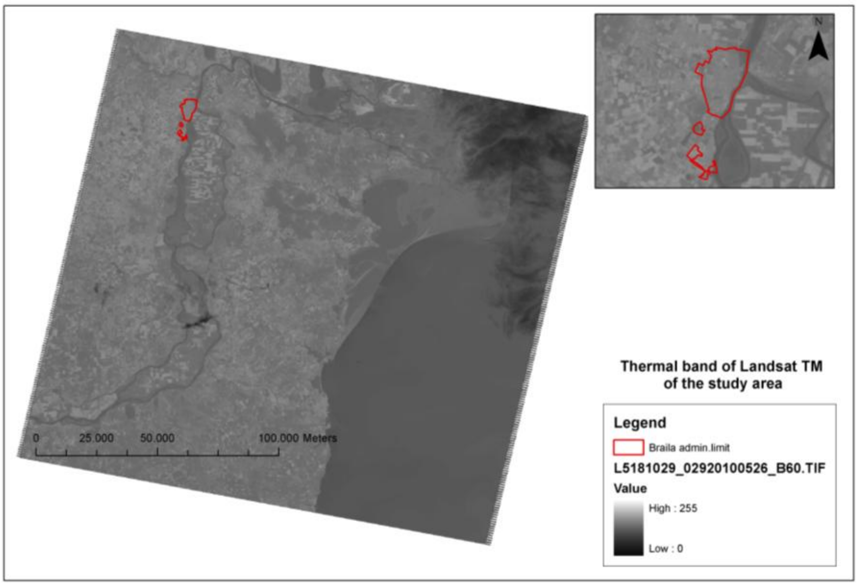


Figure 4. *Thermal band of Landsat 6 TM of the study area*

Nowadays, satellite imageries are an important tool for monitoring LULC changes because of the availability of medium to high spatial resolution (0.60 – 30 meters), wide range spectral region from visible to infrared and frequent temporal resolution (Dontree, S., 2010). Even if it is less utilized because of the low resolution, the 120 m resolution Landsat Thematic Mapper (TM) thermal infrared band 6 provides the source to extract surface temperature (Figure 4).

To estimate the thermal condition of land surface it would be useful to correlate this variable with CLC pattern. This way one sees how land surface temperature varies among different CLC types (Figure 5). The following procedure was carried out to derive the surface temperature, generate the temperature color map and analyze the data.

In order to complete the land surface temperature (Figure 6) the conversion of the Digital Number (DN) to Spectral Radiance (L_λ) must be done. The spectral radiance is calculated using the following equation:

$$L_\lambda = LMIN_\lambda + \left(\frac{LMAX_\lambda - LMIN_\lambda}{QCALMAX}\right) QCAL$$

- QCALMIN = 1, QCALMAX = 255 and QCAL = Digital Number.
- The $LMIN_\lambda$ and $LMAX_\lambda$ are the spectral radiances for band 6 at digital numbers 1 and 255, respectively.

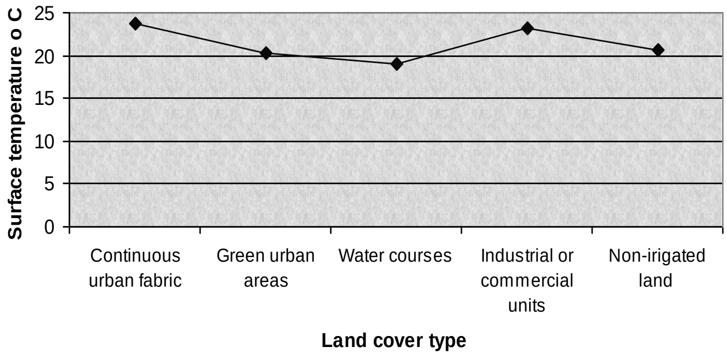


Figure 5. *Surface temperature variation in Brăila*

Conversion of the Spectral Radiance to Temperature:

$$T = K2 / \ln(K1 / L_{\lambda} + 1)$$

- T = Effective at-satellite temperature in Kelvin
- $K1$ = Calibration constant 1 (watts/meter squared*ster*µm)
- $K2$ = Calibration 2 (Kelvin)
- L_{λ} = Spectral radiance (watts/meter squared*ster*µm)

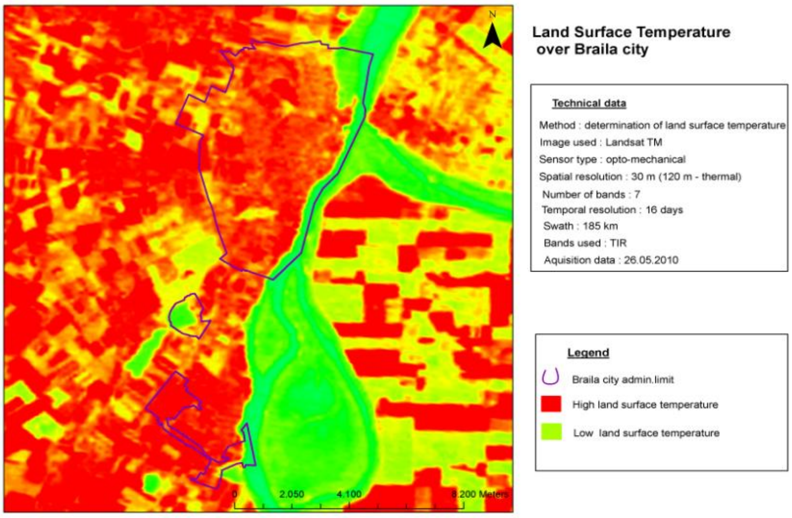


Figure 6. *Land surface temperature over Brăila City*

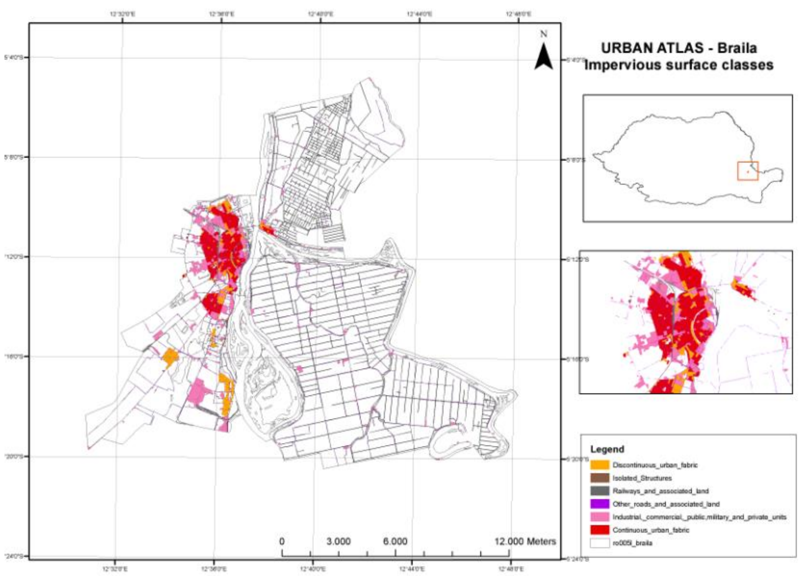


Figure 7. *Brăila impervious surface classes*

Urban Atlas Data

The Urban Atlas – a land use change monitoring product – offers a sound basis for spatial statistic calculations and the revision of urban plans. The Urban Atlas maps can provide a pan- European classification of city zones, allowing an easy comparison of information on the density of residential areas, commercial and industrial zones, the extent of green areas, the exposure to flood risks and the monitoring of urban sprawl. Urban Atlas contains as input data, satellite images with 2.5 m spatial resolution multispectral or pansharpened (multispectral merged with panchromatic) data, topographic maps at a scale of 1: 50,000, geometric resolution of 1: 10,000, MinMU = 0.25 ha. Urban Atlas data for Brăila city are used for getting impervious surfaces (Mapping Guide for a European Urban Atlas, 2008*)*.

Impervious surfaces are defined as any material that water cannot infiltrate and are associated with human activities and habitation through construction of transportation and buildings (Dengsheng, L., Moran, E., Hetrick, S., 2011). Impervious surfaces are mainly artificial structures – such as pavements (roads, sidewalks, driveways and parking lots) that are covered by impenetrable materials such as asphalt, concrete, brick, stone, and rooftops. Soils compacted by urban development are also highly impervious.

Since 1970, many methods have been developed for mapping impervious surfaces with different spatial resolution such as IKONOS and QuickBird, medium spatial resolution such as Landsat TM and Terra ASTER (Rajeshwari, 2006).

Within Brăila City, the following impervious surface classes are represented: continuous urban fabric, discontinuous urban fabric, industrial, commercial, public, military, private and transport units, railways and associated land (Figure 7).

Urban audit socio-economic data

Urban Audit is a response to the growing demand for an assessment of the quality of life in European towns/cities, where a significant proportion of European Union citizens live. The Urban Audit is a joint effort of the Directorate-General for Regional Policy (DG REGIO) and Eurostat to provide reliable and comparative information on selected urban areas in Member States of the European Union and the Candidate Countries (Urban Audit, 2004).

In order to participate to this project, the Romanian National Institute of Statistics developed the Urban Audit project in cooperation with the territorial statistical offices corresponding to regions or counties that include the selected cities. Fourteen Romanian cities are included in the Urban Audit project, of which 4 are large and 10 are of medium size: Bucharest, Cluj-Napoca, Timişoara, Craiova, Brăila, Oradea, Bacău, Sibiu, etc. This project provides information and comparable measurements on the different aspects of the quality of urban life.

Indicators

We can say that an indicator is derived from data corresponding to values that can be measured or observed, which provides information about a phenomenon (EEA, 2002). It is a quantitative or a qualitative factor that provides a simple and reliable means to measure achievements or to reflect changes within an urban system. The table below presents a number of Urban Audit domains together with their corresponding indicators.

Table 1. *Structure of Brăila Urban Audit indicators*

	URBAN AUDIT DOMAIN	INDICATOR
1.	Demography	Number of residents → 215,316
		Density of the population → 4997 residents/km²
2.	Social aspects	Number of dwellings → 78,394
		Average price/m² for an apartment → 630 EUR
		Housing average area → 35.19 m²
3.	Economic aspects	Unemployment rate→ 4.4%
		Gross domestic product/resident → 9149.7
4.	Environment	Total land area → 43.93 km²
		Proportion of area in green space → 16%
5	Information society	Percentage of households with a computer → 4%
		Percentage of households with internet access at home → 3%
6.	Culture	Number of libraries → 80

Survey data

Survey data are completed by using a questionnaire that examines a range of issues, such as employment, income, education, health, etc. The interviewing research made on the above-mentioned domains will reveal subjective indicators, which have a great importance in illustrating the quality of life of a specific area. Subjective indicators are important in measuring the quality of life from the point of view of the interviewed person. Subjective indicators measure things that are relatively intangible and directly experienced by the respective person. The objective indicators (as the one represented by the Urban Audit program) do not have access to people attitudes, beliefs, knowledge, needs, personal assessment of happiness, satisfaction, that is why it is reasonable to give special privilege to subjective indicators.

The survey data can be carried forth by different types of investigations: the interview method, the postal questionnaire, the telephone survey, and by face-to-face investigation.

For this study the telephone survey method was chosen and applied on 400 citizens of Brăila. The survey topics were related to place of work satisfaction, household incomes, family, health and the quality of information society.

Geographical data

Geographical data includes all elements, objects and attributes that have a spatial reference coordinate system, used to locate geographical entities.

Geographical data contain representations of:

- vector data for representing features;
- raster data for representing images;
- triangulated irregular networks (TINs) for representing surfaces;
- addresses and locators for finding a geographic position (Zeiler, M., 1999).

Vector data can be represented by features, networks, surfaces, location points and images. Raster technology is an efficient means of capturing large amounts of imagery data. Images provide an informative background display below feature layers on a map.

RESULTS AND DISCUSSION

The geographical information system model used for this study draw a series of results, which illustrate through each of the scheme component, an image of Brăila's quality of life.

High vegetation corresponds to green urban areas which are portions "with vegetation within urban fabric, which includes parks and cemeteries with vegetation, mansions and their grounds" (Bossard, M., Feranec, J., Otahel, J., 2000) and low vegetation, which stands for pastures, "lands which are permanently used for fodder production. They include natural or sown herbaceous species, unimproved or lightly improved meadows and grazed or mechanically harvested meadows" (Vlad, M., I., Brătăşanu, D., 2011).

In Romania, within the 319 urban settlements, where 55.2% of

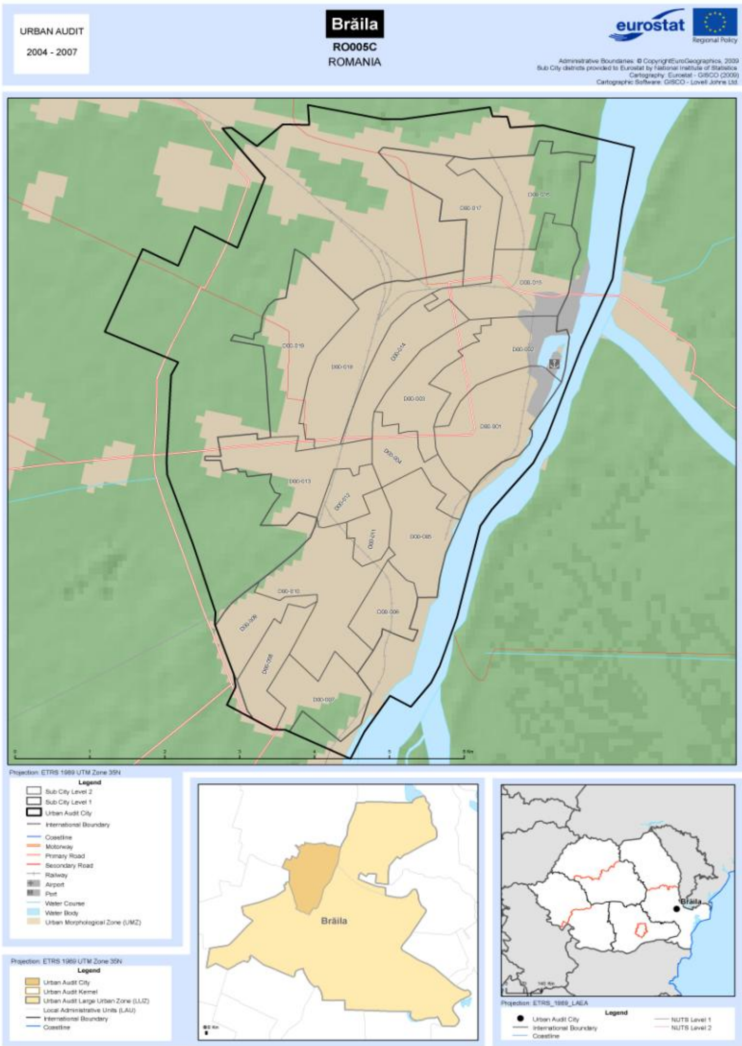


Figure 8. *Brăila geographical position*

the population lives, a decrease of the green areas was registered in the last decades because of the permanent expansion of the built space. Concerning this, the average green space area in Romania is 18 square meter/resident, whereas in Europe it is 25 square meters/resident (Vlad, M., I., Brătăşanu, D., 2011). As the World Health Organization rate is 50 square meter of green area/resident and the EU standard is 26 square meters/resident, Romania does not have the minimum level of green areas. In 2007, Brăila, a 43.92 square km city, had 2.78 square km of green areas and 215,316 residents. Thus, the average square meter/resident is 12.

As for the land surface temperature, taking into account that the image was purchased at the end of May, the highest temperatures are registered in the continuous urban fabric area and the industrial zones (23º) due to the aluminium roof material and the thermal energy caused by production activities. The roof and asphalt makes the reflectivity occur and it causes surface temperature and overall ambient air temperature in urban area to rise (Van, T., 2005). The areas with temperatures between 19ºC and 20ºC in green and yellow are green areas, pastures, non-irrigated land and watercourses (Figure 6). The relationship between surface temperature and land cover types is shown in Figure 5.

More than half of Brăila total land area is covered by impervious surfaces that induce the increase of air temperature, producing an urban heat island. The warm runoff from impervious surfaces reduces the level of dissolved oxygen in the stream water, making life difficult, mostly in summer. As impervious surfaces lead to increased temperature, they also contribute to worsened air quality.

The socio-economic point view, in relation to Urban Audit structure, as presented in Table 1, disclose the situation of the selected Urban Audit indicators in 2007, which reveal a population of 215,316 people, with a density of 4,997 residents/km². The housing average area of the 78,394 dwellings is 35.19 m², while the average price/m² for an apartment is 630 euro. The economic aspects are emphasized by the unemployment rate of 4.4% (a quite high value, the same with the national one) and a gross domestic product per resident of 9,149.7 RON. Brăila City covers 43.93 km², while green areas represent 16% of it.

Brăila's citizens are generally dissatisfied with their life: on a scale from 1 to 10 the interviewed persons average is 5 for life satisfaction and 6 for happiness. Quite significant disparities regarding household incomes were registered, as most of the citizens were worried about their monthly income. Family is highly involved in child and elderly care, the interviewed persons reporting high level of satisfaction with their family life. People report difficulties in finding a work-life balance, most of them saying that they are too tired to do household jobs because of their work. 90% of the interviewed said that good health is essential in having a high standard of quality of life; however, just 30% of them rate their health as good. The other 70% stated that they suffer from heart diseases, liver diseases, etc. When asked to rate the quality of society, people disagree with the idea of trusting their political institutions, but choose to express the highest level of trust in family and close friends.

CONCLUSION

I consider that this analysis method summarize different sets of systems which hold data particularly for evaluating each of the quality of life aspects. Satellite images can deliver data as environmental factors, the Urban Audit structure together with specific indicators present the object part of life, while survey data identify and provide subjective aspects of human well-being.

ACKNOWLEDGEMENTS

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