18. Pollution and environmental protection in Ljubljana

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The negative impacts of environmental pollution and development which is not in equilibrium with the natural self-cleaning and regenerating capacities of particular elements of the environment have in some places reached the point of endangering public health and well-being, thereby affecting the quality of life. When the anthropogenically changed environment starts to affect the quality of human life, these negative effects are particularly noticeable in urban and industrial ecosystems, and these environmental problems become increasingly important limiting factors for the development of many cities. Experts caution that the most acute problem for nearly all countries is the increasing share of the urban population. Its density is also increasing, such that the world is gradually becoming urbanized, even as living conditions in cities are generally worsening.

Ljubljana (population 267.000) and the whole of the Urban Municipality of Ljubljana (UML) is characterized spatially and environmentally by a geographical location in a large and densely settled pre-Alpine basin, a greater sensitivity of some environmental elements, a favourable location from the standpoint of transportation, a concentration of various economic activities and ongoing spatial expansion. The attractiveness of Ljubljana and environs as an area of development and hence desirable location on the one hand, and its spatial limitations and the sensitivity of some landscape elements on the other, exacerbate spatial and environmental conflicts. It is also typical of the urban development of Ljubljana that the long-term spatial and environmental dimensions of development and the public interest are subordinated to more narrowly conceived, short-term private and economic goals (Plut et al., 2006). At the same time Ljubljana as the capital of Slovenia is under the growing influence and impact of globalization and the wider challenges of sustainable development.

Different size, shape, geographical location, self-cleaning capacity, density of the urban population, economic orientation and level of prosperity influence the specific paths and measures taken for long-term sustainable urban development. A common and fundamental problem in creating sustainable cities is no longer a lack of arguments in support of green towns, but the question of which co-evolutionary strategy for urban development will have sufficient public and political support for the required sustainability breakthrough (Plut, 2007).

18.1. Environmental pollution and critical environmental problems of Ljubljana

The issue of environmental protection, alongside economic and social aspects of development, is becoming equal in importance in the planning of sustainable urban development in Ljubljana. From the standpoint of sustainable development the quality of

Ljubljana's environment has been an obstacle to development, but fortunately in most cases the degradation of the environment and its elements has not proved irreversible. A reduction of environmental pollution (through wastewater treatment, sorting and better management of solid waste, reduction of air pollution from industrial, energy, and urban sources) can already be seen in the improved quality of individual elements of the environment. However, problems relating to traffic congestion, increasing the attractiveness and accessibility of public transport, ecologically balanced land use, slowing of suburbanization, improving the attractiveness of residence in urban centres, and conservation of groundwater of suitable quality remain unresolved.

18.1.1. Air

A typical feature of most Slovenian cities is a valley or basin location. In addition to the concentration of population and resultant traffic, there are also numerous thermal energy and industrial plants, which are major sources of air pollution. This type of closed-in location often makes it impossible for environmentally damaging emissions to be distributed and dispersed to a greater distance and mixed with surrounding cleaner air. Most unfavourable of all are the frequent temperature inversions and associated fogs during the colder half of the year, which act as a lid beneath which the greatest concentrations of emissions appear. The average speed of the wind is only 1.3 m/s in January and 2.0 m/s in May, and the incidence of no wind is between 6 and 10 %, while the thickness of the inversion most often ranges from 200 to 300 meters. The closed basin location facilitates the creation of local winds and the city also directly influences them through its morphology and type of building and urban heat islands (Jernej, 2000). In the 1970s Ljubljana was one of the most polluted cities in Slovenia. In 1967 the highest 24-hour concentration of SO_2 reached a record high of 2400 $\mu g/m^3$. Excessive pollution was caused by numerous individual chimneys as well as the thermoelectric heating plant which used coal with high sulphur content.

Measurements of air pollution in the UML take place at two "city" measuring points (Figovec, Ljubljana Bežigrad) and at the edge of the municipality (Vnajnarje). The Figovec measuring site is at a location with extremely heavy traffic, but data on air pollution are, despite the spatial limitations of the representative data, nevertheless a suitable comparative indicator for the narrower urban region of Ljubljana. The measuring site in Bežigrad is outside the influence of major local sources and a suitable indicator for the air quality of the basin and wider urban environment (Okolje v MOL, 2004). For this reason we use primary data for the "city station" in further evaluation of data on general pollution of the air in the city of Ljubljana: the measuring site of Vnajnarje is located in a hilly area and higher (630 m) region of the eastern part of the municipality (at the edge of the inversion layer) and represents a higher, better ventilated, and rural part.

Taking into account the type and quantity of energy sources consumed for particular activities it is clear that the greatest emissions are produced by energy plants, especially thermoelectric and heating plants, and by traffic, which is becoming an increasingly significant source, whereas the share of emissions from households is decreasing in significance as a result of the replacement of solid and liquid fuels with gaseous ones. The share of emissions from industrial activity in Ljubljana today is practically negligible; industrial sources even in former decades were never significant polluters of Ljubljana's air.

With the changed composition of emissions in the pollution of Ljubljana's air the seasonal nature of air pollution has also decreased, as the characteristic winter pollutants of SO_2 and smoke are being replaced by year-long ones (NOx in CO_2) and pollution from the summer season (ozone).

Due to its basin location, high density of the population and associated economic activities, Ljubljana was ranked among Slovenian cities with the highest degree of air pollution beginning as far back as the 1970s, but by the end of the 1990s this pollution had decreased substantially (Špes et al., 2000). For several decades, up until the first half of the 1990s, average concentrations of sulphur dioxide (SO_2) exceeded permissible levels and were damaging to health. At the end of the 1960s average annual concentrations (SO_2) were around 250 μg/m^3, more than four times the maximum permissible levels. In the 1980s they had dropped to around 100 μg/m^3, in the 1990s below 50 μg/m^3, and by the middle of this decade the values had dropped to below 10 μg/m^3.

Table 53: Sulphur dioxide air pollution in Ljubljana.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Number of days on which levels exceeded the permissible daily concentration of 125 μg/m^3	1	1	0	0	0	0	0	0	0	0	0
Number of hours in which levels exceeded the permissible average hourly concentration of 350 μg/m^3	39	14	14	0	0	0	0	0	0	0	0

Note: for a more general illustration of pollution of the urban environment from sulphur dioxide data are taken from the Bežigrad measuring site – as representative of the wider urban environment.
Source: ARSO, Kazalci okolja (Environmental indicators), 2009.

Reasons for the reduction in SO_2 pollution of Ljubljana's air can be found mainly in the increased and more widespread use of gas for heating in the city and most of all in the replacement of domestic coal with higher quality imported coal with a lower sulphur content in the thermoelectric power and heating plant. This energy remains the main source of emissions (74.5 %), while 23.2 % comes from households. In the last twenty years the use of coal, for instance, in heating in Ljubljana has dropped from 15 % to 2 %, and there is also a noticeable increase in the use of natural gas: from 7 % to more than 30 % (Oikos, 2007).

Similar to the situation in other urban areas, traffic in Ljubljana is the principal source of nitrogen oxides, with concentrations dependent on meteorological conditions. Traffic remains a constant source of these kinds of emissions and contributes more than half (55.5 %); also important are emissions from energy converting plants, especially thermoelectric power and heating stations (28.3 %), while the remainder are emissions produced by households and industry (Oikos, 2007).

Concentrations of nitrogen oxides (NO_X, N_O, NO_2) indicate, despite minor fluctuations, a moderate increase in pollution. In the period 1997 - 2004 the annual permissible value (40 μg/m^3) was frequently exceeded at the Figovec measuring site. In 2003 the hourly permissible value (200 μg/m^3) at Figovec was exceeded for a short time on 17 occasions, and in 2002 it was exceeded 21 times. Since the density of motorized traffic in Ljubljana is increasing and at the same time EU regulations on maximum permissible values for

NO_X are becoming more stringent each year, we can realistically expect even greater exceeded values in the future (Okolje v MOL, 2004).

The highest concentrations of nitrogen oxides are measured along busy roads, but with the use of catalytic converters in cars these emissions are being reduced. However, a faster reduction is hindered by the increase in the use of diesel motor vehicles and increasing average engine size (the irrational use of more powerful vehicles for city driving).

Table 54: Air pollution in Ljubljana from nitrogen oxides.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Average annual concentrations of NO2 (annual permissible value is 40 µg/m^3)	36	42	49	38	36	50	59	59	27*	29*	28*
Number of hours in which levels exceeded the permissible hourly conc. 200 µg/m^3 (maximum allowable is 18 hours)	0	3	2	0	0	0	0	0	0*	0*	0*

*Note: * data for the Bežigrad measuring station (for an illustration of air pollution from nitrogen oxides data from the "city" measuring site of Figovec were used until 2004, while for the last three years, when this station was excluded from automatic measurement for the national network, data from the Bežigrad station were used).*
Source: ARSO, Kazalci okolja (Environmental indicators), 2009.

In recent years an excessive concentration of ozone has become an increasingly important problem in protecting the air of Ljubljana. The number of times that the daily maximum permissible concentration of O_3 is exceeded is greatest from April to August. In contrast to concentrations of SO_2 and NO_X the annual, daily, maximal hourly and eight-hourly concentrations are greatest at the edge the city (the Vnajnarje measuring station). Average annual concentrations of ozone fluctuate from year to year due to the different number of sunny days and the intensity of solar radiation (Okolje v MOL, 2004). In addition to locally produced pollution there is also a noticeable influence in the higher elevation edge of the city from the Padua lowlands, hence in some years maximum permissible daily and hourly values were frequently exceeded, on virtually the majority of days in the clear, dry, hot summer periods without wind. The concentrations of O_3 measured at the site in the centre were lower than the values at other measuring sites. The cause was the heavy motor vehicle traffic and its associated emissions of nitrogen monoxide, which due to chemical reactions reduce the creation of tropospheric ozone.

During the period studied the short-term maximum permissible thresholds of ozone in Ljubljana were exceeded more frequently than those for SO_2 and NO_X.

In the past unfavourable weather conditions contributed to very high concentrations of SO_2, produced by relatively small amounts of emissions from solid fuel stoves with low chimneys. This should be taken into account in traffic as well. A density of traffic which in many better ventilated cities would not cause excessive harmful concentrations of substances produced by traffic can already pose a hazard in Ljubljana.

Table 55: Air pollution in Ljubljana due to ozone.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Number of days on which target values of ozone were exceeded (average eight-hour concentration of 120 µg/m^3)	30	20	20	49	40	25	81	32	38	47	43
Number of days on which warning values were exceeded (more than 180µg/m^3)	7	2	0	3	1	4	18	4	11	10	8

Source: ARSO, Kazalci okolja (Environmental indicators), 2009.

From the standpoint of the internal differentiation of Ljubljana with respect to air pollution, the most important finding is that for decades large differences in SO_2 immissions were a key factor in the varying quality of the urban environment in different parts of Ljubljana, whereas in the 1990s traffic emissions were the predominant cause of urban air pollution. Due to the growth in particular of traffic emissions (and noise) and of ozone, in the 1990s, a new immissions area, covering a large part of the city centre and the areas directly adjacent to the most heavily traveled streets, urban arterials, and the ring road, gradually took shape in the the UML. Based on the growing pollution of Ljubljana's air with "traffic" emissions (nitrogen and carbon oxides and ozone), the areas that stand out are the city centre on the one hand and the immediate vicinity (up to 100 m) of urban arterial roads on the other (Špes et al., 2002).

With the use of diffuse sampling instruments, measurements of nitrogen dioxide, benzene, and ozone were conducted at 30 - 80 sampling sites (road corridors, along roads outside corridors, the urban hinterland in summer (2005) and winter (2006) (Ogrin, 2008). Results show that the concentrations of pollutants were exceeded in numerous places; most polluted were road corridors, where the average annual concentration of nitrogen dioxide exceeded 80 µg/m^3. In winter the concentrations of nitrogen dioxide were greater than in summer, because the atmosphere is more stable and the emissions burden greater due to the higher fuel consumption and colder engines.

The air was considerably polluted along major urban arterials, although not at locations along the road corridor where there are usually large residential neighbourhoods. Areas of the urban hinterland usually have lower concentration of nitrogen oxide but on the other hand the concentrations of ozone there are greatest, which is in accordance with what we would expect given the chemical properties of the creation and decomposition of ground ozone. However, it should be pointed out that there are also extensive residential neighbourhoods in these areas outside the urban core. Results show that the city topography is at least as important as the traffic load of roads when looking at air quality along Ljubljana roads. Local meteorological conditions are also important (Ogrin, 2008).

Experts (Planinšek, 2006, 61) warn that data on air quality in Ljubljana show that the air is excessively polluted primarily by particulate matter and ozone as well as by nitrogen oxides, and a large share of this pollution is caused by emissions from traffic. The region of the Ljubljana municipality ranks in the second of three levels of air pollution, and the recommended values for air quality will be difficult to achieve based on the current state.

18.1.2 Noise

Noise is becoming one of the most important factors in the quality of the residential environment, but it depends largely on microlocation, hence it is not possible to generalize about a wider urban environment based on individual data. In a quiet residential area and near hospitals, schools, and kindergartens, noise must not exceed 55 dBA. A noise level between 55 and 60 dBA is already disturbing, while above 60 dBA it is no longer suited for a residential area.

In 2001 numerous short-term measurements were made at 112 locations, the majority of them in Ljubljana residential neighbourhoods. At the same time an extensive survey of residents on noise was carried out. Based on the measurement results, data on traffic volume, and the results of surveying residents of Ljubljana, a classification of Ljubljana was carried out with respect to noise pollution (Špes et al., 2002; Okolje v MOL, 2004).

The following areas, which taken together are home to 50.000 residents, or about a fifth of the total population of Ljubljana, were found to be areas with above average noise pollution:

- the wider area of the city centre. An increased level of noise is the result of a number of factors. Several streets are subjected to above average traffic volumes, and moreover due to the number of intersections the traffic flow is characterized by stops and starts, acceleration and braking. There are also diverse service activities and dense pedestrian traffic flows, which in itself is not problematic as far as the amplitude of the noise produced, but because this type of noise is also present at times when road traffic, which is the main source of noise pollution, drops off (for example in the evening or night hours and at weekends);
- areas along major roads. The areas along roads that produce above-average noise pollution are of varying widths; their extent is influenced not only by the traffic volume but also by the presence and siting of buildings along the roads. In general roads with daily traffic volume of more than 20.000 motor vehicles (this number is just a rough guide) are the most problematic from the standpoint of noise pollution, unless they are equipped with suitable anti-noise barriers such as those found along the ring road. Above-average noise can also be detected in buildings which are sited directly along roads with less traffic, especially the numerous roads in the wider area of the town centre, as well as a number of roads outside the city centre;
- areas along the railway. This is a relatively narrow belt along the railway line, but the noise associated with rail traffic is especially intense and continues throughout the day, although at night it usually declines;
- if it were possible to record more precisely point sources of noise, we could determine areas with above average levels in the vicinity of these sources, but in our case we can only note that these are very different types of buildings, such as for example manufacturing plants, bars and restaurants, event halls, churches, playgrounds, etc.

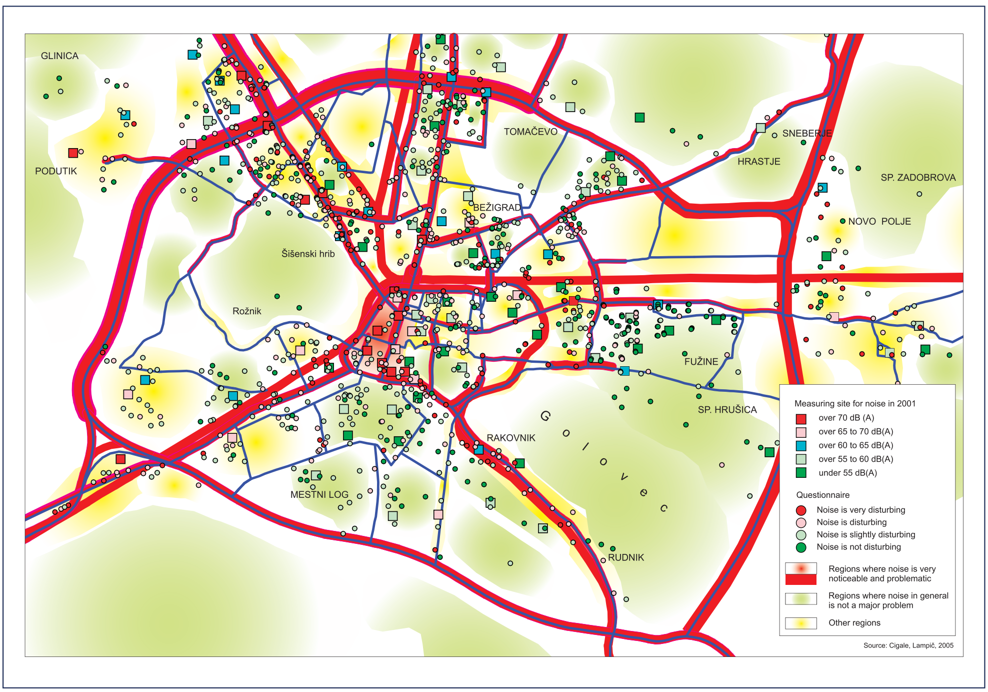
As areas in which noise in general does not represent a significant problem we can designate purely residential areas which are not close to major roads. The majority of areas at the edge of the territory of the settlement of Ljubljana, which are sparsely settled and intended for agricultural, recreational, and forestry uses, belong in this category.

The category "areas with variable noise" included diverse areas, including those which have no residential buildings but are the site of various secondary and tertiary activities. In at least some of these the noise is considerable. Loud industrial plants can themselves be a source of noise or it may be a function of the concentration of tertiary activities which cause extensive traffic flows. The relocation of these activities away from the centre of the city reduced the traffic flows to the centre, which from the standpoint of noise is favourable, but for the immediate surrounding area in the new locations of these retail and service centres it is rather less favourable, since new areas of noise pollution took shape.

In this category also belong residential areas for which according to available data there is a great degree of internal differentiation from the standpoint of noise pollution, or these values do not stand out in either direction.

It is clear from the results of research on noise in Ljubljana that the most significant source of noise is traffic. The nighttime and daytime levels of noise in residential neighbourhoods outside city centres are on the whole in compliance with domestic as well as international norms. The levels of noise in some places in larger residential settlements occasionally exceed maximum permissible values or borders on them. Noise along major arterials exceeds permissible values.

Figure 67: Summary map of regions of Ljubljana with respect to noise pollution.



18.1.3 Water pollution

Pollution of rivers

Rivers and streams in the territory of Ljubljana represent the central part of Slovenia's Sava river basin; their quality is the result of both allochthonous and autochthonous pollution as well as self-cleaning capacities. In the last decade analyses of water quality of rivers and streams in the territory of Ljubljana have classified them as moderately, severely, or critically polluted water resources. Only a few streams in the sparsely settled and higher eastern edge of the municipality are practically unpolluted.

The central Ljubljanica River at the place where it enters the territory of Ljubljana is as a rule moderately polluted (2nd- 3rd quality class); its condition worsens considerably by the time it reaches the confluence with the Sava (past the city), where pollution levels are already excessive. Thus on average the quality of the Ljubljanica in the territory of UML decreases and it is ranked among rivers with a progressive degradation regime and one of the most polluted surface watercourses in Slovenia. This has been confirmed also by saprobiological and bacteriological analyses: in the lower reach of the Ljubljanica there are often high bacterial counts present throughout the whole period. Hence the river meets criteria for bathing quality in only a few places. High levels of metals (especially chrome) have also been found in the river sediments of the Ljubljanica. The source of these pollutants are factories in Vrhnika; increased concentrations of nitrogen and organic compounds have also been found, indicating the inadequacy of the sewage and wastewater treatment network (Okolje v Mestni…, 2004). More recent data on the quality of the Ljubljanica (after 2003) indicate a slight trend towards improvement, and there was an observable improvement in 2005, when a new wastewater treatment plant for discharges from Ljubljana went into operation. In the period from June 2007 - June 2008 the chemicals content of the Ljubljanica at all sampling sites in the territory of Ljubljana was found to be acceptable, but the water quality was still not suitable for freshwater fish and did not meet minimal hygiene standards (Monitoring kakovosti…, 2008).

The Sava where it enters the territory of the Ljubljana municipality has over the past decade usually ranked among moderately polluted watercourses, but past the city and in particular after the inflow of the Ljubljanica its state changes to excessively or even critically polluted. Slight improvements in the quality of the river have been indicated by data after 2000, and the most recent data should show even greater improvement of the quality of the Sava's water due to the effects of treatment of municipal discharges.

An analysis of trends in the changing quality of the Ljubljana section of the Sava River and the Ljubljanica in the period from 1997 - 2007 showed the following key characteristics:

- an essential improvement of quality in the Sava before its confluence with the Ljubljanica;
- little change in the moderate degree of pollution of the Ljubljanica in the territory of UML up to the point where wastewater from the Ljubljana wastewater treatment plant is discharged;

- no change in the critical degree of pollution of the Ljubljanica in its lower reach up until the of the construction of the new wastewater treatment plant;
- data on the chemical state of the river (2002 - 2006), which has been monitored since 2002 (in accordance with the European Water Directive), show a relatively favourable situation. With just one exception, the Sava and the Ljubljanica did not contain hazardous chemicals. Only one chemical analysis of the Sava in Medno in 2002 indicated traces of mercury in sediments in the river before it reached Ljubljana, and after Ljubljana there were also detergents, mineral oils, and organically bound halogen (Monitoring kakovosti…, 2008). The ecological state of the water has not yet been assessed due to methodological problems.

Table 56: Quality of the Ljubljana Sava and the Ljubljanica (1998 - 2005).

Water flow	Measur-ing site	1998	1999	2000	2001	2002	2003	2004	2005
Sava	Medno before LJ	2-3	2- (3)	2– (3)	2	2-(3)	2-(3)	1-2	2
Sava	Šentjakob past LJ	2-(3)	2-(3)	2-(3)	2-(3)	2-(3)	2-(3)		2
Sava	Dolsko past LJ	3-(4)	3-(4)	3	3	(2)-3	3	2	2
Ljubljanica	Livada before LJ	2-3	2-3	2-(3)	2-(3)	2-3	2-3		2
Ljubljanica	Zalog past LJ	(3)-4	4	(3)-4	(3)-4	(3)-4	3-3/4	2-3	2

Source: Monitoring…ARSO, 2007.

Pollution of groundwater

With respect to the drinking water supply, the main source is the groundwater of Ljubljana Plain, which supplies about 90 % of the water required. The southern part of Ljubljana is supplied from Iški vršaj in Ljubljana Marsh. Average water consumption in Ljubljana is 1200 l/sec, and the average quantity of pumped water ranges from 1800 l/sec to a maximum of 2300 l/sec. To the amount of water actually consumed we must also add losses that occur in the delivery of the water to users. Data show that 46 – 50 % of the water pumped is lost along the way, hence the quantity of water taken from the groundwater is much greater than the amount of the average consumption or the quantity of water sold. Considering the decline in the growth rate of urbanization and associated demand for drinking water, especially with more rational use, the future supply is ensured, but it will be more difficult to maintain its quality. In the case of pollution of existing pumping areas, supply of drinking water could be a very big problem, and it would be necessary to replace it with a large quantity of water of suitable quality.

Principal threats to the groundwater are inappropriate environmental impacts (flow regulation, land reclamation), overexploitation of water resources, and environmental pollution. Inappropriate impacts and exploitation have negative effects in particular on the quantity of groundwater, and emissions of waste and toxic substances into the environment on its quality. Industry in the Ljubljana region produces 10 million m3 of wastewater annually, some of which is so heavily polluted that it must be treated before being discharged into the public sewer system. Household wastewater usually contains organic pollutants and the groundwater is polluted by bacteria, viruses, nitrogen compounds, and detergents. The groundwater in Ljubljana Plain is polluted by hobby gardeners as well as by farming, which is oriented mainly towards the production of vegetables and fodder. In addition to the use of pesticides and herbicides, fertilizer use also causes problems in water quality. The leaching of unused nitrogen into the groundwater due to excessive application or the use of fertilizers at inappropriate times causes higher concentrations of nitrates in the groundwater, while fertilization with naturally produced manure or slurry causes bacteriological pollution.

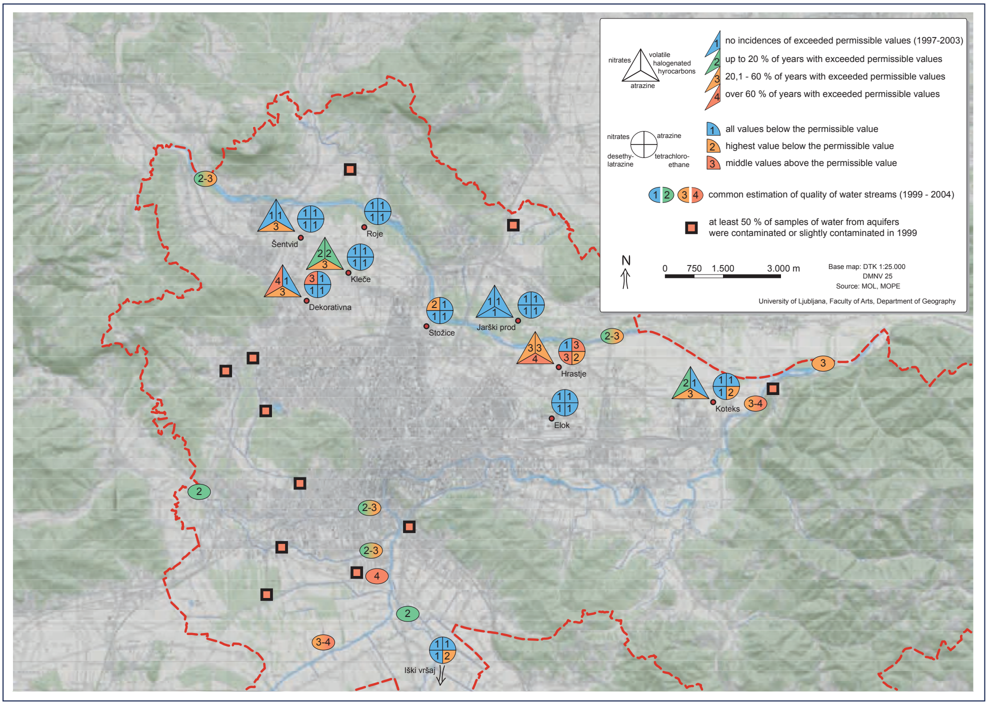
Nitrates in the underground water of Ljubljana Plain appear mainly due to inappropriate or excessive fertilization and substandard or antiquated sewer networks. In the period from 1997 - 1999 there was a growth in the concentration of nitrates, while after 2000 a slight drop was recorded (Monitoring… 2006, 2008).

Pesticides in the groundwater are usually a consequence of excessive and inexpert use in agriculture and in nonagricultural areas such as public green spaces, gardens, and areas devoted to transportation uses (Okolje v Mestni…, 2004). In the period 1997 - 2007 there were high concentrations of the pesticide atrazine as well as its metabolite desethylatrazine. In recent years the content of atrazine has been somewhat reduced, which is likely a result of the banning of the use of this pesticide in water protection areas.

Volatile halogenated hydrocarbons in the groundwater of Ljubljana Plain are the result of degreasing in industry and small businesses (dry cleaners, metalworking shops, and similar) Up until 1999 volatile halogenated hydrocarbons were present only in traces or low concentrations, but in 1999 significantly higher concentrations were recorded (Okolje v Mestni…, 2000). The concentrations of all the most important observed pollutants (nitrates, chromium, pesticides and metabolites, volatile chlorinated hydrocarbons) were lowest in the immediate proximity of the Sava River. The reason for this is the shorter retention of underground water and associated reduced possibility that the water-transporting layers are "enriched" with runoff having a higher content of pollutants from the surface.

In recent years (2002 - 2007) the quality of groundwater in Ljubljana Plain has not significantly changed, although the concentrations of some substances have been reduced. Typical of the region as a whole is a gradual reduction in the concentrations of pesticides, but nevertheless excessive concentrations still appear at particular locations (Monitoring kakovosti…, 2008).

Figure 68: Quality of water resources of Ljubljana (1997 - 2004).



18.1.4 Soil degradation

The content of heavy metals and other chemical elements in the soil (and vegetation) is an important indicator of the state of the environment and draws attention to long-term pollution. Detailed analyses of the content of chemical elements in the soil in the Ljubljana region (168 km2) have indicated large local differences in the degree of pollution of urban soils and other so-called urban sediments from heavy metals (Šajn et al., 1998). The spatial distribution of the presence of cadmium (Cd), lead (Pb), mercury (Hg), copper (Cu) and zinc (Zn) in the soil shows that it is not a function of the lithological substrate and type of soil. Extremely high values could be found in the vicinity of major roads, intersections, industrial and energy plants, waste dumps, households, and other minor sources. Special attention will need to be given to traffic emissions and investigation of the current state and trends regarding heavy metals in the layer above the groundwater in regions where it is used to supply drinking water to the population.

In the framework of the URBSOIL project in 2002 and 2003 the Centre for Soil Science and Environmental Protection at the Biotechnical Faculty (2005) conducted a systematic study of the quality of 250 soil samples from 130 locations in the Ljubljana region (depths of 0 - 10 and10 - 20 cm) with different uses: playgrounds at kindergartens, parks, river banks, green spaces along roads and intersections, primary school playgrounds, and hobby gardens. From the standpoint of spatial development planning, the following findings from the monitoring of urban soils in Ljubljana are signficant (Sofinanciranje EU projekta…, 2005) :

- soil salinity (due to salting of roads in the winter season) is not (yet) in evidence as a major problem;
- among heavy metals, lead (Pb) was the most common pollutant of the soil; the permissible value was exceeded at 52 locations in the upper layer (10 kindergarten playgrounds, 10 primary school playgrounds, 14 parks, 14 green spaces along roads and intersections, and 4 hobby gardens), and the warning value at 44 locations (including 7 kindergarten locations and 8 school playgrounds!); the more or less even distribution of increased concentrations of Pb in the city centre indicates dispersed pollution;
- the numbers of permissible and warning values exceeded in the upper layers for other heavy metals were as follows: zinc (Zn) - 22 and 5, copper (Cu) -17 and 2, cadmium (Cd) - 13 and 1.

Findings from a comparative analysis of soil samples from 1991 and 2002 showed somewhat higher values in 2002 than in 1991 for the majority of heavy metals. A comparison of concentrations of particular metals in 2002 compared to the average in 1991 indicates a moderate trend of increase in the presence of lead in the upper soil layer and a slight trend of increase in the concentrations of zinc, cadmium and nickel in the upper layer, while the presence of chromium and of iron was somewhat less (Sofinanciranje EU projekta…, 2005).

The results of monitoring of soil pollution in water protection areas of the UML in 2006 showed that concentrations of toxic substances (herbicides, pesticides, heavy metals) were for the most part below the legally prescribed values but in some specific instances permissible values were exceeded (Monitoring onesnaženosti tal…, 2007). The threshold values of arsenic and cadmium were exceeded, as was the warning value of lead. Sources of heavy metals were in all likelihood traffic or fallout from the air. The results of an analysis of the residue of phytopharmaceutical substances in the soil in the territory of the UML showed that the heaviest concentrations were from triazines, especially atrazine, followed by the metabolite desethylatrazine (Okolje v MOL, 2004).

Point source pollution of the soil by phytopharmaceutical and other substances in the territory of the UML is also caused by numerous illegal waste dumps, which are also a major threat to underground water. Potential and actual pollutants of the soil and water resources (especially groundwater) are also produced by some hobby gardeners. On average four samples out of seven of soil from vegetable gardens exceeded permissible values for DDT and derivates, and at one location warning values were also exceeded (Sofinanciranje EU projekta…, 2005).

18.1.5. Solid waste

A critical manner of solid waste management in Ljubljana is the final dumping of usually unseparated solid municipal waste at the Barje landfill (Okolje v Mestni…, 2000).

348.000 people from the gravitational area of Ljubljana (formerly the municipality of Ljubljana) and the area of Kamnik are included in the waste collection and dumping system of the Barje landfill. In 2005 137.000 tons of waste were collected and deposited (Letno poročilo…, 2006).

The Barje municipal waste landfill is located in the southern, flat, and marshy area of Ljubljana along the southern bypass. Due to its location in a flood-prone area the landfill is classified as being in a high-risk area. The total area of the landfill was 89 ha in 2003 and it is divided into an old and a new part. The area is de-gassed, planted with grass and poplars, and a constructed wetland for leachates has been set up (Okolje v Mestni…, 2000).

The new part of the landfill began operating in 1987 and covers an area of 42 ha. Of a total of five waste deposit fields, three are partially or completely full; the fields were expected to be able to provide enough space for the dumping of waste until 2010 (Okolje v MOL, 2004, 53).

A great potential danger of pollution of pumping stations in Ljubljana Plain is represented by numerous illegal waste dumps, despite the fact that 99 % of the population in the territory of the UML have access to the waste collection and disposal system. An extensive census of waste disposal sites in water protection areas of the UML from 2006 recorded 1586 illegal waste dumps (a third of them still active), of which there were 1445 in Ljubljana Plain, 104 in Iški vršaj, and another 37 in areas of local water resources (Smrekar et al., 2006). Their total area was 128.056 m^2, volume was 220.071 m^3, and the dominant type of waste was construction materials. Not much hazardous waste was detected, but it nevertheless represents a threat to the quality of the groundwater, especially waste which is organic. The UML in the past has cleaned up a large number of illegal waste dumps. However, measures have turned out to be only temporary in their effects, since enforcement policies are ineffective.

In the region under study we found that only a small portion of waste is sorted by type for recycling, even as the quantity of household waste is constantly increasing. On average 382 kilograms of household waste per capita are collected in this region (the Slovenian average is 297 kg). In 2007 less than 20 % of waste was separated for recycling: the majority of it is still mixed waste which is hauled to the Barje landfill (Snaga, 2007). Separation of municipal waste began in 2002, and over the next five years about 1400 collection sites were set up, on average one for every 185 inhabitants. In the fall of 2005, biological waste also began to be collected separately. This is relatively favourable in comparison with other EU cities, but on the other hand it is unfortunate that the quantity of separated waste collected is still so small. Since the first year of separated collection of waste, when only 4 % was separated, the share rose each year by several percent but by 2006 it had reached only 16 % (Holc, 2007). Hazardous waste is collected at a special collection centre at the Barje landfill and by means of mobile containers twice a year at 18 locations. In 2006 alone 26 tons of hazardous waste were collected in mobile containers and 37 tons at the landfill (Snaga, 2007).

18.2. Outstanding environmental problems

Although Ljubljana compared to other European cities of similar size does not rank among the most degraded urban environments, environmental problems nevertheless represent a critical issue (Špes et al., 2002; Plut et al., 2006). Its basin location, poor ventilation, the ecosystemic significance of Ljubljana Marsh, the regional water supply role of the groundwater of Ljubljana Plain, the higher relief of the eastern edge of the UML, and susceptibility to earthquakes and floods are fundamental natural limits to the spatial development of Ljubljana and self-cleaning capacities. The reduced self-cleaning capacities of the southern part of the Ljubljana and a relatively heavy burdening of the landscape creating elements of the sensitive ecosystem of Ljubljana Plain have a fundamental influence on the high fragility of the geographical environment of Ljubljana and the UML as a whole. Preservation of the crucial ventilation corridors from the edge towards the centre is very important for the Ljubljana Basin, and building along them is not desirable (Jernej, 2000). The preservation of a high-quality and recreationally attractive urban fringe as well as green spaces within the city limits is likewise important.

An environmental analysis of the past and current state and trends during the period from 1990 - 2005 highlights spatially the following most relevant environmental problems of Ljublana and the UML as a whole (Plut, 2007):

- increase in traffic emissions (nitrogen oxides, benzene) and a high level of noise in many areas of the city core, along major arterials, and the motorway bypass;
- heavy pollution of many of the city's surface water bodies and occasional excessive amounts of toxic substances in the groundwater of Ljubljana Plain that are hazardous to health;
- increase of environmental pressures on the hydrogeographic hinterland for drinking water pumping stations, especially in Ljubljana Plain;
- large quantities of waste, problems dumping it and recycling it, and a large number of illegal waste dumps;
- large ecological footprint per capita (an indicator of overconsumption of natural resources and large quantities of emissions) and excessive emissions of greenhouse gases.

Crucial and still unresolved environmental problems are traffic, wastewater treatment, and solid waste management. Environmental pressures related to road traffic and suburbanization are especially increasing. Characteristic of Ljubljana is a favourable balance between open spaces and built-up areas, which is good for the quality of life and the ecosystem. A particular feature of the urban structure of Ljubljana is the presence of extensive areas that are predominantly natural (in the shape of wedges) practically in the city centre. However, it should be noted that this is relative, since in the city centre and immediate vicinity of some residential blocks of flats there is a small extent of public green spaces, not very many trees in the area of the city, and the patches that do exist are small and dispersed.

In the 1998 - 2007 period the quality of the environment in the UML improved with respect to three forms of environmental pollution: SO_2 pollution, wastewater treatment at the new municipal wastewater treatment plant, and partially also as a result of the partial cleanup and reorganization of the Barje landfill. The state of the environment has remained practically unchanged with respect to ozone and particulate pollution, the groundwater of Ljubljana Plain, soil degradation, and noise in the city. The state of the environment has gotten worse regarding NO_X pollution, smaller watercourses, illegal waste dumps, and threats to the biosphere.

From the standpoint of sustainable spatial development of Ljubljana, the following environmental pressures are fundamental: increases in road traffic, personal consumption and associated municipal waste production, building in the region of groundwater of Ljubljana Plain and unregulated surbanization processes, especially in the ecosystemically very important Ljubljana Marsh. On average Ljubljana residents have good accessibility to city bus routes but the picture is less favourable with respect to the need for modern and rapid transportation. Reasons for this are to be found in the mentality and behaviour of residents, who still prefer to drive their own cars instead of using public transport, thereby increasing traffic congestion in the city. Despite the acute problem of traffic saturation the number of users of public urban transport is dropping (Špes et al., 2000). Based on an extensive survey in 200, 58 % of all journeys in the territory of the UML were taken by car, 19 % were on foot, 10 % by bicycle, and only 13 % using public transport. In the Ljubljana urban region 73 % of all journeys were made by car, and only 8 % using public transport (Verbič Miklič, 2004).

A key reason for the extensive spatial development of the UML with its multiple negative environmental impacts in recent decades is the extensive, scattered, and frequently unregulated growth of residential and other built up areas in suburban areas. In this way an approximately 25 - kilometre wide suburbanized belt has grown up around Ljubljana since 1970, where a large part of the population live and commute daily to work in the city. Expansion to the south has been especially intense, in the area of the flood- and earthquake- prone Ljubljana Marsh (Gašperič, 2005).

There has also been a large emphasis in the past ten years on the construction of shopping centres and the development of activities outside the traditional transportation corridors, while the development of the city centre and public transport has lagged behind. Intensive land use, an expansion of built-up areas, dispersed or only partially nucleated suburbanizaton, permeable sewage systems, shopping centres outside the core urban area, warehouses, highway bypasses and associated increased traffic density in Ljubljana Plain increase the risks to the safe and healthy supply of drinking water to Ljubljana.

18.3. Environmental protection guidelines and measures

A basin location, poor ventilation, the ecosystemic significance of Ljubljana Marsh, the regional water supply role of the groundwater of Ljubljana Plain, the higher relief of the eastern edge of the UML, and susceptibility to earthquakes and floods are fundamental natural limits to the spatial development of Ljubljana. The reduced self-cleaning capacities of the landscape creating elements (especially the air and water) of the southern part of the Ljubljana Basin, and the relatively heavy pollution burden on the landscape creating elements of Ljubljana Plain influence the high fragility of the geographical environment of Ljubljana. City policies, especially those relating to urban planning and transportation, are expected to give greater attention to adapting planning to the environmental limits in future.

Protection of the groundwater of Ljubljana Plain and calming of suburbanization processes and road traffic are basic challenges to the sustainability of Ljubljana's urban policies. A survey of some accessible environmental indicators of the sustainable development of Ljubljana underscores some positive measures for the reduction of urban air pollution (a gas supply network and district heating) and a lagging behind in resolving the traffic problem and partially also in wastewater treatment and solid waste management, which are fundamental environmental curative tasks by 2015. The reduction of the current excessive pressures from gaseous emissions, wastewater, solid waste, and aggressive land use is a sustainable condition for the future planning and environmental capacities adapted to the location of urban activities (Špes et al. 2000; Plut et al. 2006; Plut 2007).

Sustainable (environmental, economic, and social) spatial development of Ljubljana and the UML as a whole should arise from the basic principle of the environmental side, which emphasizes the sustainably more challenging principles of spatial development: the spatial arrangement and use of space should be done within the framework of environmental capacities in the territory of the UML. An environmental analysis and assessment (current state, trends and effects of degradation of the basic elements of the environment) of the spatial development of the UML (with an emphasis on Ljubljana) for the period from 1990 - 2005 shows that environmental pressures of settlement and numerous activities frequently exceeded the self-cleaning capacities, and energy and materials use and per capita ecological footprints were significantly greater than acceptable at the local, national, and planetary levels. Despite this, data show that it is possible with well thought out curative and preventive measures to achieve a higher level of quality of the residential environment and life without exhausting environmental capital, which would make it possible for Ljubljana to become a place with a high quality of life which would represent an advantage compared to other Central European cities.

A locally and regionally integrated tram and railway system is a crucial precondition for redirecting commuters away from the use of private cars and towards the use of public transport and bicycles (Trajnostni razvoj Mestne…, 2002). This would among other things also bring a significant reduction in the production of greenhouse gases and per capita ecological footprint. But solutions to the urban traffic problems of Ljubljana cannot be successful if policies are not planned and coordinated for the whole of the urban region, in which two thirds of all journeys in Slovenia take place. At the same time experience elsewhere in Europe shows that it is not physically and economically possible to ensure sufficient roads for the increasing demands of private motor vehicle use and for calming traffic. It is crucial to implement a program of construction of connections with the main railway routes (Kranj, Kamnik, Litija, Grosuplje, Borovnica) and the development of a regional Park and Ride system for cars and bicycles.

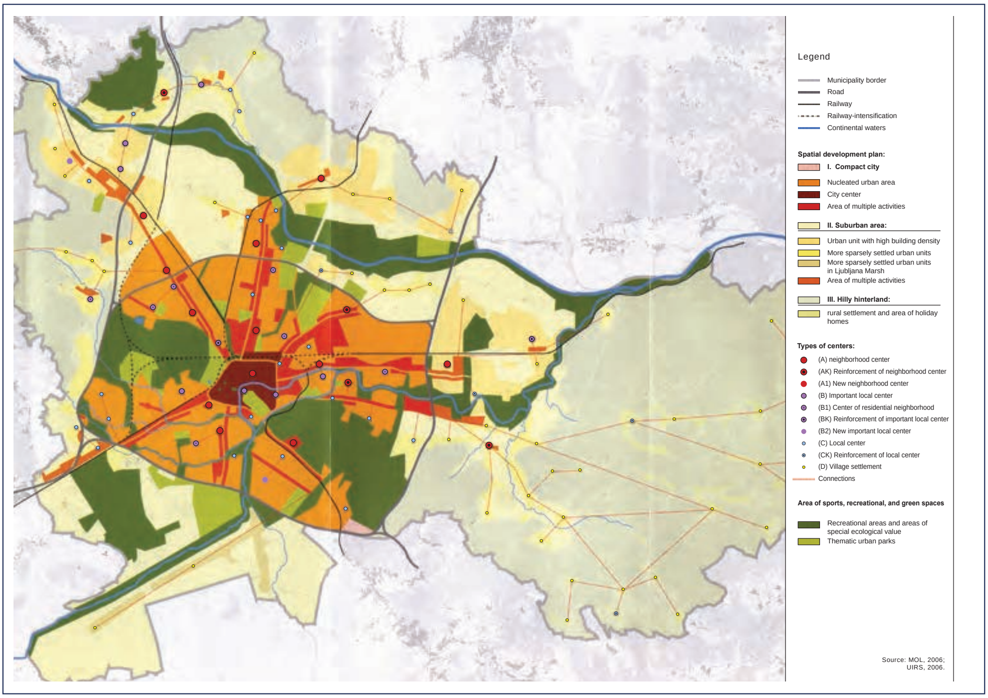
A solution of integrated public transport that would be optimal for the regional environment and settlement network (the model of decentralized concentration in the wider urban region of Ljubljana) appears to be a modern suburban railway system (nearly doubling the number of railway stations). In Ljubljana these could feed into tram lines, and a modern passenger intermodal terminal enabling rapid connections to various other public transport networks (railway, tram, regional bus, city bus, taxis) could be built in the area of the main railway station. In future a railway connection to the airport in Brnik would be appropriate if air traffic increases substantially (there is some uncertainty regarding this due to expected sharp increases in air fares as a result of the contribution of air travel to climate change). In all likelihood the planning and realization of more modern but less tested forms of public transport would require much more time; from this standpoint and also considering the currently unbearable traffic situation in Ljubljana, this would be a less appropriate solution.

Together with other appropriate policy measures it is possible to achieve the environmentally friendly goal that 20 – 30 % (rather than the current 10 %) of journeys in Ljubljana would be carried out by bicycle. Given the suitable morphology of the city, the relatively favourable climate (in comparison with the bicycle-riding Scandinavian countries), the modest relief (cycling routes which do not have steep ascents and descents), cycling in the UML has all the objective conditions to become the second most common (after public transport) , environmentally-friendly (also from the standpoint of reducing greenhouse gases) and healthy form of everyday travel for city residents (especially for distances of 1 - 5 (10) km) by 2015.

The morphological structure of the city and Golovec Hill and Šišenski Hill as relief and green wedges have shaped the extent of the compact city core and the star-shaped layout of the city along seven major urban arterials. For this reason spatial documents justifiably emphasize the importance of the star-shaped development of the city and the expansion of activities from the centre outwards along major routes (public transport and especially city railway lines). The role of locally concentrated areas of building with protected green spaces among them is crucial. The maneuvering space for efficient, sufficiently wide and contiguous ventilation corridors especially in the northern part of the city is being affected by some new construction projects, and at the same time building on agricultural land and on the ecologically sensitive Ljubljana Plain, with its important role in the water supply, is increasing. It will thus be necessary to direct the development of settlement around the edge of the city to the areas of concentration along the projected routes for city transport and to slow down and prevent sprawl and reclaim urban degraded areas for development and public green spaces, which are greatly lacking in many areas of the city centre and tower block residential neighbourhoods. We estimate that the consideration of climatically important areas and the necessity of ventilation corridors from the edge to the city centre are a strategically important sustainable direction for Ljubljana, given its basin location. It is necessary to apply the concept of the compact city, with appropriate urban renewal and reclamation of abandoned and degraded city areas.

In 2007 the Urban Planning Institute of the Republic of Slovenia prepared an updated draft of the Strategic Spatial Plan for the Urban Municipality of Ljubljana (2007) for the period until 2025, which was unanimously accepted by the City Council in 2007, although some modifications were expected. The revised draft is in accordance with the Spatial Vision Ljubljana 2025, and both documents are based on the Spatial Plan for the UML (2002) and the Strategy for Sustainable Development of the UML (2002). They also contain some new projects. In accordance with the demands of modern planning and the principles of sustainable development, the main goals are the improvement of already existing urbanized regions (development inwards, renewal), a shift away from patterns of dispersed settlement and sprawl, enhancement of the social and economic public infrastructure and the rational expansion of settlement. In comparison with the plan for the organization of space in the Spatial Plans (2002), categories of land use are more detailed as to content (compact city, edge, and hilly hinterland with various categories of land use) on the map of the plan of spatial development of the Strategic Spatial Plan, which from the standpoint of achieving spatial urban sustainability are also more appropriate.

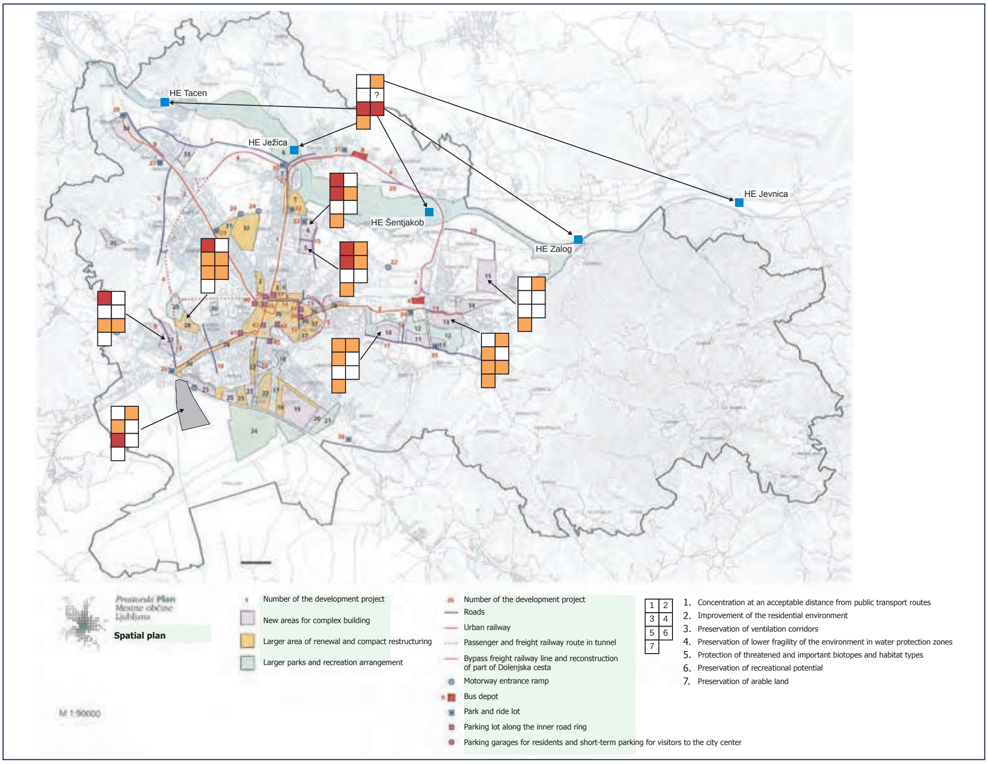
Figure 69: Spatial development plan for the Urban Municipality of Ljubljana.



With respect to the crucial goals, the document mentioned is categorized among spatial acts with weak sustainability: the key emphases are devoted to internal urban renewal, which is supportive of sustainability, but at the same time they still plan an increase in built up areas and correspondingly greater environmental pressures in areas of greater landscape sensitivity. The basic strategic goals of spatial development stem from the goals of the Spatial Plan (2002), and from the environmental standpoint the additional point of departure of (partial) consideration of climate changes and reduction in greenhouse gases is justified. Unfortunately a (radical) restructuring of traffic is no longer among the key strategic goals, and moreover the construction of a new gas-steam station for the Moste thermal power station is planned, which will cause an increase in greenhouse gas emissions. Greater attention is being given to the use of biomass and the placement of photovoltaic panels, especially on public buildings, which is environmentally and energetically appropriate.

There is a justifiably strong emphasis on a system of regional railway routes, the intensification of the railway, a bicycling program and the reorganization of the Passenger Centre of Ljubljana, while the introduction of urban railways is cartographically anticipated as merely a possibility (Strateški prostorski načrt…, 2007). Given the environmental and spatial burden of road transport, the postponement or abandonment of the construction of urban railways (trams) is unacceptable from the standpoint of redirecting settlement and building.

Figure 70: Environmentally controversial projects of the Spatial plans for the Urban Municipality of Ljubljana (2002).



The partial direction of the concentration of development along existing star-shapes along arterials, the use of existing buildings and degraded areas, and the development of settlement in the vicinity of public transport are positive developments; among other things they should contribute to a decrease in the production of greenhouse gases. From the standpoint of preserving environmental potential, greater attention is justifiably being given to the preservation of open spaces and low construction along the prevailing ventilation corridors. In this way air quality should be maintained and the urban heat island effect avoided. However, among other things the construction of new technical faculties and accompanying programs around the Biotechnical centre below Rožnik Hill with connections with technological parks is foreseen, and the area will be connected to public transport. The construction of the Stožice central football stadium (for about 15.000 spectators) will have an impact on an open, ventilated but also partially degraded space, as will the multipurpose sports hall in Stožice (up to about 8000 seats). In contrast to the Spatial Plans (2002) the draft of the Strategic Spatial Plan (2007) mentions the possibility of the incineration of waste as one of the variants for waste management and district heating. The possible location is not cartographically defined, but in the text it is indicated as one among alternative microlocations (TE-TOL, Energetika Ljubljana, Barje). The construction of hydroelectric power stations along the Sava (Tacen, Gameljne or Ježica, Šentjakob and Zalog, and outside the territory of the UML Jevnica), which require comprehensive and multilayered sustainable safety assessments are also anticipated.

18.4. Conclusions

The environmental aspect of sustainable development of Ljubljana is undervalued compared to the economic and social aspects. Key to the future sustainable spatial and regional development is, in addition to an increase in environmental efficiency, a decrease in numerous environmental pressures by means of curative and preventive measures. From the spatial aspect, foremost among preventive measures is a spatial and geographical arrangement of settlement which is optimal from the standpoint of environmental protection and nature conservation and in accordance with varying and usually fairly limited capacities of the environment and natural resources (basin location, groundwater).

For the territory of the UML, the realization of the sustainable principles cited means that the following must be at the forefront:

1. preservation of the environmentally favourable star-shaped layout of the city and green wedges, which enable on the one hand the sustainably optimal organization of public transport and on the other hand a high quality of the residential environment, the quality of sustainable urban life, and appropriate areas of bioproductive and recreational open space with an additional ventilating role;
2. balancing of the density of building and other critical environmental pressures between the more heavily burdened northern and the less heavily burdened southern halves of the urban space of Ljubljana, with denser building along public transport routes;
3. preservation and through protective measures an increase in the all too necessary self-cleaning capacities, the landscape and biotic diversity of the urban and rural ecosystem of the UML;
4. a gradual reduction in the high per capita use of natural resources and production of various emissions in the UML (including the reduction of per capita greenhouse gases) along with the appropriate spatial organization of areas of residence, work, and leisure activities as an important global goal of Slovenia and the European Union.

Our assessment is that the degree of material welfare and simultaneous environmental pressures is at a level which requires sustainable developmental environmental spatial and regional development of Ljubljana as an environmentally responsible European city.