



THE ACOUSTIC ZONING - A COMPARASION OF LEGISLATION AND EXPERIENCES IN ITALY AND SERBIA

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Abstract - *The acoustic zoning is a fundamental tool to manage and plan to use of the territory taking into account the noise pollution. The priority aim of the acoustic zoning is to achieve a correct and accurate interpretation of urban planning characteristics of the different city areas, through preliminary analysis, regarding the city planning tools, road network of the city, the traffic regulations, the displacement of the different activity on the territory (recreation, habitation, business etc.). The comparison of the noise mapping with the acoustic zoning plan points out the critical area where the limits issued by the legislation are exceeded and actions to reduce the noise are needed. The acoustic zoning is mandatory for municipalities as a necessary instrument in order to be able to proceed with the effective environmental noise pollution monitoring and assessment. The different methodologies of acoustic zoning have been used in EU countries. In this paper, a comparison of legislation and experiences in acoustic zoning in Italy and Serbia will be given.*

1. INTRODUCTION

The general public has become aware that many of the benefits of living in modern cities are illusory. They now know that each advance in the speed or convenience of transport or in the application of power to reduce physical effort is usually accompanied by a reduction in the quality of the environment.

Population density and industrialization cause the accumulation of waste products that pollute the environment. Environmental noise has been included because it is a major factor in reducing the pleasure of living in modern cities.

Noise pollution is a growing problem. The growth of noise pollution is directly linked to the development of cities and industry.

The ideal solution would be to eliminate of excessive noise at the source or at least on the propagation paths. However, until the technology is sufficiently advanced to achieve this at reasonable cost or people are ready to abandon the comforts and amenities that come with life in the modern cities, the solution can be the proper planning of the city territory.

Planning must take into account the trends in industrial growth, living conditions and transport needs with the aim of

predicting the future environment and ensuring that any changes are beneficial.

The acoustic zoning, which is a method of delineating areas with particular requirements, is a logical step in planning to achieve the necessary reconciliation between the desired comfort of living in the cities and the noise source. When combined with a means for defining restrictions or specifying compatible land usages, it provides a rational solution to an otherwise intractable problem.

The acoustic zoning is a fundamental tool to manage and plan to use of the territory taking into account the noise pollution. The comparison of the noise mapping with the acoustic zoning plan points out the critical area where the limits issued by the legislation are exceeded and actions to reduce the noise are needed.

2. ACOUSTIC ZONING METHODOLOGY

Acoustic zoning means the classification of city territory in zones with homogenous environmental noise levels. The priority aim of the acoustic zoning is to achieve a correct and accurate interpretation of urban planning characteristics of the different city areas, through preliminary analysis, regarding the city planning tools, road network of the city, the traffic regulations, the displacement of the different activity on the territory (recreation, habitation, business etc.).

In addition, the aim of acoustic zoning is to prevent the deterioration of areas in which acoustic pollution is not evident and to improve conditions in those found to have noise levels that produce negative effects on public health.

In addition, it aims to constitute a reference tool for the correct planning of new urban development areas.

Acoustic zoning is mandatory for municipalities as a necessary instrument in order to be able to proceed with the effective environmental noise pollution monitoring, even though phased in gradual steps. It will thus be possible to obtain a reference picture to understand which areas should be protected, which of them have acceptable noise levels, which of them are noise-polluted, where the development of noisy activities can be permitted, and where it is necessary to foresee noise control measures.

From the operative standpoint, the phases preparatory to acoustic zoning can be summed:

- the initial step consists of an analysis of the city territory, after which the preliminary acoustic zoning plan is drawn up, followed in an almost parallel manner by the environmental noise measurements procedure;
- lastly, from analysis of the measurements and preliminary acoustic zoning plan, the final acoustic zoning plan can be determined.

In order to draw up the acoustic zoning plan, it is necessary to obtain and examine in detail many documents. A primarily important aspect is the analysis of the general city plan (city-plan utilization zones) in order to ascertain the actual correspondence between planned uses and actual uses.

It is particularly important to investigate location of:

- hospitals;
- schools;
- parks;
- protected areas;
- acoustically important craft activities;
- acoustically important commercial activities;
- significant industrial plants; and
- road infrastructure.

In fact, careful on-the-spot investigations often reveal, considerable discrepancies between the existing general city plan with relative variants and the real development of the territory concerned.

There are two main approaches for the acoustic zoning and for the identification and evaluation of the different areas:

- the qualitative approach;
- the quantitative approach.

The qualitative approach is based on the direct and in-depth analysis of the characteristics of the territory involved in the acoustic zoning, based on city-planning scheme.

The quantitative approach is based on a computation of a set of parameters and indexes able to characterize the territory analyzed.

Two main factors determine the number and spacing of acoustic zones, the ease with which normal activities and land uses can be subdivided into noise categories and the degree of certainty with which noise exposure can be evaluated or predicted

It would be ludicrous to designate zones at either 1 dB or 20 dB spacing. The first would assume great predictive accuracy combined with a fine graduation in usage classification while the second would assume that our knowledge of future noise exposure and levels to suit particular activities is most inexact

Sufficient research data exists to indicate that transport noise could be predicted within a tolerance of ± 5 dB and this figure also represents a reasonable compromise for controlling industrial noise. Present measuring systems are within this range and changes in subjective response to noise are observed for variations below this limit.

3. ACOUSTIC ZONING LEGISLATION

3.1 Italian legislation

Acoustic zoning was introduced by Italian decree DPCM 1/3/91 [1], then it has been confirmed by Framework Law on Environmental Noise 447/95 [2] and DPCM 14/11/97 [3].

Italian decree DPCM 1/3/91 and subsequent Framework Law on Environmental Noise 447/95 set the maximum daytime and nighttime acceptability limits for noise pollution levels with reference to the physical and functional characteristics of the local area and how it is used.

The Italian Framework Law on Environmental Noise 447/95 established the competences of the government and the different local authorities. The municipalities have to:

- adopt the acoustic zoning;
- provide the coordination with the town planning system adopted, especially with plans regarding noise sources;
- adopt the noise abatement plan

DPCM 14/11/97 defines the threshold of the different limit values (Table 1):

- emission limit value: maximum noise value emitted by the source, measured in proximity to the noise source, but close to spaces occupied by the public;
- input limit value: maximum noise value introduced into enclosed or outdoor spaces by the whole of the noise sources, measured close to the receptor;
- quality value: noise value to achieve in the future, in order to obtain the aims expected by the law.

The limit values mentioned in Table 1. are referred to the ambient noise at the receiver and 1m outside the building facade.

The limit values are not referers to the transport infrastructures: road, railway, airport, port, etc. The Decrees on transport infrastructures establish the “buffer zones”: areas, with a defined width, where are in force specific limit values, related exclusively for the noise emitted by the considered infrastructure, usually higher than limits expressed by the acoustic zoning. Out of the “buffer zones”, the noise emissions of the infrastructure contribute to the limit values of the considered area.

For example, the Presidential Decree No. 142 [4] set the maximal noise levels for new and existing road infrastructures (Table 2 and Table 3). Noise-relevant band breadth is the width of land measured in horizontal projection, for each side of the road, starting from the border road.

All the municipalities are obliged to define the acoustic zoning, which represents the most important act, considering the acoustic planning, able to manage the environmental noise.

The acoustic classification of the territory, or acoustic zoning, classifies the territory of the municipality in six areas, related to different city planning characterization, activities and conditions for the use of the territory.

The six homogeneous areas are characterized by different input noise limit values, in $L_{eq}(A)$, on two temporal periods, referred to day period (06-22) and night period (22-06). In

conformity with the norm UNI 9884, green color refers to the class I, yellow to the II, orange to the III, vermilion red to the IV, violet red to the V and blue to the VI [5].

The Framework Law prescribes, related to Acoustical territorial zoning, the prohibition of the direct contact of the

areas characterized by a difference of the limit values higher than 5 dB(A) of Leq measured.

If the respect of this duty is not possible, especially in urban areas, an abatement plan will be expected.

Table 1. Limit values defined by DPCM 14/11/97

Territorial areas	Input limit value Leq dB(A)		Emission limit value Leq dB(A)		Quality limit value Leq dB(A)	
	day	night	day	night	day	night
Area I – Particularly protected areas: the areas belong to this zone are territories where the quiet represents a priority characteristics: hospitals, schools, areas dedicated to relax and recreation, public park, residential rural areas, more interesting urban planning areas, etc.	50	40	45	35	47	37
Area II – Areas mainly dedicated to a residential use: the areas belong to this zone are mainly characterized by local road traffic, low population density, low presence of commercial activities and absence of industrial and handcrafted activities.	55	45	50	40	52	42
Area III – Mixed areas: the areas belong to this zone are characterized by local and crossing road traffic, by media density of population, presence of commercial activities, offices, low density of handcraft activities and absence of industries; rural areas characterized by the presence of equipment.	60	50	55	45	57	47
Area IV – Intensive human activities areas: the areas belong to this zone are characterized by busy road traffic, high density of population, high presence of commercial activities and offices, presence of handcraft activities; areas close to main road traffic and railway infrastructure; ports, areas with a presence of factories.	65	55	60	50	62	52
Area V – Mainly industrial areas: the areas belong to this zone are characterized by the presence of factories and a low presence of residential buildings.	70	60	65	55	67	57
Area VI – Exclusively industrial areas: the areas belong to this zone are interested exclusively by industrial activities and there are not residential buildings.	70	70	65	65	70	70

Table 2. Limit values for new road infrastructures

Road types	Sub-types	Noise-relevant band breadth (m)	Schools*, hospital, rest/nursing homes Leq dB(A)		Other receptors Leq dB(A)	
			day	night	day	night
A - Motorway		250	50	40	65	55
B - Main out-of-town roads		250	50	40	65	55
C - Secondary out-of-town roads	Ca - Dual carriageway	250	50	40	65	55
	Cb - All secondary out-of-town roads	150	50	40	65	55
D - Urban fast roads / dual carriage ways		100	50	40	65	55
E - District urban		30	Defined by DPCM 14/11/97 and compliant with noise zoning of urban areas			
F - Local		30				

Table 3. Limit values for existing road infrastructures

Road types	Sub-types	Noise-relevant band breadth (m)	Schools*, hospital, rest/nursing homes Leq dB(A)		Other receptors Leq dB(A)	
			day	night	day	night
A - Motorway		100 (group A)	50	40	70	60
		150 (group B)			65	55
B - Main out-of-town roads		100 (group A)	50	40	70	60
		150 (group B)			65	55
C - Secondary out-of-town roads	Ca - Dual carriageway	100 (group A)	50	40	70	60
		150 (group B)			65	55
	Cb - All secondary out-of-town roads	100 (group A)	50	40	70	60
		150 (group B)			65	55
D - Urban fast roads / dual carriage ways	Da - Inter-district dual carriageway	100	50	40	70	60
	Db - All urban fast roads / dual carriage ways	100	50	40	65	55
E - District urban		30	Defined by DPCM 14/11/97 and compliant with noise zoning of urban areas			
F - Local		30				

* For schools is the only daytime limit

3.2 Serbian legislation

The Serbian Law on Environmental Noise [6] regulate: subjects of environmental noise protection; measures and conditions for environmental protection against noise; environmental noise measurements; access to the information on noise; surveillance and other issues relevant for environmental protection and human health.

The Law on Environmental Noise established the competences of the government and the different local authorities. The municipalities have to:

- determine measures and requirements for protection against noise, i.e. sound protection in plans, programmes, and projects, including those to which it gives approval in the strategic impact assessment procedure, environmental impact assessment, or IPPC permitting procedure;
- perform acoustic zoning in its territory, determine prohibits and restrictions in accordance with the Law;
- enact local environmental noise protection action plans, i.e. provide for conditions and take care of its implementation;
- provide financing for environmental noise monitoring in the territory of local self-government units;
- supervise and control implementation of environmental noise protection measures.

Degree on Methodology for Determination of Acoustic Areas [7] closely prescribes the methodology for determination of acoustic areas.

Determination of acoustic zones shall be done based on referent spatial planning maps showing the land use, settlement network and infrastructural systems, touristic areas, natural and immobile cultural resources, and based on the referent urban planning maps showing the prevailing land use, division as per zones and parts according to morphological, planning, historical-ambient, shaped and other characteristics.

Acoustic zones shall be determined according to the existing development status, land use, as well as according to planned land use and shall be defined through noise indicators limit values (day and night-time), expressed in decibels.

Acoustic zoning classifies the territory of the municipality in six areas, related to different city planning characterization, activities and conditions for the use of the territory. The zones are defined in [5] and shown in Table 4.

The six homogeneous areas are characterized by different noise limit values on three temporal periods, referred to day period (06-18), evening period (18-22) and night period (22-06).

Regulation on Noise Indicators, Limit Values, Assessment Methods for Indicators of Noise, Disturbance and Harmful Effects of Noise in the Environment [8] prescribe environmental noise indicators, limit values, assessment methods for indicators of noise, annoyance and harmful effects of noise to human health.

Limit values for noise indicators in settlements, according to residential zones, are given in Table 4. Limit values are equal for day and evening time. The limit values refer to overall noise from all sources in the considered area. Limit values provided for in Table 4 refer to common noise indicators and the rating noise level.

Table 4. Limit values for outdoor noise indicators

Zone	Land use	Noise level in dB (A)	
		Day and evening	Night
1.	For rest and recreation, hospitals and recovery facilities, cultural-historical locations, large parks	50	40
2.	Touristic areas, camps and school zones	50	45
3.	Residential areas	55	45
4.	Business-residential areas, commercial-residential areas and children's playgrounds	60	50
5.	City centre, trade, commercial, administrative zones with dwellings, areas along the motorways, main roads and city roads	65	55
6.	Industrial, storage and servicing areas and transport terminals without dwellings	At this area borders, noise must not exceed the limit value of the neighbouring area	

4. ACOUSTIC ZONING EXAMPLES

4.1 Acoustic zoning in Italy

According to what has been prescribed by the Italian legislation, the territory of many Italian cities (Rome, Palermo, Taranto, Naples, Bologna, Modena, Florence, Chioggia (Venecia district), etc.) have been divided into six classes of use destination, associating to each of them limit values of emission, immission and quality. The examples of the acoustic zoning plan are given in Fig. 1 and 2 for Rome and Taranto territory.

The distributions of the noise zones within the municipal territory for some Italian cities are reported in Table 5 [9, 10]. The zone III covers the majority of the territory except for Naples.

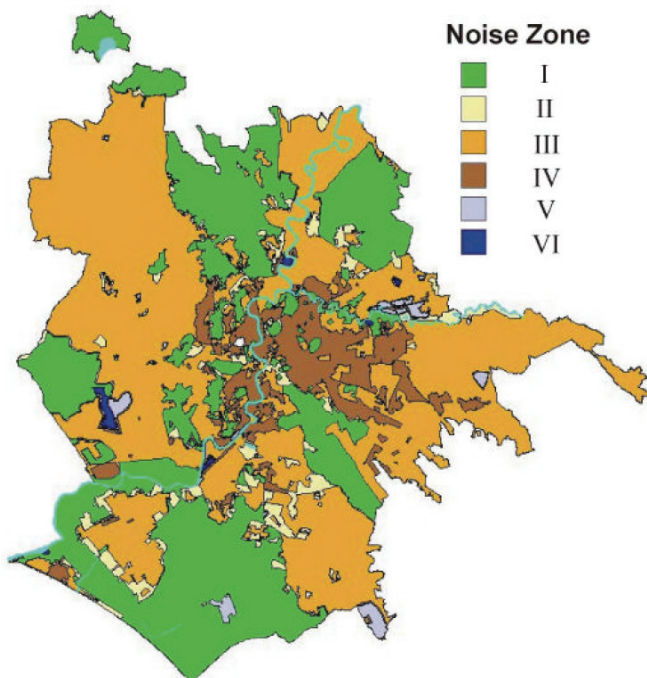


Fig. 1 Noise zoning plan of Rome [9]

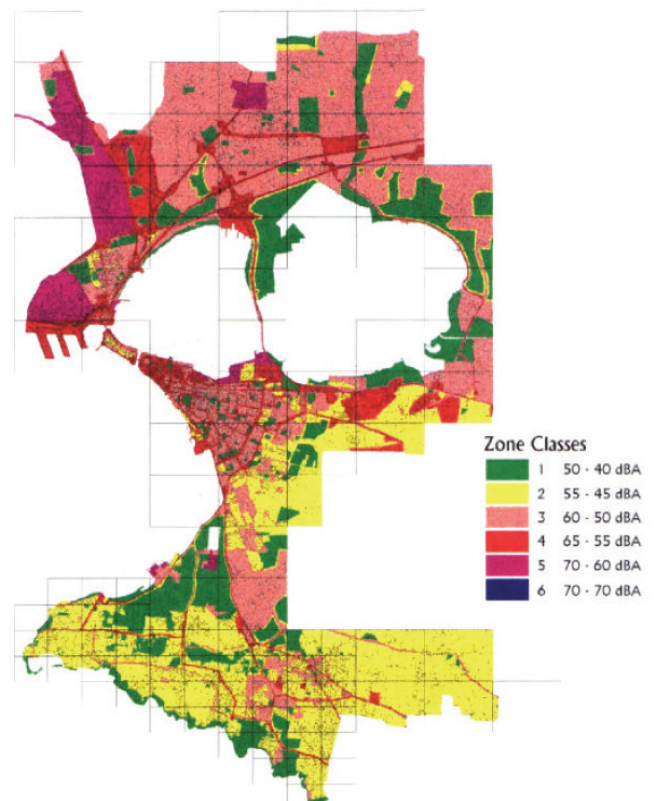


Fig. 2 Noise zoning plan of Taranto [10]

Table 5. Distribution of the noise zones (percentage of the municipal territory) in Italian cities

City	Rome	Taranto	Naples	Bologna	Modena
Inhabitants/km ²	1912		8500	2638	960
Zone I	32.6	17.0	26.4	4.0	1.8
Zone II	5.0	31.0	19.4	23.0	3.6
Zone III	52.1	34.0	21.9	45.0	78.1
Zone IV	8.7	11.0	28.9	18.0	13.1
Zone V	1.1	7.0	2.6	9.0	3.4
Zone VI	0.3	0	0.8	0	0

4.2 Acoustic zoning in Serbia

The acoustic zoning of some Serbian cities (Šabac, Smederevo...) were carried out according to the Serbian regulation [6, 7, and 8].

The territory of Šabac has been divided into five zones by Degree of measures for noise protection [11]. No part of territory was defined by the acoustic zoning as a residential zone. The zone 1 (rest and recreation, hospitals and recovery facilities, cultural-historical locations, large parks) covers the majority of the territory (Fig. 3).

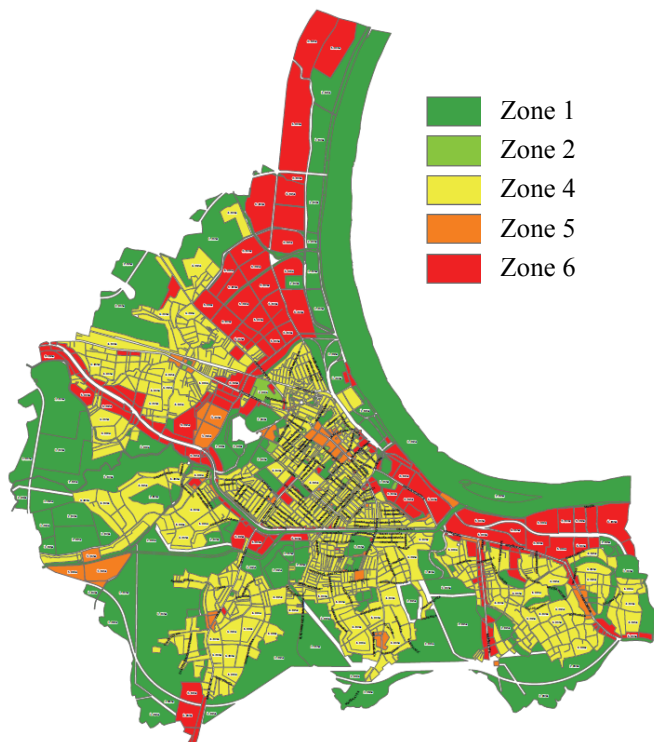


Fig. 3 Noise zoning plan of Šabac [11]

The acoustic zoning of city of Nis will be presented in detail. Draft of acoustic zoning plan (Fig. 4, 5) has been finished and final version will be created after revision of draft plan by the municipal authorities.

The acoustic zoning of city of Nis has been carried out taking into account the areas defined by Spatial Plan of the Administrative Area of the City of Nis in the period 2011-2021. and General Urbanistic Plan in the period 2010 - 2025, their densities of population, office buildings, shops, factories, and activities related to sport and recreation.

City of Nis is one of the oldest cities in the Balkans. It is the second largest city in Serbia. The administrative area of city of Nis extends for 596.71 square kilometers and covers five municipalities (Crveni krst, Pantelej, Medijana, Palilula, Niška banja). According to the preliminary results from the 2011 census, the whole municipal area of the city of Niš (including both, urban and rural parts of municipality) has a population of 257.867, while the population of urban Niš was 177.972, while its administrative area has a population of 257.867.

Nowadays, the city is connected by the highway E75 with Belgrade and Central Europe in north, and Skopje, Thessaloniki and Athens in the south. The road E80 connects

Niš with Sofia, Istanbul towards the Middle East, and Pristina, Montenegro and the Adriatic Sea to the West. The road E771 connects the city with Zaječar, Kladovo and Drobeta-Turnu Severin in Romania. The city is also a major regional railway junction. The Niš Constantine the Great airport is the second most important airport in Serbia. The first airfield was built in 1910. The city public transportation consists nowadays by 14 bus city lines and 48 bus suburban lines. The city is crossed by main roads, city roads and collector roads with the total length of 275 kilometers. Road traffic noise measurements were also carried out in the period 1996 to the present day.

A digital drawing of the territory (in a .dwg file) was firstly examined especially:

- land use plan;
- residential areas plan;
- business areas plan;
- industrial areas plan;
- transport network plan.

The classification of the territory of the municipality in homogeneous areas characterized by the noise limit values is carried out by the identification of the six areas, through the main following parameters:

- density of population;
- presence and typology of road and railway traffics;
- presence and importance of commercial, handcraft and industrial activities
- presence of “sensitive receptors”: activities, and buildings where they are carried out, which have to be more protected (hospitals and recovery facilities, cultural-historical locations, schools)

The first step for the characterization of the six areas was the identifying of the areas more easily identifiable:

- the zone 1 and zone 2, (particularly protected area), characterized by higher protection and lower limit values (40-50 Leq dB(A)), and
- the zone VI (mainly industrial areas).

The following areas were classified by qualitative method as particularly protected areas (zone 1 and zone 2):

- hospital, home for the aged;
- schools (elementary and secondary schools, faculties and university);
- areas dedicated to relax and recreation;
- touristic areas;
- public park,
- more interesting archeological and cultural zones.

The following areas were classified by qualitative method as industrial areas (zone 6):

- business and industrial zones, production and infrastructural facilities;
- storage of industrial character without residential buildings.

Afterwards, the areas were classified into zone 3, 4 or 5 by quantitative method according:

- density of population (number of inhabitants per square meters);
- presence of commercial activities and offices (area of the store / total area);
- presence of handcrafted activities (area of the stores / total area);
- typology of road traffic (number of vehicles per hour).

The road and rail networks and their buffer zones indicated in Table 6. are placed on the previous acoustic zones identified.

The width of buffer zones around road is not defined by the Serbian regulation. The values of the buffer zones given in the table 6 are determined by the authors of this paper based on the characteristics of the roads in the city of Nis.

The width of buffer zones is the width of land measured in horizontal projection starting from the border road.

Table 6. *The width of buffer zones around road*

Road types	Width of buffer zone (m)
Highway	25
Motorway	20
Regional road	15
Local road	10
City highway	10
Arterial road	15
Collector road	10
City rail	15

By the analysis of the draft of the noise zoning plan it can be concluded that the zones 3 (residential areas) and 5 (city centre, trade, commercial, administrative zones with dwellings, areas along the motorways, main roads and city roads) cover the majority of the administrative area of the city of Nis (Fig. 5). In contrast, the zone 4 (business-residential areas, commercial-residential areas and children's playgrounds) covers the majority of the Municipality of Medijana (the central municipality of the city of Nis).

CONCLUSION

The acoustic zoning, which is a method of delineating areas with particular requirements, is a logical step in planning to achieve the necessary reconciliation between the desired comfort of living in the cities and the noise source.

For the classification of areas into acoustic zones can be used quantitative criteria and/or quality. In general, the attribution of extreme classes (particularly protected areas and industrial areas) is directly, using a qualitative method, the intermediate classes instead most frequently assigned through quantitative methods, based on analysis of parameters (population density, density of commercial establishments, production activities, offices, traffic...). With well-integrated geographical information and land use, the quantitative method can allow working more quickly for the allocation of zones, making uniform approach in different situations, constraining the choices assessments more objective.

To achieve the objective of an "acoustical planning" of the territory, able to control noise emissions, cooperating with the existing "planning system", it is also important to avoid the excessive subdivision of the zoning, the breaking up of the territory into small areas.

A comparison of legislation and experiences in acoustic zoning in Italy and Serbia shows that there is the similar approach in the acoustic zoning but that there are differences especially in the determination of limit values different for different sources of noise.

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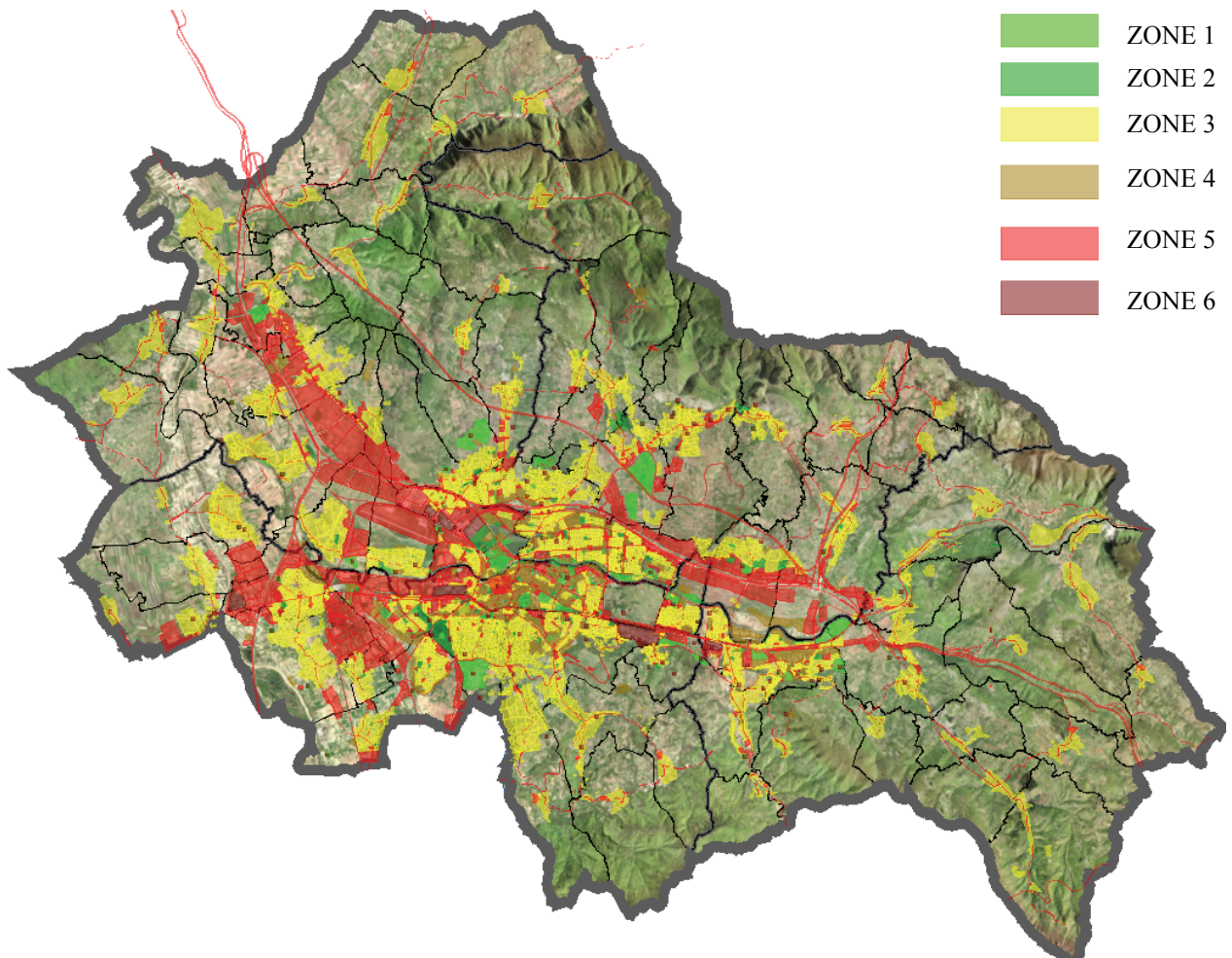


Fig. 4 Draft of noise zoning plan of administrative area of the city of Nis



Fig. 5 Draft of noise zoning plan of the Municipality of Medijana