WALKING AS A CLIMATE FRIENDLY TRANSPORTATION MODE IN URBAN ENVIRONMENT

CASE STUDY: BELGRADE

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Abstract: A large percent of CO_2 (carbon dioxide) emissions in Serbia originate from transport. In the last two decades, the number of private car users in Belgrade evidently increased compared to the number of users of environmentally friendly modes of transport. The purpose of this paper is to present an overview of approaches to the improvement of the physical aspect of the open public spaces, which aim to increase the number of users of climate friendly modes of transport, particularly walking. Research was done using three methods: observation of the intensity of pedestrian movement in relation to different periods during the day, direct surveys of citizens and the evaluation of immediate pedestrian surroundings. Three kinds of results were obtained: the trends and concentration of pedestrian movement along the main street lines; the attitude of citizens pertaining to reliable pedestrian movement and elements which contribute to their commitment to walking; and the rhythm of activity units, transparency, and variety of activities on the ground floor of buildings. The contribution of the study is in combining different research methods. The interpretation of the results forms the basis for directing future research and campaigns on topics of climate friendly modes of transport in urban areas.

Keywords: CO_2 emission, transport, walking, public space, street fronts, Belgrade, Vracar.

1. Introduction

The problem which was noticed in the last two decades was the trend towards the increase of the numbers of private cars and, at the same time, decrease of the number of pedestrians, especially in Belgrade. In this paper, special attention is devoted to the transport sector and a number of its characteristics in Serbia are also identified. The circumstances in the country drastically changed at the beginning of 21st century. The reason for this lies in the improved economic situation and political stabilization of the country after the changes that followed the year 2000. Researches which have been done recently show that CO_2 emissions have a rising trend. Taking into account the sector analysis of CO_2 emissions, it is found that transport is in the third place, with 14 % of the total CO_2 emissions. In contrast to the rest of the world and European trends observed in the last twenty years, the situation in Serbia differs. The reason for this can be found in the distinctiveness of

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the transitional period which Serbia entered twenty years ago.

Research was done using three methods. The first method was to determine the intensity of pedestrian movement in relation to different periods during the day. The second were direct surveys of citizens who live in the Municipality Vracar. The aim of this part of the research was to determine the willingness of citizens to choose walking as a form of movement. The third was the evaluation of immediate pedestrian surroundings, which was reduced to an analysis of activities and physical characteristics on the ground floor of buildings along the observed streets connecting local centres. Territorially, the study covered the area of the Municipality of Vracar, one of the central municipalities of Belgrade.

The paper consists of four parts. The first part identifies sources of CO_2 emissions in Serbia and Belgrade. This part presents two different periods: the period of the 1990s, when a reduction of CO_2 emissions was recorded, and the period after 2000, when an increase in CO_2 emissions was observed. Possible solutions to reduce CO_2 emissions were considered in the second part of the paper, with special focus on the transport sector. In this part, the principle of green transportation hierarchy will be explained as one of the possible alternatives of solving the problem of CO_2 emissions. Special attention is devoted to walking as an environmentally and climate friendly mode of transport, and its relationships to public transport. Part three presents the study results which analyze pedestrian movement and quality of the pedestrian environment in the territory of the Vracar Municipality. The aim of these analyses is to define elements that stimulate walking in the researched area and enable the continuity of pedestrian directions that connect the local centres. In this study, three methods were used: Space Syntax methodology, analysis of activities and physical characteristics on the ground

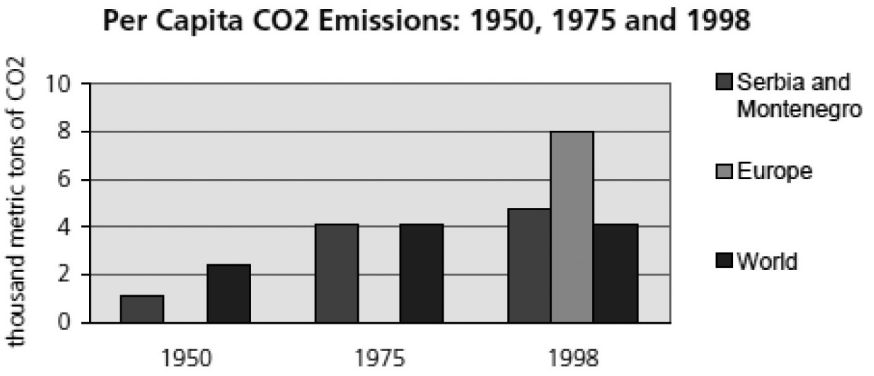

Fig. 1.
CO_2 Emissions per Capita
Source: Climate and Atmosphere – Serbia and Montenegro, (Earth Trends, 2003)

floor of buildings along the streets. The last part includes interpretation and discussion of the results in the form of references and directions that will result in an increase of the intensity of pedestrian movement.

2. Theoretical and Research Background

Since 1989, Serbia has started the process of transition from the socialist to the capitalist political system. There are two characteristic periods: the period from 1990 to 2000 with the main denominators of war with the neighbouring countries, economic sanctions, and an unstable political situation, and the period from 2000 until the present, characterized by certain political stabilization and economic progress (Krstić-Furundžić and Đukić, 2009). Based on a thus defined period frame we can also analyze conditions in the environmental domain and related to CO_2 emissions.

Data from the earlier periods demonstrate the growing trend in CO_2 emissions. According to the research of the World Recourse Institute, conducted during the 1950s, Yugoslavia had two times less CO_2 emissions relative to world emissions (Fig. 1). In the next 25 years, more precisely in 1975, CO_2 emission had the growing trend per capita. During the mentioned period, the total CO_2 emissions in Yugoslavia had a similar value to world average CO_2 emissions per capita (Earth Trends, 2003).

The same source indicates that in 1998 an increase of CO_2 emissions per capita in Serbia and Montenegro was noticed compared to the world, but at the same time they were less than CO_2 emissions in Europe.

Throughout the period from 1990 to 2008 different trends were noted in CO_2 emissions. These data for fuel combustion are expressed in megatons in relation to the approach by sector (Fig. 2). A variable situation (Fig. 3) is also present in the transport sector. This was published in the International Transport Forum Report in 2008.

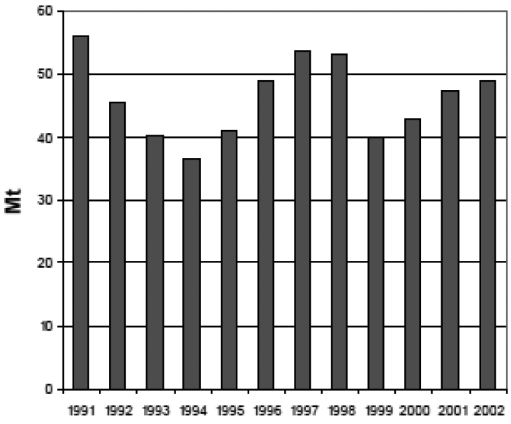

Fig. 2.
CO_2 Emissions from Fuel Combustion – Sectoral Approach
Source: IEA, 2005

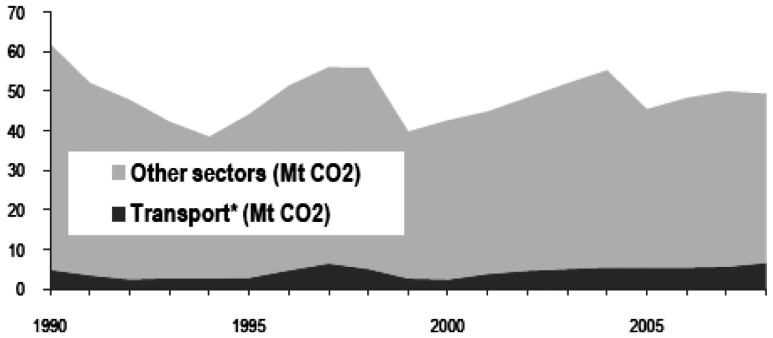

Fig. 3.
Relation Between Total CO_2 Emissions and Emissions from the Transport Sector
Source: International Transport Forum

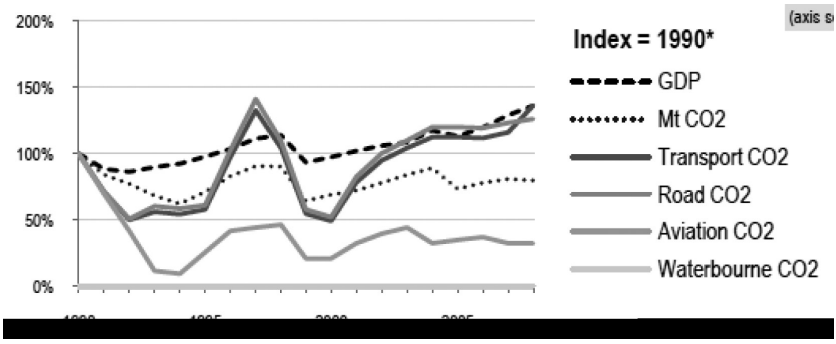

Fig. 4.
CO_2 Emissions During the Period from 1990 to 2008
Source: International Transport Forum

Transport and the Economy	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	1990-2008	%/year**	% 2007-2008
Population (millions)	10.23	10.39	8.16	8.16	8.15	8.12	8.09	7.44	7.41	7.38	7.35	-28%	-1.82%	-0.41%
GDP PPP (billion 2000 US dollars)	37.53	36.76	36.62	38.26	39.79	40.79	44.08	42.56	44.99	48.37	51.08	36%	1.73%	5.60%
Road passenger km (million pkm)	23264	12896	3056	4257	4086	3865	3676	4820	5480	4456	4719	-80%	-8.48%	5.90%
Road and Rail freight tkm (million tkm)	15789	5898	2499	2464	2721	3043	3441	4161	5030	5712	5451	-65%	-5.74%	-4.57%
Road pkm/capita	2274	1241	374	522	501	476	454	648	740	604	642	-72%	-6.78%	6.33%
Road and Rail freight tkm/$ gdp	0.42	0.16	0.07	0.06	0.07	0.07	0.08	0.10	0.11	0.12	0.11	-73%	-7.34%	-9.63%
Passenger cars per 1000 inhabitants	..	..	..	..	..	..	..	..	204	200	..	..	..	..
CO2 Emissions														
IEA CO2 from fuel combustion (Mt)*	61.87	44.12	42.63	44.84	48.4	51.96	55.26	45.41	48.26	49.96	49.35	-20%	-1.25%	-1.22%
... of which transport CO2 (Mt)*	4.85	2.81	2.39	3.8	4.61	5.06	5.45	5.46	5.43	5.63	6.6	36%	1.73%	17.23%
Transport as a percentage of total*	*7.8%*	*6.4%*	*5.6%*	*8.5%*	*9.5%*	*9.7%*	*9.9%*	*12.0%*	*11.3%*	*11.3%*	*13.4%*			
Road (Mt)	4.42	2.7	2.3	3.66	4.44	4.87	5.31	5.31	5.27	5.45	5.57	26%	1.29%	2.20%
Rail (Mt)	0	0	0	0	0	0	0	0	0	0	0	..	..	..
Domestic Aviation (Mt)	0	0	0	0	0	0	0	0	0	0	0	..	..	..
International Aviation (Mt)	0.43	0.11	0.09	0.14	0.17	0.19	0.14	0.15	0.16	0.14	0.14	-67%	-6.04%	0.00%
Domestic Navigation (Mt)	0	0	0	0	0	0	0	0	0	0	0	..	..	..
International Shipping (Mt)	0	0	0	0	0	0	0	0	0	0	0	..	..	..
Other Transport (Mt)	0	0	0	0	0	0	0	0	0	0.04	0.88	..	..	2100.00%

Fig. 5.
Country Profile – Serbia. CO_2 Emissions
Source: International Transport Forum

This report indicates that CO_2 emissions in the transport sector in 1990 were 7.8 % of the total CO_2 emissions in Serbia. From that period, a decreasing trend is noticed until 2000 (1995: 6.4 %; 2000: 5.6 %). After that, a growing trend was present until 2008, with CO_2 emissions from transport in 2008 amounting to 13.4 % of the total (Stupar and Đukić, 2009).

2.1. Period from 1990 to 2000

The period from 1990 to 2000 is characterized by a difficult economic situation and political instability in the country. The most important events that marked this period are war with the neighbouring countries, economic sanctions and a complicated political situation. In accordance with the above-mentioned and opposed to other Eastern European countries, there was little regard for the environmental aspect. However, this period is characterized by a decline in CO_2 emissions (ECMT, 2003). It was not the raised awareness of the negative effects of CO_2 that characterized these times. In effect, it was the continuing economic instability that brought about a reduction in industrial production, lower volume of traffic, and a decline of construction activities.

These defined circumstances were reflected in the transport sector. During this period a decrease in CO_2 emissions until 1996 can be noted. From 1996 an increase in CO_2 emissions is registered, reaching its maximum value in 1997. After that, there is again a decreasing trend, reaching its minimum value in 2000 (Fig. 4).

Values that were recorded by the International Transport Forum are presented in Fig. 5. During the period from 1990 to 2000, the highest CO_2 emissions expressed in Mt were recorded in the domain of the road transport

Transport and the Economy	1990	1995	2000
Population (millions)	10.23	10.39	8.18
GDP PPP (billion 2000 US dollars)	37.53	36.76	36.62
Road passenger km (million pkm)	23264	12896	3056
Road and Rail freight tkm (million tkm)	15789	5898	2499
Road pkm/capita	2274	1241	374
Road and Rail freight tkm/$ gdp	0.42	0.16	0.07
Passenger cars per 1000 inhabitants	..	..	..
CO2 Emissions			
IEA CO2 from fuel combustion (Mt)*	61.87	44.12	42.63
... of which transport CO2 (Mt)*	4.85	2.81	2.39
Transport as a percentage of total*	*7.8%*	*6.4%*	*5.6%*
Road (Mt)	4.42	2.7	2.3
Rail (Mt)	0	0	0
Domestic Aviation (Mt)	0	0	0
International Aviation (Mt)	0.43	0.11	0.09
Domestic Navigation (Mt)	0	0	0
International Shipping (Mt)	0	0	0
Other Transport (Mt)	0	0	0

Fig. 6.
Country Profile – Serbia. CO_2 Emission
Source: International Transport Forum

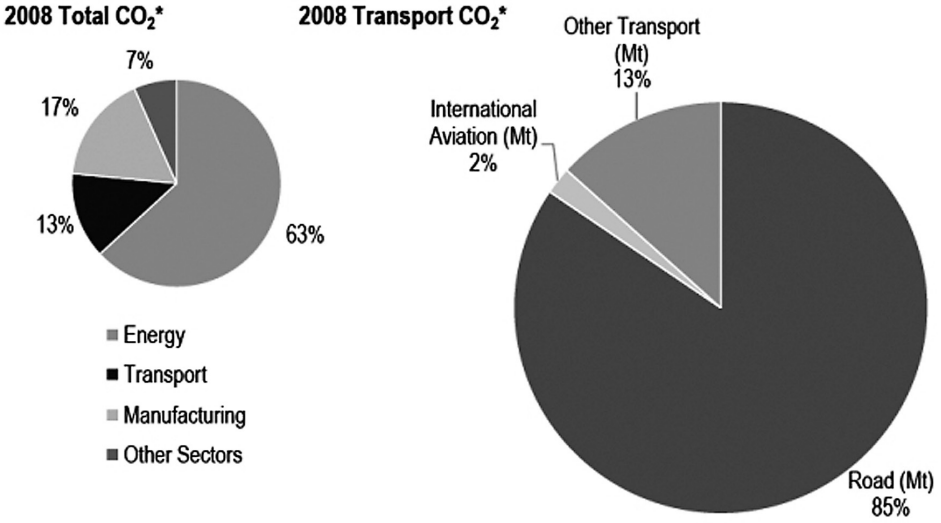

Fig. 7.
Share of Traffic in Overall Emissions, and Distribution of the Share of Traffic According to Types of Transport
Source: International Transport Forum

Overall

	City	Score
1	Copenhagen	87,31
2	Stockholm	86,65
3	Oslo	83,98
4	Vienna	83,34
5	Amsterdam	83,03
6	Zurich	82,31
7	Helsinki	79,29
8	Berlin	79,01
9	Brussels	78,01
10	Paris	73,21
11	London	71,56
12	Madrid	67,08
13	Vilnius	62,77
14	Rome	62,58
15	Riga	59,57
16	Warsaw	59,04
17	Budapest	57,55
18	Lisbon	57,25
19	Ljubljana	56,39
20	Bratislava	56,09
21	Dublin	53,98
22	Athens	53,09
23	Tallinn	52,98
24	Prague	49,78
25	Istanbul	45,20
26	Zagreb	42,36
27	Belgrade	40,03
28	Bucharest	39,14
29	Sofia	36,85
30	Kiev	32,33

CO_2

	City	Score
1	Oslo	9,58
2	Stockholm	8,99
3	Zurich	8,48
4	Copenhagen	8,35
5	Brussels	8,32
6	Paris	7,81
7	Rome	7,57
8	Vienna	7,53
9	Madrid	7,51
10	London	7,34
11	Helsinki	7,30
12	Amsterdam	7,10
13	Berlin	6,75
14	Ljubljana	6,67
15	Riga	5,55
16	Istanbul	4,86
=17	Athens	4,85
=17	Budapest	4,85
19	Dublin	4,77
20	Warsaw	4,65
21	Bratislava	4,54
22	Lisbon	4,05
23	Vilnius	3,91
24	Bucharest	3,65
25	Prague	3,44
26	Tallinn	3,40
27	Zagreb	3,20
28	Belgrade	3,15
29	Sofia	2,95
30	Kiev	2,49

Energy

	City	Score
1	Oslo	8,71
2	Copenhagen	8,69
3	Vienna	7,76
4	Stockholm	7,61
5	Amsterdam	7,08
6	Zurich	6,92
7	Rome	6,40
8	Brussels	6,19
9	Lisbon	5,77
10	London	5,64
11	Istanbul	5,55
12	Madrid	5,52
13	Berlin	5,48
14	Warsaw	5,29
15	Athens	4,94
16	Paris	4,66
17	Belgrade	4,65
18	Dublin	4,55
19	Helsinki	4,49
20	Zagreb	4,34
21	Bratislava	4,19
22	Riga	3,53
23	Bucharest	3,42
24	Prague	3,26
25	Budapest	2,43
26	Vilnius	2,39
27	Ljubljana	2,23
28	Sofia	2,16
29	Tallinn	1,70
30	Kiev	1,50

Buildings

	City	Score
=1	Berlin	9,44
=1	Stockholm	9,44
3	Oslo	9,22
4	Copenhagen	9,17
5	Helsinki	9,11
6	Amsterdam	9,01
7	Paris	8,96
8	Vienna	8,62
9	Zurich	8,43
10	London	7,96
11	Lisbon	7,34
12	Brussels	7,14
13	Vilnius	6,91
14	Sofia	6,25
15	Rome	6,16
16	Warsaw	5,99
17	Madrid	5,68
18	Riga	5,43
19	Ljubljana	5,20
20	Budapest	5,01
21	Bucharest	4,79
22	Athens	4,36
23	Bratislava	3,54
24	Dublin	3,39
25	Zagreb	3,29
26	Prague	3,14
27	Belgrade	2,89
28	Istanbul	1,51
29	Tallinn	1,06
30	Kiev	0,00

Transport

	City	Score
1	Stockholm	8,81
2	Amsterdam	8,44
3	Copenhagen	8,29
4	Vienna	8,00
5	Oslo	7,92
6	Zurich	7,83
7	Brussels	7,49
8	Bratislava	7,16
9	Helsinki	7,08
=10	Budapest	6,64
=10	Tallinn	6,64
12	Berlin	6,60
13	Ljubljana	6,17
14	Riga	6,16
15	Madrid	6,01
16	London	5,55
17	Athens	5,48
18	Rome	5,31
=19	Kiev	5,29
=19	Paris	5,29
=19	Vilnius	5,29
=19	Zagreb	5,29
23	Istanbul	5,12
24	Warsaw	5,11
25	Lisbon	4,73
26	Prague	4,71
27	Sofia	4,62
28	Bucharest	4,55
29	Belgrade	3,98
30	Dublin	2,89

Fig. 8.
Green City Index Ranking European Cities According to Ecological Parameters, 2009

subcategory. In 1990 it was 4.42 Mt, 1995 – 2.7 Mt, 2000 – 2.3 Mt. Throughout this period, the use of public transport in Belgrade increased. The reason for this is the decrease of car use due to economic sanctions and resultant lack of fuel.

2.2. Period from 2000 until the Present

The period from 2000 until the present can be roughly characterized as a stabilization phase. This is mostly reflected in the embrace of democratic values, the termination of conflicts and war operations in the country and the region, political stabilization, etc. The general situation related to environmental aspect and CO_2 emissions is variable. This can be seen in the table (Fig. 6). However, with respect to the transport sector there was a trend of increase, which had a linear character.

This was evident in 2001 when this amounted to 8.5 % of the total CO_2 emissions. The growing trend in the transport sector continued until 2008 when its share was 13.4 % of the total CO_2 emissions (Fig. 6). According to data from the International Transport Forum (Fig. 7), in 2008 the transport sector was in 3rd place compared to the other sectors (energy, manufacturing, and other). That year CO_2 emissions were 6.6 Mt per capita.

When this situation is analyzed in relation to the distribution of CO_2 emissions from transport by type, road transport contributes with 85 %.

2.3. CO_2 Emissions and Transport in Belgrade

According to the most recent study, entitled European Green City Index, Belgrade, the capital of Serbia, is in 27th place considering the key environmental parameters (score 40.3/100) (Economist Intelligence Unit, 2009). CO_2 emissions are one of the included parameters. According to that criterion, Belgrade is in 28th place, and according to transport criteria it is in 29th place. Cities are evaluated based on the eight environmental categories. The categories include CO_2 emissions, energy, buildings, transport, water, land use, and air quality. Belgrade achieved the best ranking in terms of/against the energy parameter (17th place). The reason for this lies in the decline and reduction of heavy industry, as a consequence of the situation in the 1990s. The worst result for Belgrade is in the field of transport and water. In these categories Belgrade is ranked 29th (Fig. 8) of 30 European cities (transport 3.98/8.81; water 3.90/9.21). CO_2 emissions per capita are 3.9 t compared to the average CO_2 emissions of 5.2 t. Considering this subcategory Belgrade is ranked 7th in the overall ranking and 1st in the category of mid size cities. The reason for this is reflected in the fact that the majority of electricity production in Serbia comes from hydropower.

However, a poor result is evident in the subcategory in which CO_2 emission is measured per unit of GDP. Here, Belgrade's result is three times above the average. Considering this situation, this is one of the key national goals relevant to CO_2 emissions (Fig. 9).

Relevant to traffic, the main reason for such a poor rating lies in the high intensity of freight transport. The fact that there are no bypass routes means that freight vehicles enter the city and move along directions that pass near the centre of the city. Research shows that 11,000 lorries and trucks enter the city every day.

When it comes to public transport Belgrade has very good results. The study shows

that 40 % of people commute using public transport while the remaining 35 % walk or use bikes. This is 75 % which is more than the 63% of using a non motor transport as the average value for European cities. This result was achieved due to the extensive public transport system. However, public transport vehicles (buses, trams and trolleys) are in very bad condition, so some work needs to be done to modernize them. The traffic control and management system is outdated: there is no adaptive control, bus priority or traffic response signal timing (Economist Intelligence Unit, 2009).

2.4. Initiatives and Measures for Improving the State of Transport and CO_2 Emissions

The overall result for Belgrade in the domain of transport could change primarily by displacing freight traffic, which is planned by linking the main routes E70 and E75. Greater use of environmentally and climate friendly transport is another way of making a difference. This will also result in decrease of CO_2 emissions in this sector. The strategic approach of Belgrade in this domain is defined in the General Plan of Belgrade 2021, Transportation Model of Belgrade 2007, Traffic Master Plan of Belgrade: Smart Plan 2021 and the Development Strategy for the City of Belgrade 2012.

In accordance with these documents, the Secretariat of Transport of the City of Belgrade and other institutions implement various initiatives and projects in order to resolve these problems. The aim is to increase the use of public transport to a level of 50 %, and in addition to encourage other forms of sustainable transport, i.e. walking and cycling. One of the projects of that kind, which showed good results, is the implementation of parking

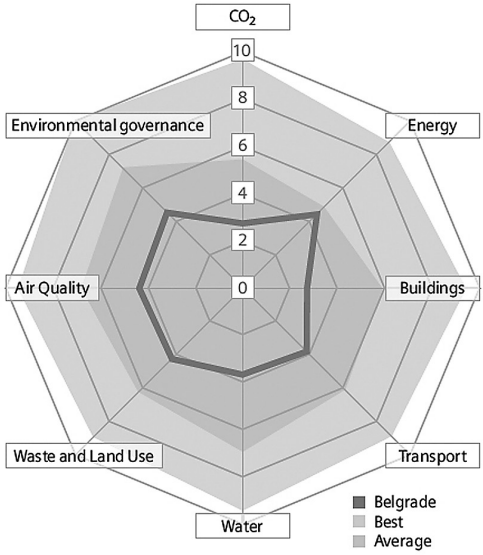

Fig. 9.
Diagram of Values for Ecology Parameters (Groups)
Source: Europe Green City Index, 2009

zones in the centre of the city. This project restricts the duration of parking to 1h, 2h and 3h depending on the zone. When the time expires, the driver is required to move the car to another location. This measure led to the reduction in the number of cars in the central city area.

In addition to city institutions that implement measures to improve transportation, organizations from the NGO sector and professional associations also deal with these issues. These organizations promote certain forms of sustainable transport. Using social marketing instruments they are trying to raise people's awareness of the environmental issues and the importance of greater use of sustainable modes of transport in the city.

The City of Belgrade Development Strategy from 2009, in the topic area related to traffic, provides for the construction and development of the transport system of Belgrade. This will allow sustainable mobility of citizens, still supporting the rapid development of the city and its competitiveness in the region of Southern Europe (Stojkov, 2008). One of the operational goals is the implementation of a transport system that will contribute to the environmental optimization of the city. This will be achieved by:

- Construction of the first line of the high capacity public transport system in Belgrade
- Stimulating the use of Beovoz trains in commuter transport (shorter but more reliable intervals) in the public transport system of the City
- Reorganization of public city transport in the vicinity of the Beovoz train corridor as well as within the whole network
- Introduction of river passenger transport
- Increased level of transport safety
- Development of new technologies (traffic management and control, ITS)
- Development of bicycle transport
- Stimulating pedestrian transport
- Rehabilitation and modernization of city streets in all urban centres in line with transport demands and standards
- Modernization of local roads (Stojkov, 2008).

The Strategy envisages the retaining of the level of passenger car travel, amounting to 25-30%. The use of public transport must reach the level of 45-50% of daily trips and a high level of service must be ensured. Walking is supposed to be at a level of 20-25% in intercity movement. Paratransit (cycling, taxi and other types of collective transport) must reach the level of 5-10% of daily trips (Grad Beograd, 2005).

In accordance with these goals pedestrian and bicycle transport should be significantly improved. The main tasks related to this are: freeing public space intended for pedestrians from parked vehicles and other barriers, increasing attractiveness of public transport, and creating conditions for the realization of attractive pedestrian and cycle spaces and routes.

Along with the general aims of the City of Belgrade related to the improvement of transport and decrease of CO_2 emissions, this paper also deals with measures which would stimulate pedestrian movement in the central area of the city. A commitment to pedestrian

movement in Belgrade is considered more practical in relation to bicycle traffic. We found that this is due to the characteristic morphology of the terrain and actual street profiles that do not include bicycle paths.

The other reason lies in the promoting of the principle of the green transport hierarchy (Fig. 10). In this hierarchy priority is given to pedestrian movement, followed by bicycle traffic, and then public transport. After those three sustainable modes of transport, come service vehicles, and lastly, the private car.

3. Research Polygon

The research polygon was the territory of the Municipality of Vracar, City of Belgrade. This research forms part of a broader research aimed at defining recommendations for the revival of local centres in an attempt to create a multicenter territory that would provide steady development of the city as a whole. Local authorities were also very interested in this study and its results, because they share the same goals.

Regarding territorial and demographic characteristics of the territory, one of the purposes of research was evaluation and improvement of pedestrian links between the local centres. Accordingly, there is a tendency towards improving the quality of life and achieving environmental goals related to the reduction of the CO_2 emissions and the boost of climate friendly modes of transport. With respect to the principle of the green transport hierarchy, the main goal is to stimulate walking and the utilization of public transport in the territory of Vracar.

This study was also inspired by the results of surveys that included citizens of Vracar and that were conducted in 2010 by the NGO "5km/h"

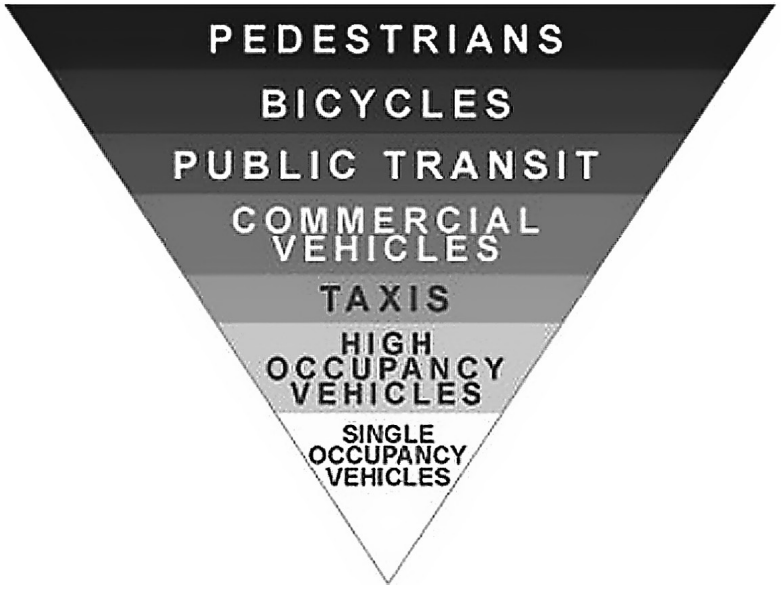

Fig. 10.
Green Transport Hierarchy
Source: http://thenewgay.net/wp-content

within the project *Make a step – Improve the environment* (Vukmirović, 2010a). This research showed that 46 % of examiners always use their private car, and that 36 % of examiners use their car when going to work. Another result of the study showed that 37 % of citizens do not take care of the distance of their travel when they use their private car. The third result showed that 44 % of the examiners spent about 10 minutes to find a parking place in Vracar, and 38 % spend from 10 to 20 minutes.

Taking into account the size of the territory of Vracar, 15 minutes of walking are required for covering much of the study territory (Fig. 11). These results represent a good starting point for determining measures that would stimulate greater intensity of pedestrian movement in Vracar.

This study also aims at determining the advantages and disadvantages related to the quality of the pedestrian environment. In accordance with this information, guidelines would be provided which can be used for motivating pedestrian movement and improvement of the quality of public spaces in Vracar.

4. Methodological Framework of the Study

Considering that one of the aims of the study is to establish the territory of polycentricity, streets that connect the local centres in Vracar were analyzed. These are the main streets in the study territory: Njegoseva Street, Milesevska Street and Maksima Gorkog Street.

The first part of the research includes the analysis of the quality of the pedestrian environment by using a system of criteria that are related to: safety, accessibility, legibility, comfort, attractiveness and live ability (Bazik,

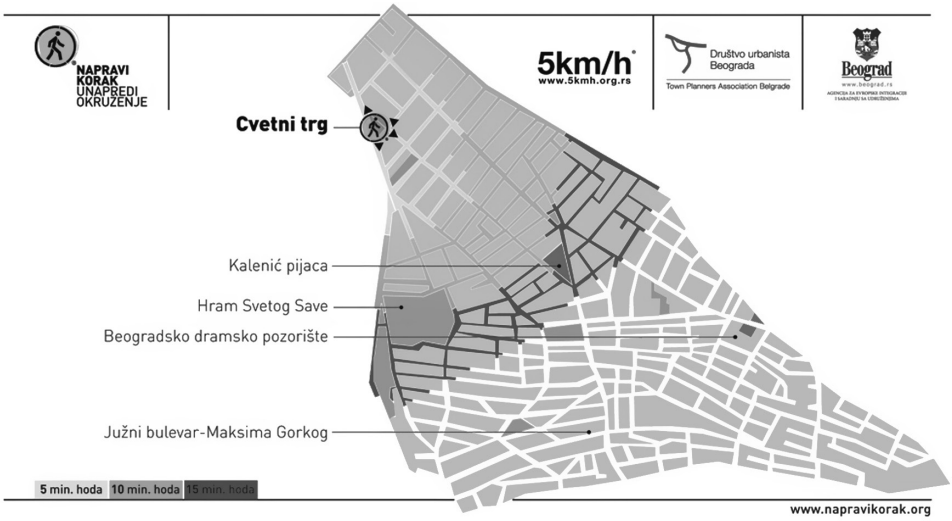

Fig. 11.
Cvetni Trg, Vracar. Distances Within the Territory at 5, 10 and 15 Minutes
Source: Make a Step – Improve the Environment Project

2006). The research was done at the Faculty of Architecture, University of Belgrade, within the course of Public Space Design, coordinated by Professor Dragana Bazik. A hierarchy was established among the set criteria; this meant that if basic criteria were not fulfilled, above all safety and accessibility, it would not be possible to have other characteristics which contribute to the live ability of a certain space.

The second part of the study aimed at examining the situation along the observed paths in more detail. Primarily this relates to the analysis of the current intensity of pedestrian movement and the establishing of a casual relationship with the consequent content and physical characteristics of the ground floor of buildings along the streets.

Three methods were used in this research:

- Space Syntax methodology, defined by Bill Hillier (Hillier and Hanson, 1984). This method was used to evaluate the intensity of pedestrian movement along the studied paths in different periods of the day. The research was done at the Faculty of Architecture, University of Belgrade, within the master studio UrbanLAB, coordinated by Assist. Professor Aleksandra Djukic.

- A method of detailed analysis of ground floor activities. The aim of this study was to establish the relationship between the intensity of pedestrian movement and the character defined by activities and contents on the ground floor of buildings along the streets. This research was done within the master studio UrbanLAB coordinated by Professor Djukic.

- The method defined by Jan Gehl (Gehl et al., 2006; Tan, 2006), and related to the study of physical characteristics of the pedestrian environment. This method includes the analysis of the physical characteristics of the ground floor of buildings (especially rhythm and scale) and sidewalks. This research was done by the NGO "5km/h" in 2010.

5. Results

The analysis of the quality of public spaces in Vracar incorporated all public spaces in the study territory. They were processed according to quality criteria. Each catalogued sheet, related to the specific public space and criterion, had a section for evaluation (ranging from 1 for the worst condition to 5 for the best condition) (Fig. 12).

In addition to the estimate of the state of public spaces by using a set scale, detailed analyses of open public spaces, were conducted one by one. The aim of this part of research was to evaluate positive and negative features of the observed area. The results of this more extensive study were used to examine the state of the selected paths that were our object of interest. Here is what we found.

Based on the set criteria, from the aspect of safety Milesevska St. was characterized most positively, and Maksima Gorkog St. most negatively; from the aspect of accessibility Njegoseva St. was characterised most positively, and Cara Nikolaja II St. most negatively; from the aspect of legibility Njegoseva St. was characterized most positively (no negative comments), and Cara Nikolaja II St. most negatively; from the aspect of attractiveness Njegoseva St. was characterized most positively (no negative comments), and Maksima Gorkog St. most negatively (no positive comments); from the aspect of liveliness Njegoseva St. was

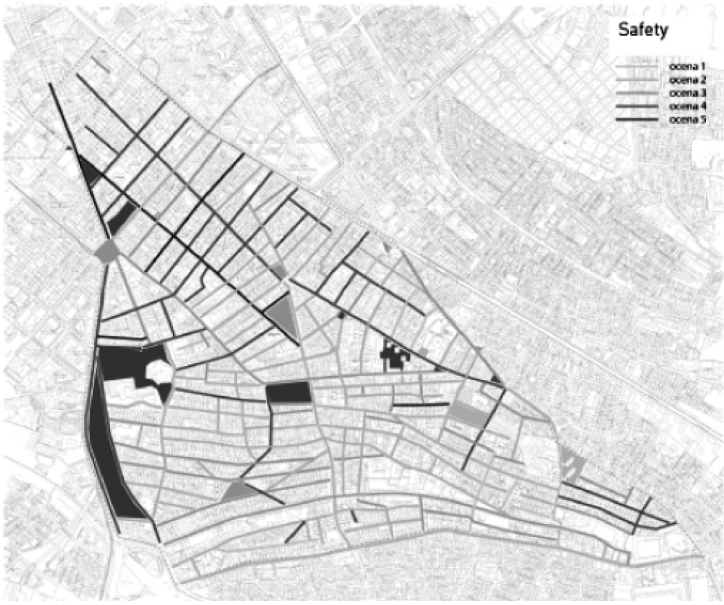

Fig. 12.
Public Space Quality in the Territory of Vracar According to Safety Criteria
Source: Faculty of Architecture, 2010

Fig. 13.
Intensity of Pedestrian Movement from 4pm to 5pm
Source: Faculty of Architecture, 2010

characterized most positively (no negative comments), and Cara Nikolaja II St. most negatively (no positive comments). It is assumed that the reason for such results is the recent reconstruction of Njegoseva St, which provided for wider sidewalks, lower frequency of vehicle transport, activation of contents on the ground floor of buildings. On the other hand, Maksima Gorkog and Cara Nikolaja II Sts. have extremely frequent vehicle transport, narrow sidewalks, intense pollution, discontinued sections of street fronts, both vertically and horizontally. This part of research highlighted the general condition by which we can define guidelines and recommendations. Further research examined the situation along the observed streets in more detail.

The next part of research aimed at determining the actual use of identified paths by analyzing the frequency of pedestrian movement on a daily basis (Đukić and Vukmirović, 2009). This analysis was conducted by using the Space Syntax method. The results of this research revealed certain unevenness in the frequency of pedestrian movement, both with respect to different times at which measurements were conducted, and with respect to concrete parts of the identified path (Fig. 13).

Measurements were conducted on workdays, four times a day. In the morning from 8 am to 9 am, when local inhabitants perform activities such as going to work or school or grocery shopping; from 11 am to 12 noon, which coincides with the end of school hours for elementary school students, recess for high school students and a lunch break for the employed (this period also coincides with the start of working hours of cafes and restaurants); in the afternoon, from 4 pm to 5 pm, when local inhabitants come back from work; and from 7 pm to 8 pm, in the so-called evening hours. The results showed that pedestrian movement was most frequent from 4 pm to 5 pm if we observe the entire polygon where measurements were conducted. On the other hand, from 7 pm to 8 pm the number of pedestrians was at its lowest. Another conclusion is that there are differences along paths relative to the intensity of pedestrian movement or the phenomenon of discontinuity.

Further research led toward the establishment of correlation between pedestrian movement and characteristics of the pedestrian environment (Vukmirović, 2010b). Therefore, further investigation encompassed an analysis of activities on the ground floor of buildings

Fig. 14.
Segment of Street Fronts in Maksima Gorkog and Milesevska Streets
Source: Association 5km/h Belgrade

on the observed path, with a focus on the diversity of activities, their density on certain parts of the path, and characteristics of shop fronts and entrances, i.e. transparency.

Content analysis provided for certain correlations between frequency of pedestrian movement in the observed period, content attractiveness and its disposition along the paths. The analysis demonstrated that the frequency of pedestrian movement is proportionate to the number of activities, i.e. their density and diversity in specific segments of the investigated streets. Besides, a greater frequency is observed during the afternoon, from 4 pm to 5 pm. This period is considered as the most frequent, when the employed are coming back from work, while other inhabitants spend their time in the open. Important differences with respect to certain segments of the paths are observed in the early morning and evening hours. This is especially the case in areas characterised by density of cafes and restaurants on one hand, and zones with facilities that are closed in the evening hours on the other. From 11 am to 12 noon there is higher frequency of pedestrian movement in the areas close to schools.

The analysis also considered shop windows and entrances, i.e. transparency and direct linkage between activities on ground floors of buildings and open public space. Same as above, the intensity of pedestrian movement was higher along fronts at which shop windows were less distant and occupy larger surfaces. This was particularly visible during evening hours, when the transparency of protective curtains was observed.

With respect to characteristics of sidewalks, the width and quality of pavement was analyzed along the paths of interest. Along Makisma Gorkog St., characterized by the greatest intensity of pedestrian movement, the sidewalk width varies from 1.5 m to 2.0 m. The conclusion is that it does not match the actual and expected intensity of pedestrian movement. Makisma Gorkog St. has not yet been reconstructed and the state of the pavement is very poor. Along Milesevska St., the sidewalk width was around 1.5 m. This width was measured between the parked cars and the facade of buildings. The sidewalks are not reconstructed and they are in very poor condition. Njegoseva St. was reconstructed and totally transformed in 2008. The sidewalks were extended; the new pavement with an informative character was created. The width of the sidewalks varies from 3.0 m to 6.0 m. This is a positive feature considering the physical aspect, but the lack of activities along the street contributes to the low intensity of pedestrian movement.

6. Discussion

Based on the analysis and assessment of the current situation in the territory of Vracar, elements which encourage intense pedestrian movement in the study area were identified. In addition, problems and obstacles that negatively affect the choice to walk as a mode of transport were recognized.

In order to improve this situation and to motivate more people to walk, the following alterations are envisaged:

- implementation of a new street regulation along the paths that citizens have characterised as unsafe and inaccessible;
- establishment of continuity with respect to the vertical and horizontal regulation along the identified paths;
- anticipation of the measures for

stimulation of attractive activities and their even distribution along the paths, which would allow for proportional use of space during all periods of the day;

- enlargement of shop window surfaces in order to achieve greater contact between activities in buildings and open public spaces, and

- provision of new and more transparent types of protective curtains to stimulate pedestrian movement during evening hours.

The above-mentioned measures and recommendations would result in:

- higher intensity of pedestrian movement as a way of transport;

- higher intensity of pedestrian movement along the main streets which connect the local centers of the Vracar territory;

- polycentricity of the territory and equality in the development of the area;

- raised awareness about the need to use environmentally and climate friendly modes of transport, especially over short distances;

- better quality of life in Vracar.

To achieve the above-mentioned improvements it is necessary to integrate them into the guidelines of urban plans and projects, to ensure public participation and education of citizens, local authorities and experts in the field of urban planning, design and transportation.

Acknowledgments

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BUDUĆI IZAZOVI U MOTIVISANJU GRAĐANA DA KORISTE PEŠAČKO KRETANJE KAO ODRŽIVI VID TRANSPORTA: STUDIJA SLUČAJA – GRADSKA OPŠTINA VRAČAR

Aleksandra Đukic, Milena Vukmirović

Sažetak: Veliki procenat emisije CO_2 (ugljen dioksid) u Srbiji potiče od saobraćaja. U poslednje dve decenije evidentirano je povećanje broja privatnih automobila, za razliku od broja korisnika ekološki prihvatljivih vidova saobraćaja. Cilj rada predstavlja prikaz pristupa za poboljšanje fizičkog aspekta otvorenih javnih gradskih prostora, čime se teži povećanju saobraćaja koji ne utiče negativno na klimatske promene, a fokus je stavljen na pešačko kretanje. Istraživanje je sprovedeno korišćenjem tri metoda: posmatranje intenziteta pešaka u različitim periodima u toku dana, anketiranje građana i vrednovanje kvaliteta neposrednog pešačkog okruženja. Na osnovu sprovedenih analiza dobijene su tri vrste rezultata: koncentrecija pešaka duž glavnih uličnih poteza, stav građana u odnosu na pešačko kretanje i utvrđivanje elemenata koji doprinose njegovom povećanju i ritam, transparentnost i raznovrsnost aktivnosti u prizemljima objekata. Doprinos istraživanja ogleda se u kombinovanju različitih istraživačkih metoda i tumačenju rezultata u cilju usmeravanja budućih istraživanja i kampanja na temu ekološki prihvatljivih vidova saobraćaja u urbanom okruženju.

Ključne reči: emisija CO_2, saobraćaj, pešačko kretanje, javni gradski prostor, ulični frontovi, Beograd, Vračar.