Urban Sensing – Smart Solutions for Monitoring Environmental Quality: Case Studies from Serbia

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1. Background

Environmental problems are among the most pressing issues today. Environmental decisions of a good quality require right information at the right time. Providing up-to-date environmental data is essential for identifying sources of pollution, and understanding their behaviour – such as their movement, effects they impose on the built and natural environment, exposure of population etc. These data can help us define priorities and steer decisions related to development in the right direction. Acquiring these data is the area where IT smart solutions are widely applicable.

The biggest threat to the environment in Serbia comes from the energy sector, which is primarily based on fossil fuels – mostly coal, mining activities, and outdated industry, often located near or in the populated areas. Resultant air, soil and water pollution is further aggravated by the often-improper disposal of hazardous waste and wastewater.

Some places are affected more than others. For example, in 2010, in the city of Bor – one of the environmental "hot spots" in Serbia – the annual concentration of SO_2 exceeded by three times legally-defined maximum value, while daily concentration limits were exceeded by 111 days at the annual level (Agency for Environmental Protection, 2011). A number of other cities, such as Pančevo (another environmental "hot spot"), Užice, Niš, Obrenovac, etc., are also known for exceeding the legally-defined limits of different pollutants. The capacities and resources of most municipalities to monitor air pollution are limited, and accurate data are often not readily accessible by local population. (United Nations Environment Programme, 2004)

During the 1990s, unfavourable political and economic situation in the country stalled investments in environmental protection and clean technologies, at the expense of environmental and natural resources. Starting from 2000s, however, the support for environmental protection regained the focus, resulting in many changes in national policies, environmental protection programs and capacities and related legislation.

National policies, environment and planning

Serbia signed and ratified Kyoto protocol in 2007, and officially applied for EU membership at the end of 2009. Government of Serbia is committed to harmonizing its laws and other regulatory acts with those of EU, which, among others, relate to sustainable development and environmental protection.

Responsibility for environmental issues in Serbia is handled mainly by the Ministry of Environment, Mining and Spatial Planning, since it is in charge of defining policies concerning environmental protection. In addition to the Ministry, a number of other Serbian institutions have among their duties monitoring and protecting quality of environment (e.g., water, forests, agricultural land etc.).

The National Strategy for Sustainable Development was adopted in 2008. This Strategy has been based on the widely accepted principles defined by the Johannesburg Declaration on Sustainable Development, The UN Millennium Development Goals and the EU Sustainable Development Strategy (EU SDS).

Spatial and urban planning is regulated by the Ministry of Environment, Mining and Spatial Planning and the National Agency for Spatial Planning. These institutions are responsible for

defining the content, method and procedure of developing and issuing planning documents. In 2010, the Spatial Development Plan of Serbia for the period 2010-2020 was adopted as a key national document addressing spatial and urban development. It provides the foundations for every regional and local plan and program.

Sustainable development, environmental protection and planning documents are tied by the Environmental impact assessments (EIA) and Strategic Impact Assessment (SIA). EIA and SIA are required for planning and development of different projects, and are a prerequisite for obtaining a construction permit. Before a construction permit can be issued, the Ministry of Environment, Mining and Spatial Planning or local Environmental Secretariats – the jurisdiction depending on location, type and scale of the project – have to review and approve the EIA and SIA.

The state of affairs on the local urban level is being monitored by local governments and their respective bodies. They undertake different actions and programs independently of the state. Some of them go along the lines of national policies, but there are others whose initiatives are often carried out with partners from other countries, or international organizations.

There are local governments that are well advanced in providing the responsive solutions to enhance environmental quality in their cities and towns, two of which are presented in this paper. These two “good practice” case studies provide solutions to improve environmental quality in their communities, but also raise environmental awareness among the citizens. They also illustrate how small steps can generate big changes, and how innovative solutions can be easily accessible on a low cost.

National policies and the IT

Both of these cases are supported by IT smart solutions, which are at this time readily available throughout the country. In Serbia, internet is being used by 56% of population (Internet World Stats, 2010). The number of users has grown more than seven times in the last 10 years.

Serbia adopted a series of national strategic documents concerning development of information society, reform of public administration, e-government, etc., all of which have created a favourable environment for further development of IT tools to support every segment of management, including spatial and urban development and environmental protection (Lalović, 2010). In 2007, Serbia signed the eSEE Agenda Plus for the Development of the Information Society in South Eastern Europe, and accepted i2010 as a general framework for development of information society. This was followed by the National strategy for the Development of E-Government 2009 – 2013, and National strategy for the Development of Information society 2020 (adopted in 2010) among others.

The Spatial Development Plan of Serbia 2010-2020 lists development of spatial information system for monitoring the spatial and urban development as one of its key priorities. Development of the system is based on the Infrastructure for Spatial Information Directive (INSPIRE) that supports “establishment of infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment.” (European Parliament and the Council of the European Union, 2007) Environmental monitoring facilities, air quality monitoring stations, water-monitoring stations etc. are to be part of the system. (INSPIRE Drafting Team DS, Consolidation Team & Thematic Working Groups, 2008) Serbian National Agency for Spatial Planning, responsible for carrying out of the project, is to adjust its work to the ESPON (European Observation Network for Territorial Development and Cohesion) requirements and methodology.

2. Smart systems in Serbia

The two cases that we present here are part of the joint efforts: on one side, the enhancement of environmental quality and environmental protection, and on another, development of IT and introduction of smart systems in managing the spatial and urban affairs. They illustrate how a productive link between IT and managing environment can be established, and how taken together they affect planning, making it more responsive and "fast forward" practice.

The two systems presented here, although different, can both be used as effective tools to aid planning practise in monitoring environmental parameters, and extending the information base necessary for planning. Both are GIS based, provide the site based information, real-time monitoring, effective user-centric service, and positively affect environmental awareness among the citizens.

Figure 1 – Locations of the presented cases in Serbia (Source: Own work, based on map from Wikimedia Commons)

EcoBus project in Pančevo

The City of Pančevo - an environmental "hot spot"

The city of Pančevo is located in the northern part of Serbia, about 15 km Northeast from Belgrade, and 4 km from the Danube River. With its population of 74000(town)/122000(municipality) inhabitants (Statistical Office of the Republic of Serbia, 2011), and the area of 755 km², it is the administrative centre of the South Banat District of Serbia, and the most important port on the Tamiš river. On the southern edge of the city of Pančevo, within the built-up area, a major industrial complex is located, including a petrochemical plant, an oil refinery and a fertilizer plant.

In Serbia, Pančevo is known as one of the most polluted cities, and it is one of the environmental "hot spots" of this country, identified as such by UNEP. It is generally accepted[1] that the most urgent issue in Pančevo is the air pollution – an ongoing problem that lasts for more than three decades. Its main cause is the aforementioned industrial complex, local heating facilities (including the inefficient home heating systems) and traffic (The Municipality of Pančevo, 2004).

The industrial complex presents the biggest challenge. It is located in close proximity to the residential area, and does not comply with the standard of a minimum distance from the built up areas (The Municipality of Pančevo, 2004). Furthermore, the dominant wind comes across the industrial zone, carrying numerous polluting agents towards the residential areas[2] Use of the obsolete technologies, worn out equipment, and insufficient investments in improvements and modernization of the production process, are further aggravating the air-quality. Finally, the problem escalated during the 1999 NATO air strikes, that caused a release of hazardous substances with the long-lasting effects, such as organic chlorine compounds, and heavy metals whose harmful effects are well documented (The Municipality of Pančevo, 2004).

Due to the significant threats to the environment and public health, in late 1999 UNEP, UNDP, local government of the City of Pančevo, together with its Italian partners installed four air-monitoring stations – now part of the EuroAirNet (European Air Quality Monitoring Network). Hourly results are tracked and analysed by the Secretary of Environmental Protection, and displayed in the City Hall and on the official website of the city of Pančevo.

In 2003, Pančevo established the Secretariat of Environmental Protection, as a governance body in charge of measuring, monitoring and managing the quality of the environment. In the same year Local Environmental Action Plan (LEAP) program was started, supported by the European Agency for Reconstruction. The resulting document provided directions for further actions. Since 1999, Pančevo was one of the places where the UNEP Clean-Up Programme started, in order to remedy the consequences of the 1999 NATO bombing for the environment. The project lasted until 2004, during which period the local government, in cooperation with UNEP and its partners, worked hard to address some of the key environmental issues.

EcoBus Project

EcoBus is one of the projects being carried out over the last several years. In 2010, as a result of cooperation between Telekom Serbia, Ericsson, and City of Pančevo, the EcoBus Smart City Service was conceived and implemented in Pančevo. EcoBus project is framed within the SmartSantander project funded by European Union under its Future Internet Research and Experimentation Initiative (FIRE) program.

Figure 2 - EcoBus instrument mounted onto public transportation vehicles (Source: Bielsa, 2012)

The technology is simple and user friendly. EcoBus uses instruments mounted onto the existing public transportation vehicles in order to monitor a set of environmental parameters over a broad city area. Sixty public transportation vehicles are equipped with these devices, which detect and measure six parameters: temperature, relative humidity, carbon monoxide, carbon dioxide, nitrogen dioxide, as well as a vehicle location. Constant readings of these parameters are performed whenever the vehicle is moving and, in this way, data are collected from various locations. These data are then delivered to the central server via the wireless network for further analysis and database storage (Bielsa, 2012).

This real-time information about the air quality, atmospheric measurements data and location of the vehicles is freely available on the interactive map accessible to virtually anyone with an internet connection or mobile phone. Data are also used for monitoring traffic and making the readjustments if needed (Bielsa, 2012).

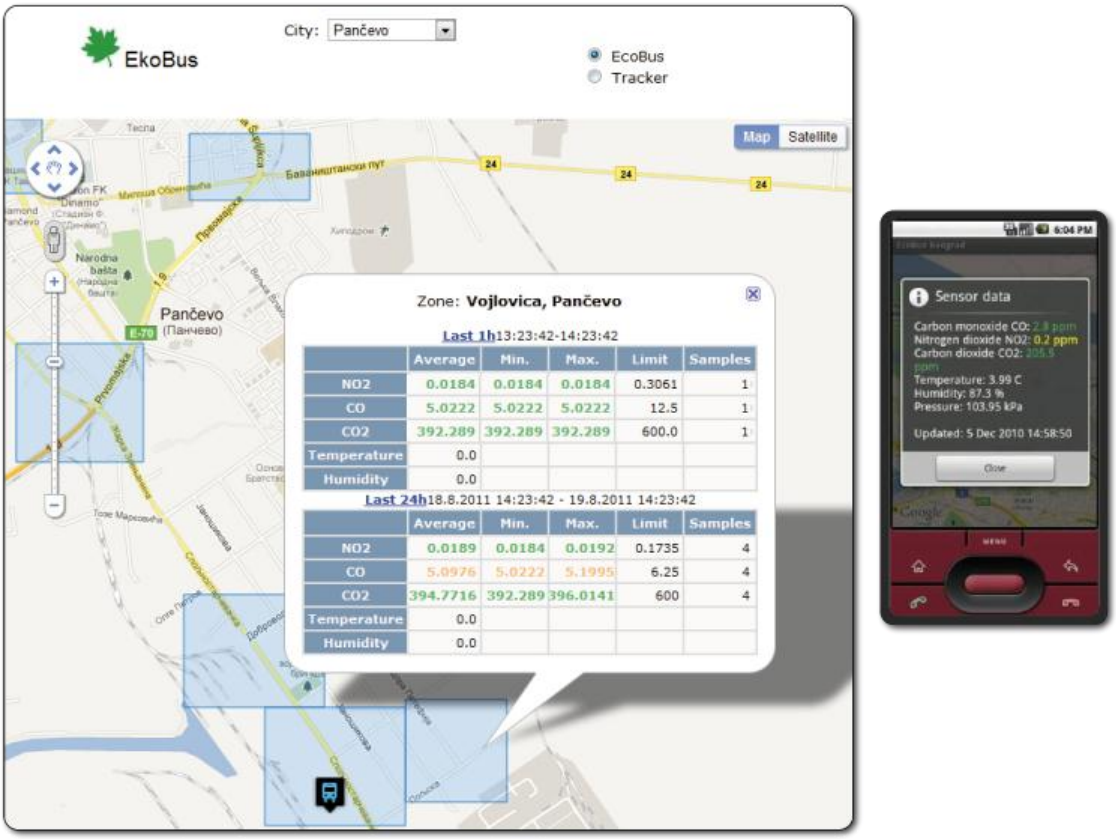

Figure 3 – Querying the environmental data from the interactive map using web and Android application (Source: Bielsa, 2012)

EcoBus is a pilot project, and is a part of a bigger project – the SmartSantander project that is being carried out in Belgrade, Guildford, Lübeck and Santander, exploring technologies to be used for environmental monitoring. This project "envisions the deployment of 20,000 sensors" in these cities (SmartSantander Project, 2012).

System48 project

Inđija municipality - one of the most advanced municipalities in Serbia

Another example, named System48, comes from Inđija. Inđija is a town and a municipality in the northern part of Serbia, about 40 km northwest from Belgrade, located on the intersection of two most important European corridors: Corridor 10 (highway E-75) and Corridor 7 (the River Danube). It covers an area of 385 km², and is inhabited by approximately 26000(town)/47000(municipality) people (Statistical Office of the Republic of Serbia, 2011).

In 2002, the municipality of Inđija made a strategic development plan, in which the improvement of local administration was among the first priorities. The administration started the installation of an integrated information system right away – essentially creating e-government platform – in order to enable all citizens to participate in solving local problems, as well as to facilitate their day-to-day communication with the local administration. A constant improvement of administration, elimination of red-tape and readiness to use technological solutions, have made the municipality of Inđija one of the most advanced municipalities in Serbia. Municipality of Inđija was awarded two times by FDI magazine (issued by Financial Times) in 2008 and 2012, partly because of its efficient administration.

System48 project

An important part of the Inđija's civic network is the System48. It is a municipal information system designed to improve cooperation between the local government, municipal departments, and public utility enterprises on one hand, and service recipients on the other. It allows citizens to easily report different issues, including those specifically relevant to environmental qualities: pollution incidents such as sewage leaks, improper disposal of waste, and similar. The inquiry can be sent online (using the text form, or pointing the location of the issue on the map), using SMS, phone or in person. In 48 hours, citizens are guarantied to receive a proper response, followed by action of the respective department if needed. In this way, citizens are encouraged to actively take part in municipal affairs. Furthermore, receiving a feedback assures citizens that the municipality government is actively listening to the public and working on solving problems.

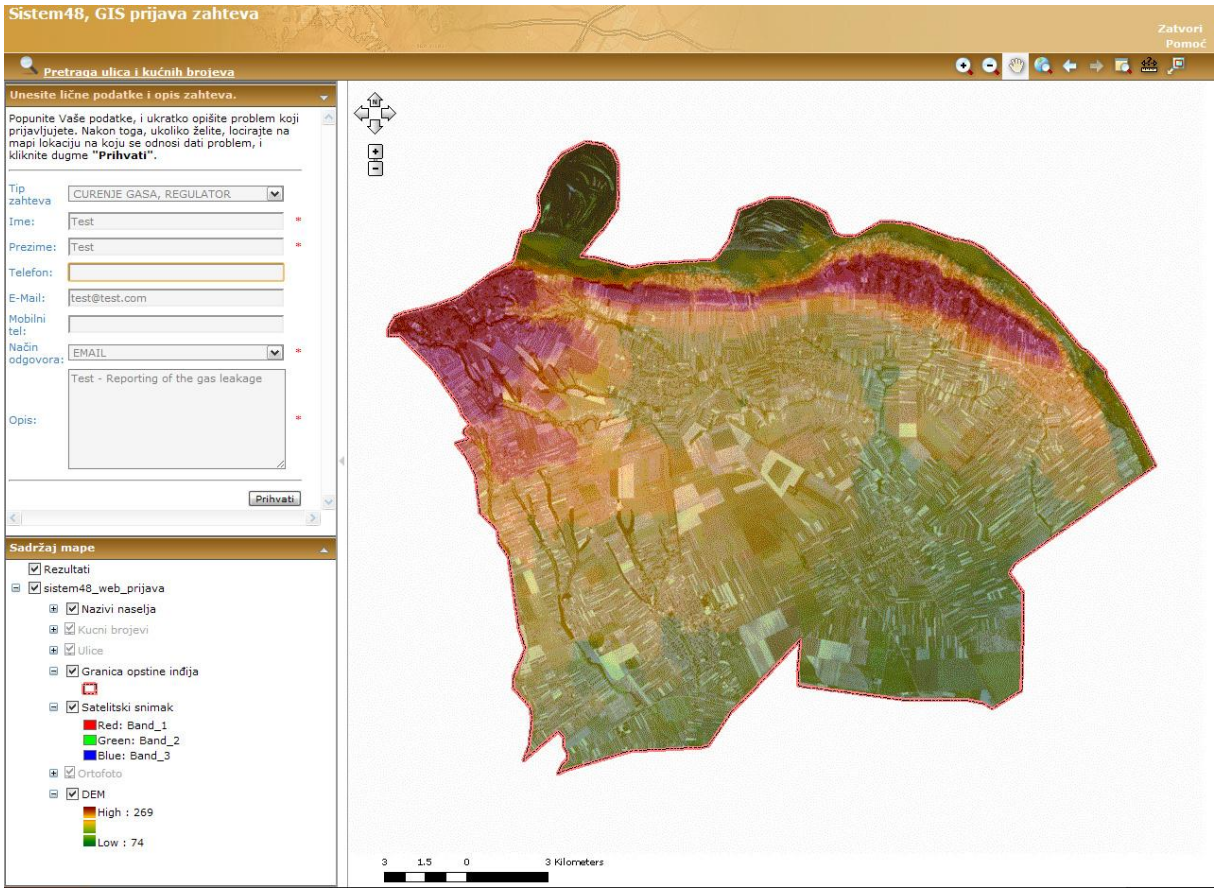

Figure 4 – Reporting an issue and pinpointing its location on the web-based map (Source: http://gis.indjija.net:7777/sistem_web_prijava/)

System48 can be used as a tool to identify the sources of pollution. Thus, it can also be viewed as a form of participatory sensing. This crowd-sourced data helps municipal service providers to define priorities, but also to receive a valuable feedback from public that can be

used for the planning purposes and evaluation of the existing planning measures. The value of the system for planning purposes rests within the stages of the on-going and post-project monitoring, as well as a means of securing relevant information on vulnerable sites, environmental quality, specific issues that require immediate planning responses, etc.

In the background of this system exists a service centre. All reported issues and feedback information are managed and stored in a single place. As soon as the issue is reported, operators in the centre route the information to the appropriate municipal authority or the public utility company. To make this system work, weekly meetings are held between the mayor, heads of municipal departments and executives of utility enterprises.

System48 is based on the similar CitiStat system, implemented in Baltimore, US (Microsoft, 2007). It is installed in 2004, and Inđija is the first urban area in Europe where such system was installed. By 2007, this system was used more than 6500 times (citizens inquires) (Microsoft, 2007), and by 2012 more than 15000 times. Since its implementation in the municipality of Inđija, System48 has been implemented in a number of other municipalities in Serbia.

What do these systems have in common?

These two systems are designed having different objectives in mind. EcoBus was designed to solve the problem of collecting current data about the air pollution over a large area. System48 was designed to foster communication between local government, municipal departments, and public utility enterprises on one hand, and citizens on the other.

However, though different in their objectives, these two systems have much in common. They both provide **information about specific location**, they are both **based on GIS**, and both provide different, but related information that is updated almost in **real-time**. They both offer **user-centric service** – EcoBus allows users to query specific data about air pollution and bus location, while System48 fosters a two-way communication between citizens and municipality government, and heavily relies on the input of its users. Finally, it is because of this user-centric approach that they both help **rise environmental awareness** among the population.

These systems are not part of the planning process yet. Though the data they provide is freely available, they lack a standardized interface, or the system itself has not been recognized as representative by the institutional bodies, as compared to the officially established measurement system. Their interface is crude and data obtained are not being officially verified. Therefore, we can observe it as an experiment, a set of emerging and promising tools that may become a standard part of planning methodology and tools planners use in the future. Yet, for the time being, they have not been integrated in the planning practice.

GIS is already an established tool planners employ, and it has proved itself useful for informed decision-making and spatial analysis. Therefore, it is important that solutions for monitoring the environmental quality produce GIS-compatible data. Both EcoBus and System48 comply with that criterion, as the data are visualised via web-based GIS application on the internet. However, at the moment, neither of them can export data to be utilized in other software packages.

3. Smart systems for planning practice

Implementation of smart solutions for monitoring the environmental quality, similar to those described here, can benefit the following:

- Data gathering, and
- Supporting public participation.

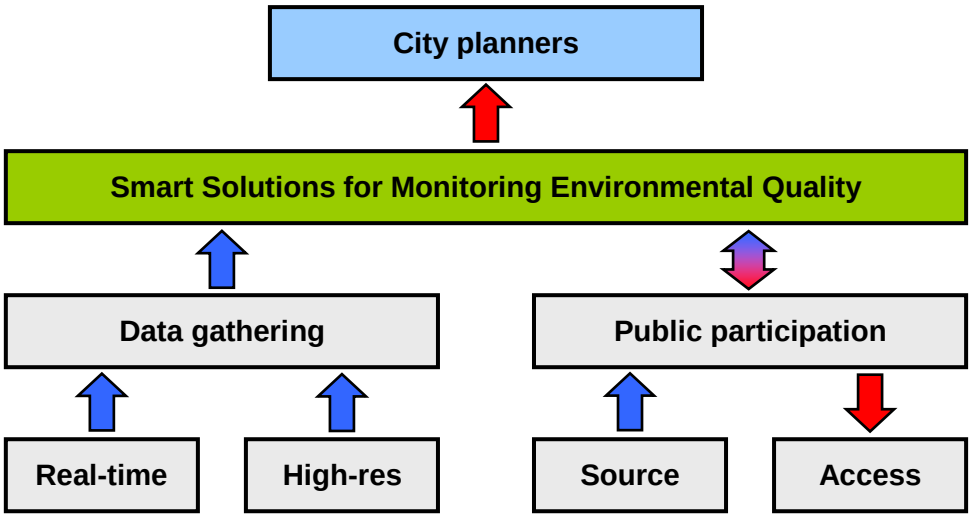

Figure 5 - Smart systems in planning practice (Source: Own work)

Data gathering

In order to produce a high quality output (i.e. plan), one needs a high quality input (i.e. information). Smart solutions can help acquire:

- The most current and up-to-date data, and
- Very specific and detailed data, i.e. spatial information.

High quality information is a prerequisite for the qualitative analysis of the state in the field, trends, development of accurate models, and precise impact assessments. All of these contribute to a better evaluation of different development scenarios, resulting in the better quality planning products. The high-resolution spatial information can expose the small-scale details relevant for making appropriate responses (e.g. small sources of pollution, or flow of the air pollution around the buildings), that might be otherwise missed if only the low-resolution interpolated data are used. They can also be used to support planning at a micro scale (e.g. urban design), which is often in need of detailed local data.

The real-time data can be very beneficial in defining priorities and in providing responses to problems that need immediate attention and quick reaction, when a potentially dangerous environmental situation is the case. The up-to-date information can be transmitted to the public in order to make them informed, or aware of what is going on in their communities. The real-time data are important in the on-going projects monitoring, e.g. control of the emissions during the course of construction, or in choosing an alternative sequence of actions for a project implementation stage, but also for the post-project monitoring. e.g., to verify the desired impacts of a plan, project, or new policy in question.

With recent developments in participative sensing[3] and massive deployment of sensors in urban areas (e.g., the SmartSantander project “envisions the deployment of 20,000 sensors in Belgrade, Guildford, Lübeck and Santander” (SmartSantander Project, 2012)) it is not unreasonable to imagine that very soon we will have an incredibly detailed and fine-grained data about our environment. Faced with such a huge amount of data, the interpretation of data relevant for decision-making becomes a key challenge planners will be faced with in the future. The development of algorithms that can filter such massive and diverse data, in order to figure out what are the patterns, and how the reality could be understood and explained in an unbiased way is a complex problem planners are challenged with nowadays (Presser, 2011)

The other potential problem with the crowd-sourced data is its verifiability. Since the data are sourced from public, their validation becomes a challenging task, as there is no governmental or other institution in Serbia to vouch for their accuracy.

Public participation

Aside from data gathering, the other important benefit arising from implementing smart solutions for monitoring environmental quality is the way they enhance public participation and environmental awareness of general public – local population in particular. "Sustainable planning practice implies public participation from the moment the process is started, and co-operation and partnership become *sine qua non* of a democratic process". (Dutton, 2003) In this regard, the smart systems work two-fold:

- Enabling public to access information, and
- Using public as a source of information.

Public participation demands that citizens are well informed, that the development process can be followed easily, and – one of the key requirements – that public has access to information, i.e. that the information realm becomes a public domain (Lalović, 2010). Access to environmental information enables citizens to personally participate in safeguarding their surroundings and in environmental protection. If the information is readily available, or presented to the citizens in a form that is easy to understand and use, then they can participate by making their own decisions that are environment responsible, e.g. responding to the rising emissions by giving preference to public transport over private automobiles.

On the other hand, engaging citizens in participatory sensing, i.e. not only as recipients but also as sources of information on the environment, in order to supplement government-generated data with more detailed data, can provide a valuable input for planning purposes. The same could be used for monitoring projects in progress, or as part of the post-project evaluation and analysis. Last but not least, the communication between citizens on one hand, and planners and local authorities on the other, which is being established in this way, helps people rebuild their trust in government, which is very much needed nowadays.

"Environmental issues are best handled with participation of all concerned citizens … States shall facilitate and encourage public awareness and participation by making information widely available." (United Nations, 1992)To facilitate public participation, it is necessary to raise public awareness, which can be achieved through formal education, seminars, campaigns or other means of communication with citizens, and closer cooperation with NGOs, and that needs to become a fundamental part of every national or local environmental strategy (Stalna konferencija gradova i opština, 2006).

[1] In late 1999, by The Municipality of Pančevo, UNEP, UNDP and Italian Province of Ravena.

[2] For a detailed list of polluting agents, see The Municipality of Pančevo (2004) *Local Environmental Action Plan for the Municipality of Pančevo, Summary Report*. Pančevo: The Municipality of Pančevo

[3] Examples of recent developments can be seen at: http://research.cens.ucla.edu/projects/2006/systems/urban_sensing/, http://research.cens.ucla.edu/areas/2007/Urban_Sensing/default.htm, http://senseable.mit.edu/copenhagenwheel/, and http://urban.cens.ucla.edu/projects/cyclesense/.

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