

## Smart Cities and Sustainability Models

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*In our age cities are complex systems and we can say systems of systems. Today locality is the result of using information and communication technologies in all departments of our life, but in future all cities must to use smart systems for improve quality of life and on the other hand for sustainable development. The smart systems make daily activities more easily, efficiently and represent a real support for sustainable city development. This paper analysis the sustainable development and identified the key elements of future smart cities.*

**Keywords:** *Intelligent Cities, Sustainability, Indicators, Regional Development, Intelligent Solution*

### 1 Introduction

Paper aims to analyze the models for sustainability cities development and to highlight the influence of new theologies.

The first part presents information about the sustainability and sustainability development. The second part is the analysis of models for sustainability cities development. The third part will present the necessity of use smart solutions in our society and will highlight the implication of these in sustainability development. The paper concludes with the presentation of the impact of smart solutions and how to use all their facilities for the sustainable development of cities.

Digital devices connected through the Internet, are producing a big quantity of data. And all this information can be turned into knowledge using the computational power. With this knowledge we can improve the efficiency, productivity and quality and on the other hand we can reduce costs and cut waste.

Around the world are highlights the potential of smart systems to facilitate sustainable development, economic growth, societal progress and improved efficiency.

European Commission, Europe 2020 program - a strategy for smart growth, sustainable and inclusive growth has identified three key factors for the crisis and preparing for the next decade of the European Union economy: smart growth (promoting knowledge, innovation, education and society digital), sustainable (competitive production with efficient use of resources) and inclusive growth

(increased market participation, skills and poverty reduction). Given, on the one hand, the key elements identified by the European Commission and on the other hand first priority axis of Regional Operational Programmer 2007-2013 consists of supporting the sustainable development of urban growth poles- think we can say that it is essential to consider the development of cities by adopting innovative, creative and intelligent solution in all economic fields.

In our age sustainability is a major global issue that requires urgent attention with the intensification of human activities that wantonly use natural resources and degrade the environment. The development of a sustainable community is one of the effective solutions. In specialty research [11], [12], [19], [20] definition of sustainability is related to the quality of life and efficiency.

The research will identified the basic areas to implement smart solution in the cities for sustainable development.

### 2 The sustainability concept

The concept of sustainable development may have different meaning by the context in which it is used. For this reason, we will present several descriptions of sustainable development that would include multiple aspects of this concept.

In the MACED [19] (Mountain Association for Community Economic Development) sustainable community development is the ability to make developments which respect

the relationship between the three elements: economy, ecology, and equity. So, we can say that the city sustainability is a multi-dimensional concept that includes economic, social and political dimensions.

To define sustainable development is better to start from Brundtland commission's report [20], which discuss this concept. The main idea is that the sustainable development is the kind of development, which satisfies the current needs without endangering the future generations to satisfy their own. This definition of sustainable development is the most frequently used in literature.

The sustainable development has in view the economic and social development but without disturb the environmental protection. The definition presented in the report of the Brundtland commission contains two essential concepts:

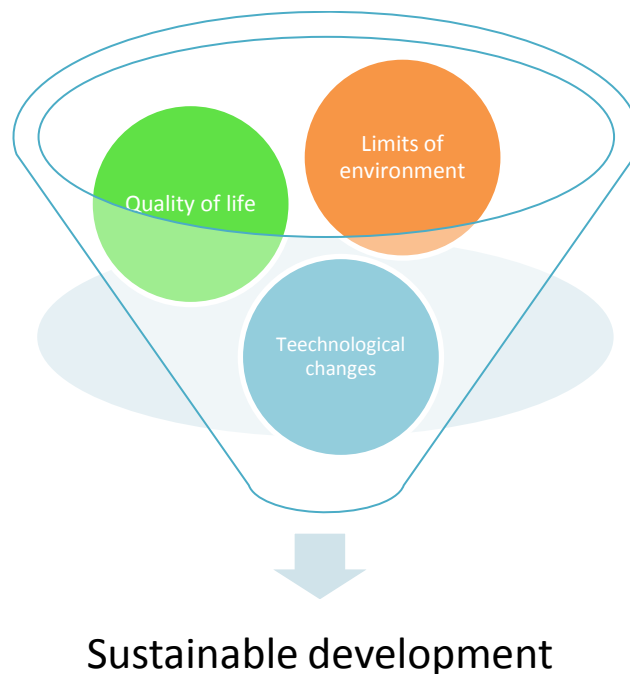
- 1) the concept of needs for everybody but especially the needs of the world's poor, which should be given priority;
- 2) the idea of limitations, if we start from the effect of technologies progress we will say

that we don't have limits, but on the other hand we must have in view the ability of the environment to satisfy present and future needs.

In our society is evidence that human activity has caused unprecedented environmental change, and population growth will soon stress the world's natural resources to the breaking point. Global warming, air pollution, land degradation, declining per-capita availability of fresh water, food shortages, and reduced biodiversity are some of the starkest challenges and here we found some limitations. Top priorities for cities include sustaining water, energy, and food supplies, managing water and reducing greenhouse gas emission.

The sustainable development concept has three urgent goals (Figure 1):

- a) to improve quality of life - it is the goal of development,
- b) to live in accordance with the limits of the environment – it is the goal of sustainability,
- c) to invest in technological progress.



**Fig. 1.** Goals of sustainable development

We can say that the goals of sustainable development are the same with the objectives of smart cities. We need to invest in our lo-

cality for improve quality of life. In smart cities technical progress is the support for a less consume of resources.

Cities have become the focal points of sustainable development because they represent major consumers and distributors of goods, services and on the other hand because of a large number of citizens. In our age, many cities tend to be large consumers of goods and services, but they don't have in view the limits of resources and technical progress.

### 3 Sustainability models

In literature we find different type of models, but before start to discuss about it we can split them in economical sustainability and ecological sustainability.

For the beginning in economical sustainability we must to say that the key assumption is that natural capital (fuels, minerals, etc) can be substituted by man-made capital in some extent (machines, buildings, knowledge, etc). The analysis is better to start with the essential assumption involved in the Solow/Hartwick approach. According to the definition formulated by them, we should think of sustainability as an investment problem, in which we must use returns from the use of natural resources to create new opportunities of equal or greater value. In this theory [10] if, for example, we cut down forests but build factories, we have a good result if the economic value of the new solution exceeds the economic value of the forests. In this theory the consumption is the most important indicator of welfare and on the other hand the amount of investment in produced capital (buildings, roads, knowledge stocks, etc.) that is needed to exactly offset use of non-renewable resources [4].

In ecological sustainability the key assumption is that natural capital (fuels, minerals, etc) are not substituted by man-made capital (machines, buildings, knowledge, etc). In this case [15] we must to calculate the area required to produce the resources consumed and to assimilate the wastes generated by the investment in produced capital. But this model has two problems. The first is the difficulty to quantify diverse resources as the unit of land area and second problem is that not all of resources are substitutable.

Using the hybrid model from economical and

ecological sustainability models Chang in 2010 highlight that are both individually necessary but insufficient conditions for sustainable development. The hybrid model suggests how much should be invest in man-made capital so as to keep consumption per capita constant. But this model shows that economical sustainability and ecological sustainability are both individually necessary but insufficient conditions for sustainable development.

We must to have in view the satisfaction who is one of the base elements of improve the quality of life.

$$sY = \left( \frac{\alpha}{g_A + g_S + \alpha} \right) (Y_R - a)R + nK$$

where:

- R - is an exhaustible resource like oil;
- $\alpha$  - is the parameter associated with renewable capital;
- YR - is the marginal productivity of non-renewable capital;
- a - is the cost of using non-renewable capital;
- n - is the higher the population growth rate;
- $g_S$  - is the rate of satisfaction;
- $g_A$  - is the rate of technical progress.

This equation suggests how much should be invest in man-made capital so as to keep consumption per capita constant and the increase of satisfaction in the same time. While the rate of technical progress and the rate of satisfaction are growing fast, we need to invest less.

If an economy has positive population growth rate, constant level of technology and less satisfaction ( $n > 0$ ,  $g_A = 0$ ,  $g_S < 0$ ), then the amount of investment in man-made capital needed to maintain per capita output at the current period level is more than the total Hotelling rents  $(Y_R - a)R$  - the maximum rent that could be obtained while emptying the stock resource [4].

If an economy has constant population, positive technological progress and the positive satisfaction growth rate ( $n = 0$ ,  $g_A > 0$ ,  $g_S > 0$ ), then the amount of investment in man-made capital needed to maintain per capita

output at the current period level is less than the Hotelling rents.

So we can say that cities with high rate of population growth and slow technical progress often face decreasing consumption per capita and satisfaction and have severely degraded environment. On the other part economies with positive population growth, technological progress and satisfaction progress could be a good solution for our society.

Having in view these models we can say that for a sustainability development we must to use less the non renewable resources and to produce using the smart solutions new resources. All of this will improve the quality of life which is the most important goal of our society.

#### 4 Smart systems

The smart system represents a real support for an urban development which will generate a sustainable development of our cities.

To improve the quality and performance of cities is recommended to involve all interested parties to implement efficiently smart systems. The city development depends on the hand by efficiently use of non renewable resource thought smart solutions and on the other hand by efficient use of smart solutions to produce renewable resource. In many countries the telecommunications systems infrastructure currently exists, but isn't use to the real value.

About 65% of the world population will be urban until 2025 [6], [7], [8]. Problems due to urbanization are becoming increasingly important and require smart solutions especially in the areas that are considered primary. Using smart systems to improve the quality of life of citizens, but also and more efficient consumption of natural resources deemed to be limited.

Research has focused on the study areas (Figure 2): education, health, transport and public administration.

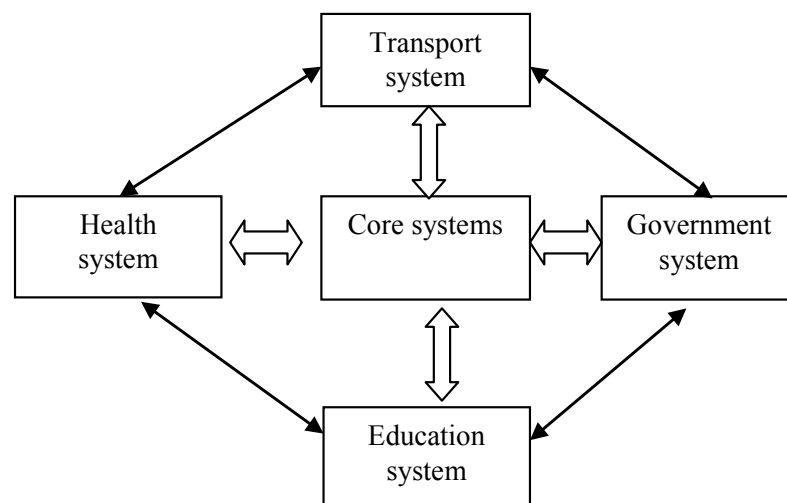


Fig. 2. The core systems of the smart city

Applications for an intelligent educational system are:

- data systems that collect, integrate, analyze and present information on key performance factors such as presence, knowledge and assessment criteria for school transfers;
- education cluster - to involve all stakeholders in the educational preparation of future generations;

- using cloud computing in schools each pupil or student can access the most advanced educational content, software and computing resources and storage.

Changes that occur each time and complexity of electronic technology society that uses a new type of electronic communication devices have resulted in continued growth in the volume [14], diversity and service activities carried out in any field.

The existences of an intelligent educational

system - focuses on the efficient use of existing infrastructure and modernize it where is necessary - considered crucial during an economic crisis when funds are needed for education [5]. But most importantly, a comprehensive education should refocus learning on the two key components of any system of education: student and teacher.

Through a smart educational system, according to the latest data published by IBM in 2010, [21], teachers can analyze student data electronically - from academic results, to information on mobility and presence. This information will help teachers identify individual student needs and to individualize instruction as to improve the process of their results, while retaining confidentiality. Smart systems are also ensuring that universities do not bear alone the burden of education but also to other interested parties.

An intelligent educational [22] system is based on three elements: interconnection (a resource sharing technology education), instrumentation (accumulation of necessary data) and intelligence (making decisions that enhance the learning process).

Applications for an intelligent transportation system are:

- Intelligent traffic management system;
- Intelligent system for the collection of all fees related to motor vehicles.

In Bari for example, using a smart application installed on fishing boats, local fishermen can immediately determine local fish markets. Directly from the boats, using touch screen systems, fishermen enter the type of fish and send it to markets [1].

Other examples for intelligent transport system [2]: a smart traffic system helped the city of Stockholm reduce traffic by 20%, reduce emissions by 12% and increase public transportation, in Singapore was introduced a smart card for all transport payments. So, we have the same card for parking, car tax and transport. In Singapore, introducing a Smart Card for all payments were merged which means parking, car tax and transport.

The smarter solution to healthcare is one that uses information to create real insight into patient care and organizational performance.

Healthcare providers, researchers and directors can work smarter by creating an electronic view of patient data. They can get real time visibility into how their operations are running. And they can use wider ranging sample data to achieve more medical breakthroughs.

Applications for an intelligent health system are:

- Intelligent system for data integration and its focus on the patient, so that each person have their own information and have access to a team of specialists who can work across the network. Electronic medical record - eliminating paper records made to reduce medical errors and improve efficiency;
- Intelligent system that connects doctors, patients and insurance companies;
- Electronic Bulletin of medical;
- Programming visit / consultation to electronic medical.

University Hospital Motol in Prague [13] - one of the largest health institutions in the Czech Republic completed the first implementation of Grid Medical Archive Solution Europe: a system that provides secure storage and archiving solution for the patients' medical records least 10 years.

Sainte-Justine Hospital in Quebec [22] are using automatic procedures for gathering, managing and updating critical data for research, often scattered in different departments.

Spain Public Health Service [2] has implemented a regional integrated system that allows patients to go to several health centers in the region, with the certainty that that doctor has access to the complete and updated patient data, thus making treatment faster and more accurately.

For a smart city we have need smart public services which improve the collaborating across departments and with communities. Across an entire world have many examples of smart solutions in public services for improve the quality and increases the benefits of citizens.

In the United Kingdom and Singapore, governments are educating citizens about mul-

tiple ways to obtain services and encouraging them to use new technologies [21].

Smarter government means collaborating across departments and with communities, helping to promote economic growth and at the most important level making operations and services truly citizen-centric.

Applications for government services:

- Intelligent systems for processing documents within the government;
- Intelligent system takeover suppliers' invoices, payment of taxes, public procurement tender for access to government services, business forms online;
- Electronic information services for citizens.

Through collaborating of all departments with communities the activities will become more transparent and accountable, the g can manage resources more effectively, and to give citizens access to information about decisions that affect their lives. Thought smart application each employee can to work with the same versions of documents.

## 5 Conclusions

The use efficient the resource using the smart solutions for a quality life is the main goal for sustainability development and four future cities. Our society today is more interconnected, intelligent and the non-renewable resource is positioned in the middle of it, because everybody tries to don't use this resource or to use efficiently this. In our age the sustainable development depends on the access to more and smarter solution. For smart and sustainable growth of a city is important to promoting a use more efficient of resource, a competitive economy and an economy base on knowledge and innovation. Having in view the models of sustainability we can say that for cities development we must to use efficiently the smart solutions. This will determinate less consume of non renewable resources and in the same time increases the produce of new resources like solar energy. All of this will improve the quality of life and the efficiency which are related with the definition of sustainability.

We can resume our research that for sustain-

ability development of cities in our day we must to use smart solution.

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## References

- [1] N.Y. Armonk, (2010, July 2) Italy's University of Bari Uses IBM System z Cloud to Help Local Fisherman Auction Day's Catch While Still at Sea, *IBM Corporation*, [Online], Available at: <http://www-03.ibm.com/press/us/en/pressrelease/32051.wss> [Accessed 26 July 2011].
- [2] B. S. Begawan, B. Darussalam, (2010, August 3) Let's Build a Smart Planet: Smarter Cities, *IBM Japan Green ICT Seminar*, 2010 [Online], Available at: [http://aimp.apec.org/Documents/2010/TEL/TEL42-DSG-WKSP2/10\\_tel42\\_dsg\\_wksp2\\_004.pdf](http://aimp.apec.org/Documents/2010/TEL/TEL42-DSG-WKSP2/10_tel42_dsg_wksp2_004.pdf) [Accessed 26 July 2011].
- [3] L. Bourdeau-Lepage, D. Kolarova, "Knowledge Society and Transition Economies", *Romanian Journal of Regional Science*, Vol. 2, No. 2, 2008, pp. 53-79
- [4] Y. Chang, (2010, May 3) Economic Models for Sustainable Urban Development, *Division of Economics and RSIS*, [Online], Available at: [http://www.globaltechalliance.org/Presentation%20slides/ChangYoungHo%20\(NTU\)%20Economic%20Models%20for%20Sustainable%20Urban%20Development%20\[Compatibility%20Mode\].pdf](http://www.globaltechalliance.org/Presentation%20slides/ChangYoungHo%20(NTU)%20Economic%20Models%20for%20Sustainable%20Urban%20Development%20[Compatibility%20Mode].pdf) [Accessed 26 July 2011].
- [5] S. Choenni, R. Walker, R. Bakker, W. Baets, "E-learning as a vehicle for knowledge management", *14th International Conference of Applications of Prolog INAP2001*, The University of Tokyo, Sanjo Conference Hall, Japan, Oct 20-22,

- 2001.
- [6] S. Dirks, C. Gurdgiev and M. Keeling, (2010, May 10) "How cities can optimize their systems for the talent-based economy," *Copyright IBM Corporation* 2010 [Online], Available at: <http://public.dhe.ibm.com/common/ssi/ecm/en/gbe03348usen/GBE03348USEN.PDF>
- [7] S. Dirks, M. Keeling and J. Dencik, "IBM How Smart is your city? Helping cities measure progress," *Global Business Services Government Executive Report IBM Institute for Business Value Copyright IBM Corporation*, 2009, [Online]. Available at: <http://public.dhe.ibm.com/common/ssi/ecm/en/gbe03248usen/GBE03248USEN.PDF> [Accessed 26 July 2011].
- [8] S. Dirks, M. Keeling, "A vision of smarter cities How cities can lead the way into a prosperous and sustainable future," *IBM Global Business Services Government Executive Report IBM Institute for Business Value Copyright IBM Corporation* 2009, [Online]. Available: <http://public.dhe.ibm.com/common/ssi/ecm/en/gbe03227usen/GBE03227USEN.PDF> [Accessed 26 July 2011].
- [9] G. Doukidis, N. Mylonopoulos, P. Athanasia (Nancy), „Social and Economic Transformation in the Digital Era” *Publisher Idea Group*, 2004, [Online], Available at: [http://books.google.ro/books?id=YdICTQsmxzQC&printsec=frontcover&dq=Social+and+Economic+Transformation+in+the+Digital+Era&source=bl&ots=TXmAFYV7e5&sig=VMUBQA7nVFH52dp0XRvcwn\\_KgOo&hl=ro&ei=HbFiS4efHdeJ\\_gbK6vDtAw&sa=X&oi=book\\_result&ct=result&resnum=1&ved=0CAwQ6AEwAA#v=onepage&q=&f=false](http://books.google.ro/books?id=YdICTQsmxzQC&printsec=frontcover&dq=Social+and+Economic+Transformation+in+the+Digital+Era&source=bl&ots=TXmAFYV7e5&sig=VMUBQA7nVFH52dp0XRvcwn_KgOo&hl=ro&ei=HbFiS4efHdeJ_gbK6vDtAw&sa=X&oi=book_result&ct=result&resnum=1&ved=0CAwQ6AEwAA#v=onepage&q=&f=false) [Accessed 26 July 2011].
- [10] J. M. Harris, "Basic Principles of Sustainable Development," *Global Development and Environment Institute*, 2000, Tufts University Medford MA 02155, USA [Online], Available: <http://ase.tufts.edu/gdae> [Accessed 26 July 2011].
- [11] T. B. Levent, P. Nukamp, "Quality of Urban Life: A Taxonomic Perspective", *Studies in Regional Science*, Vol. 36 (2006), No. 2 pp.269-281
- [12] P. Riganti, P. Nukamp, "The value of urban cultural heritage: An intelligent Environment Approach", *Studies in Regional Science*, Vol. 36, No. 2, 2006, pp. 451-469.
- [13] M. Vorisek, V. Kralikova, J. Rydval and M. Soucek, "University Hospital Motol in Prague Case Study," *Sectoral e-Business Watch*, 2008, [Online], Available at: [http://ec.europa.eu/enterprise/archives/e-business-watch/studies/case\\_studies/documents/Case%20Studies%202008/CS08\\_RFID\\_Motol.pdf](http://ec.europa.eu/enterprise/archives/e-business-watch/studies/case_studies/documents/Case%20Studies%202008/CS08_RFID_Motol.pdf) [Accessed 26 July 2011].
- [14] L. Yi-Chen, "Global information society: operating information systems in a dynamic global business environment," *Publisher Idea Group*, 2005, [Online]. Available at: [http://books.google.ro/books?id=9RbOjX9JS28C&pg=PA16&pg=PA16&dq=Global+information+society:+operating+information+systems+in+a+dynamic+global+business+environment&source=bl&ots=ui4s7EPFi5&sig=ukcz2gy1uruJKTUs\\_KIXIY9IVss&hl=ro&ei=tbBiS4nzNZmf\\_AaywNCDDBA&sa=X&oi=book\\_result&ct=result&resnum=1&ved=0CAwQ6AEwAA#v=onepage&q=&f=false](http://books.google.ro/books?id=9RbOjX9JS28C&pg=PA16&pg=PA16&dq=Global+information+society:+operating+information+systems+in+a+dynamic+global+business+environment&source=bl&ots=ui4s7EPFi5&sig=ukcz2gy1uruJKTUs_KIXIY9IVss&hl=ro&ei=tbBiS4nzNZmf_AaywNCDDBA&sa=X&oi=book_result&ct=result&resnum=1&ved=0CAwQ6AEwAA#v=onepage&q=&f=false) [Accessed 26 July 2011].
- [15] M. Wackernagel et al., "Tracking the Ecological Overshoot of the Human Economy," *Proceedings of the National Academy of Sciences*, 2002, pp. 9266–71.
- [16] Noua Ordine Mondiala a Educatiei – World Bank- [Online]. Available at: <http://mate.info.ro/News.aspx?ID=569> [Accessed 26 July 2011].
- [17] BECTA - Next Generation Learning, *Copyright Becta* 2008, [Online]. Available at: [publications.becta.org.uk/download.cfm?resID=37348](http://publications.becta.org.uk/download.cfm?resID=37348) [Accessed 26 July 2011].
- [18] The Future of the Internet Economy, *OECD Ministerial Meeting of the future of the Internet Economy*, Seoul, Korea,

- 17-18 June 2008, [Online]. Available at: <http://www.oecd.org/dataoecd/20/41/40789235.pdf> [Accessed 26 July 2011].
- [19] Mountain Association for Community Economic Development (MACED): Hart Environmental Data [Online]. Available: <http://www.subjectmatters.com/indicators/Sustainability/DefinitionsCommunity.html> [Accessed 26 July 2011].
- [20] Our Common Future: The Brundtland Report, [Online]. Available at: <http://anped.org/index.php?part=176> [Accessed 26 July 2011].
- [21] IBM Group - A planet of smarter cities, 2010 [Online], Available at: [http://www.ibm.com/smarterplanet/files/us\\_en\\_us\\_cities IBMCCA1043.pdf](http://www.ibm.com/smarterplanet/files/us_en_us_cities IBMCCA1043.pdf) [Accessed 26 July 2011].
- [22] IBM Group - Diagnosis for a smarter planet, 2009, [Online], Available at: [http://www.championsg.com/champion.nsf/ObjectsView/IBM\\_SmarterHLC\\_Diagnosis/\\$File/smarterplanet\\_healthcare.pdf](http://www.championsg.com/champion.nsf/ObjectsView/IBM_SmarterHLC_Diagnosis/$File/smarterplanet_healthcare.pdf) [Accessed 26 July 2011].



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