



# **PROPORTION & URBANISM & ENVIRONMENT**

**EDITED BY ANTÓNIO CASTELBRANCO & OKSANA TURCHANINA**

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# **Proportion & Urbanism & Environment**

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# PART 1

## RETHINK

### A New Transdisciplinary Intellectual Framework

### Moving Towards Sustainability

## Sustainable Development, an Intellectual Framework

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### Synthesis of Part 1

In order to deal with the new complexities, both in architecture, and the planning of urban settlements and their drainage basins, it is necessary to create a more inclusive intellectual framework and methodology than what is available now, which only conveys traditional reductionist approach to problems. Herein, we review some of the history and influences that have produced our current view of the world, or paradigm.

*“When I was born, the expressions and phrases which are to save humanity had already been written, one thing was missing: - to save humanity”.*<sup>1</sup>

Almada Negreiros

*“The causes of the collapse of Rome, were studied thoroughly, and one of the lessons that can be assimilated is that everything is connected to everything else, not only in its consequences, but also in its causes”.*<sup>2</sup>

Jane Jacobs

*“You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete”.*

Buckminster Fuller

### Introduction

The idea of saving mankind is a recurring theme in the history of civilization, the prophets of doom invariably based their theories on this assumption. However, the work presented here is not so much about the idea of the salvation of the humanity as such, but in the reinterpretation of our relationship with the environment that sustains us. At the beginning of this new millennium, humanity is, in environmental terms, facing unprecedented challenges. The pressures on the biosphere and on its ecosystems are at the root of the environmental crisis which is becoming undeniably evident with time.

Indeed, “in 1950 the world population was about three billion; after only fifty years the number has more than doubled. It was predicted and it is true that in 2008, 50% of the world’s population will live in cities”<sup>3</sup>. The population flow to the cities has further increased the pressure on the environment to the extent that in the cities, energy consumption is more pronounced. The resulting wastes and residues of these population concentrations now have large proportions. The result of the detachment of the urban population from the countryside and nature is the lack of understanding and the perception of the complexity of the cause/effect underlying environmental problems.

Therefore, it is the responsibility of planners and architects to design, build and implement the new or renewed urban areas in order to install and house these human flows. However, these projects will need to be executed/built according to a new holistic intellectual framework, which will insure their sustainability.



In this sense, the concept of sustainability and its understanding should be clearly defined.

In general, the term sustainability refers to the ability of an ecosystem of a corporation/firm or of any other system, to remain in operation for an indefinite period, without going into decay because of the exhaustion of its resources.

For Phil Hawes, “the term sustainability should be understood as the ability of a given culture to continue support the activities to which it is engaged; particularly in food production, in getting water, clothing, shelter, energy, health, transportation, education, and so on, to its citizens for an extended period of time - which can be measured in thousands of years - without destroying or seriously damaging the environment that gives it sustenance”<sup>4</sup>.

However, the definition most commonly accepted is one that was proposed in the Brundtland Report (the document entitled Our Common Future), which defines sustainable development as “development that meets present needs without compromising the ability of future generations to meet their own needs”<sup>5</sup>.

The significance of apprehending the concept of “sustainability” in terms of planning and architecture is fundamental for the further understanding of the following chapters.

Therefore, it is relevant to present and describe chronologically the set of events that are at the base/ origin of the concept of Sustainability.

From here, the logical sequence will be the development of an intellectual framework that may contribute to the theory and practice of sustainable architecture and urbanism.

Underlying the idea of sustainability - in the context of this book - is the concept of holism (a word that comes from the Greek word Holos, meaning “all, whole, entire”). In fact, this book intends to follow the concept of holism not only in its organizational scheme but also in the matters addressed here.

Holism is the theory that states that the properties of a system, whether it is an ecosystem of humans or other organisms cannot be seen, analyzed and explained solely by the sum of its components, i.e., in any complex system the whole is greater than the sum of its parts.

1.1 Carbon dioxide (CO<sub>2</sub>) and interdependence in the biosphere - the rules of the system

In architecture and in particular on the theme of building systems the term system presupposes the existence of a set of parts to which applies a set of rules are applied (“a kit of parts with a set of rules”<sup>6</sup>). This definition, despite its simplicity, is sufficiently informative and also applicable to living systems, whether natural or human ecosystems.

The concept of interdependence of systems has a particularly important significance when it comes to ecosystems, not only from the point of view of its strength and its longevity, but also the manner in which their relations unfold.

For example, the relationship between the emissions of CO<sub>2</sub> and the negative effects on the climate of the biosphere, “the greenhouse effect caused by burning fossil fuels was predicted by the Swedish chemist Svante Arrhenius in 1896 two years before the publication of Ebenezer Howard’s book, Garden Cities of To-morrow”<sup>7</sup>.

However, it took forty years for the issue to be raised, “the idea that mankind could change the climate by burning fossil fuels and releasing gases in sufficient quantities, was suggested by G. S. Callandar a British scientist, in 1938. No one took him seriously. It was only in 1957 that Roger Revelle, one of the leading American oceanographers, resurrects this idea, describing it with the name of ‘geophysical experience in large-scale. It was also in that same year

that David Keeling, a young American researcher at the Scripps Institution of Oceanography in California, set up a permanent carbon dioxide monitoring system, during the International Geophysical Year, thirty years later, that same unit, on top of Mount Mauna Loa in Hawaii, is still one of the most important sources of data for research on the greenhouse effect”<sup>8</sup>.

In 1972, the Club of Rome announced in its book, the Limits to Growth, that concentrations of CO<sub>2</sub> in the atmosphere will double.

“The atmospheric concentration CO<sub>2</sub>, observed since 1958 at Mauna Loa, Hawaii, increased steadily. Currently, the increase on average is 1.5 parts per million (ppm) per year. Calculations include the known differences of CO<sub>2</sub> between the atmosphere, biosphere, and oceans and predict that the concentration of CO<sub>2</sub> reached 380 ppm in 2000, an increase of about 30% of the probable value in 1860. The source of this exponential increase of atmospheric CO<sub>2</sub> is due to the increasing use of fossil fuels by humans”<sup>9</sup>.

Indeed, the US National Oceanic and Atmospheric Administration in its March 2007 report announced that “CO<sub>2</sub> concentrations in the atmosphere have reached the 387 shares per million”<sup>10</sup>, proving the accuracy of the estimates made in 1972.

The images of the melting of the Uppsala Glacier (Fig. 1.1, 1.2), are



Figure 1.1 - Glacier Uppsala, Patagonia, Argentina (Photo taken in 1928)

one of the most compelling evidence of climate change that have occurred in a short time.

James Lovelock, wrote: “us being, the only organized form of intelligence, we have the duty, if not the right, to take care of the Earth and to govern responsibly? But how can we manage if we do not know what it is? We must first ask: what is the earth? It may seem a trivial matter - everyone knows what the Earth is - but unfortunately this does not seem to be a common perspective. It is by seeing the Earth as a tidy affair that we tend to act like bacteria, never noticing the consequences of our unlimited growth”<sup>11</sup>.

Lovelock has had in recent decades, a remarkable influence in the field of environmental sciences and, in particular, the way we analyze the Biosphere as a system of complex relationships. In its research in the 60s, Lovelock observed a system that was, in terms of atmospheric chemistry, absolutely unstable - but still persisted for hundreds of millions of years. Having concluded that the control mechanisms underlying the functioning of the biosphere and the stability of its ecosystems should have something to do with one’s biological activity: Life.

In any case, the impact of human activities on the biosphere is noticeable and the international scientific community has warned us about climate change. Alerts consolidates itself in the climate

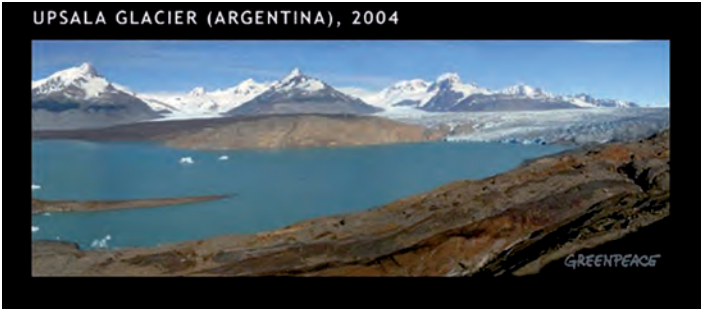


Figure 1.2 - Glacier Uppsala, Patagonia, Argentina (Photo taken in 2004)

record of the last 100 years, which indicate an increase from 0.5 to 1.0 ° C of global average temperature. In Portugal, the temperature is increasing about 0.45 ° C per decade since the 70's.

As can be seen, the scale at which the problems - generated by human activities in the biosphere - unfold transcends the old scientific methodologies, outlined in the XVIII and XIX centuries. Indeed, for the effective understanding of our surroundings other intellectual schemes are needed - in other words a new intellectual framework - that, when associated with highly sophisticated tools that can predict and give answers to environmental problems caused by human activities.

1.2 Consequences of perceived environmental impacts  
Conferences on the environment

The effects of population growth and the resulting pressures on the Earth's ecosystems began to be the subject of global concern in 1972 when the United Nations Conference on the Human Environment in Stockholm which resulted in the Stockholm Declaration. This statement was remarkable since it began the worldwide movement for the protection of natural ecosystems.

In 1987 the World Commission on Environment and Development published Our Common Future or the Brundtland Report<sup>12</sup>, (by Gro Harlem Brundtland, Norway's Prime Minister, who chaired this committee). It is a document which defines sustainable development as "development that meets present needs without compromising the ability of future generations to meet their own needs". It is further proposed new forms of international cooperation in order to guide policy and actions in order to make the necessary changes.

This report presents a critical view of the current development model in industrialized countries, followed by developing countries, in the case of a model that can be characterized by the excessive use of natural resources without considering the regenerative capacity of ecosystems.

The report also points to a series of measures to clarify the meaning of sustainable development, of which stand out:

- "The protection of ecosystems
- The use of new materials in construction;
- The restructuring of the distribution of residential and industrial zones;
- The use and consumption of alternative energy sources such as solar, wind and geothermal;
- The reuse of recyclable materials"<sup>13</sup>.

Twenty years later in Rio de Janeiro at the UN Conference on Environment and Development (UNCED, Rio de Janeiro in June 1992), was attended by representatives of developed and developing countries, and hence resulted in the agenda 21<sup>14</sup>.

In this document, the 190 signatory countries recognize that climate change and the greenhouse effect are the things that most compromise the stability of the Biosphere. Thus, the new conservation policies have become common responsibility to all signatories, and the main objective is to stabilize the concentration of gases causing the greenhouse effect in the atmosphere. But, despite having contributed to increased global awareness of the prevention of environmental degradation, Eco-92 highlighted the difficulty of implementing their proposals.

In 1997 in Kyoto, Japan, a new convention on the environment took place, which resulted in the Kyoto Protocol<sup>15</sup>. This paper presents for the first time, an agreement that binds the signatory countries to reduce their emissions of the gases that cause the greenhouse effect (carbon dioxide CO<sub>2</sub>, methane CH<sub>4</sub>, nitrous oxide N<sub>2</sub>O, hydrofluorocarbons HFC, perfluorocarbons PFC, hexafluoride SF<sub>6</sub>).

Signatory parties of this Protocol, industrialized nations, detailed in Annex B<sup>16</sup> (including Portugal) committed to reduce its emissions by 5.2% compared with their 1990 levels during the first commitment period 2008 - 2012. Despite not having reached an agreement on the significance of this item, the protocol establishes three "flexibility

mechanisms" that allow industrialized countries to meet the emissions reduction requirements, beyond their own territories. This means that by obtaining carbon credits (Certified Emission Reduction units, RECs) countries with an emission surplus can sell "carbon credits" among countries within the same carbon market.

Only two mechanisms correspond to Annex B countries: joint implementation and emission trading.

The third mechanism, CDM (Clean Development Mechanism), refers to projects that reduce or absorb greenhouse gas emissions in other countries other than where they were produced and that are not included in Annex I<sup>17</sup>, thus relating the industrialized countries listed in Annex II<sup>18</sup> with those who are in transition to a market economy, such as the Eastern European countries of which some have already joined the European Union.

In any case, with regard to Portugal, the Kyoto Protocol was ratified in May 31, 2002; and entered into force on February 16, 2005. Portugal committed not to exceed its emissions by over 27% as compared to 1990 levels for the period 2008-2012.

1.3 Environmental oriented experiences  
in planning and architecture

Indeed, in 1898 in London, Ebenezer Howard published, a book To-morrow, that was later published under the title of Garden Cities of To-morrow and was really the precursor of the integration of the city into the countryside concept. In his book, Garden Cities of Tomorrow, Howard argued the need to promote and strengthen a synergistic relationship between the rural/agricultural and the urban areas (with its small manufacturing factories, companies, schools, hospital, museum, library and a concert hall, as well as the houses, churches and gardens). Since the concept was designed to accommodate 30,000 people on 370 hectares (corresponding to 81 inhabitants / ha) in the area of the city center and 2 000 inhabitants in the agricultural part with 1 850 hectares (1.1 inhabitants/ha) devoted to agriculture and designed as permanent rural borders.

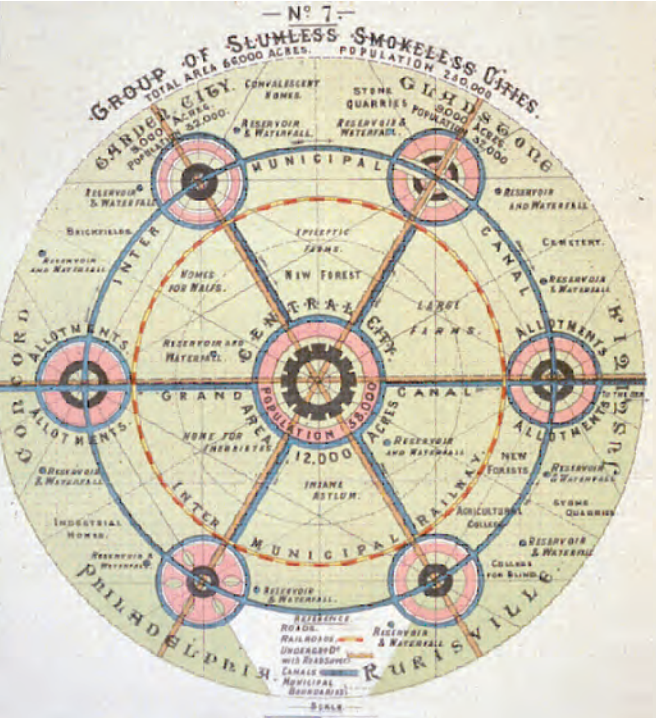


Figure 1.3 - Schematic drawing of the Garden City

The cities of Letchworth (1904) and Welwyn (1921) were designed and built following these concepts. However, none of these cautioned one of its basic concepts: that ownership of the land remained in the community, so that the increase in land value would revert to the community's own benefit.

Ebenezer Howard argues that for a city to be healthy, it is necessary for the healthy way of life of the countryside to be introduced in the city, so that the advantages of urban life, particularly with regard to culture, science and politics are sublimated by a stronger relationship with nature. In order to make this union - country / city



- viable Howard suggested and explained the functional and financial scheme for the Garden City (Fig 1.3.).

In any case, remembering the assumptions of Garden City, “probably the biggest similarity between the modern movements and concepts developed by Ebenezer Howard is the central theme of his work - in which the solution to the social question lies in the union of society the beauty of nature in order to create a more harmonious and fairer community. Howard saw the need for this synergy”<sup>19</sup>.

The concept of Garden City is undoubtedly one of the theoretical basis for Broadacre City project of Frank Lloyd Wright, in addition to being one of the reference architects of the twentieth century, he was also an educator who founded his own school of architecture: Taliesin (East & West). Wright designed a unique experience in architectural education and environmental awareness - the architect Paolo Soleri and Phil Hawes were both his students, although they do not consider themselves his followers in terms of urban planning.

In this inspiring environment Wright taught and built - with the help of his students - a building from local materials that integrates and

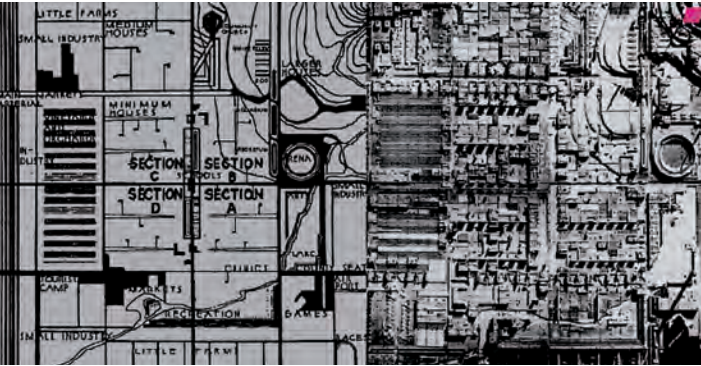


Figure 1.4 - Broadacre City design and mockup



Figure 1.5 - Perspective Broadacre City

diluted on its territory. A building that has become paradigmatic of environmentally and sustainable architecture.

It will be interesting to note that although Wright have had a particular sensitivity to the integration of architecture in its surroundings, the concept of Broadacre City (Fig. 1.4 and 1.5) is of urban sprawl in absolute, total dependence on the automobile therefore a proposal that from an environmental point of view, would not be sustainable.

Although, inspired from many of the teachings and experiences of Wright, Paolo Soleri addressed the issues of urban planning in a substantially different manner. While Wright recommends urban ideal with a heavy reliance on car use - as in Broadacre City - confirming the imminent expansion and urban sprawl, after the 2nd World War in America, Soleri chooses the concept of concentration and miniaturization. Indeed, in 1948 the two architects separated and followed different paths.



Figure 1.6 - Dome of Arcosanti



Figure 1.7 - Model overview of Arcosanti

In 1956, Soleri inaugurated Cosanti foundation, which started the works for the construction of Arcosanti (Fig. 1.6). This is a project for an experimental city, which (as in Bio-2) is also located in the Arizona desert. Arcosanti was designed according to the concept of arcology (meaning architecture + ecology) that he developed.

In Arcosanti, Soleri wanted to put into practice the theoretical principles of arcology. Arcosanti intended to become a mega-structure capable of housing and give sustenance to 5000 inhabitants, the equivalent of a small town (Fig. 1.7).

According to Soleri, this project aimed to improve the human condition and preserve the nature while functioning as a living organism<sup>20</sup>. Following the principles of miniaturization and complexity of the organization of the urban space, city allows a reduction by 98% of (compared with a typical American city) the space required to house the same amount of population.

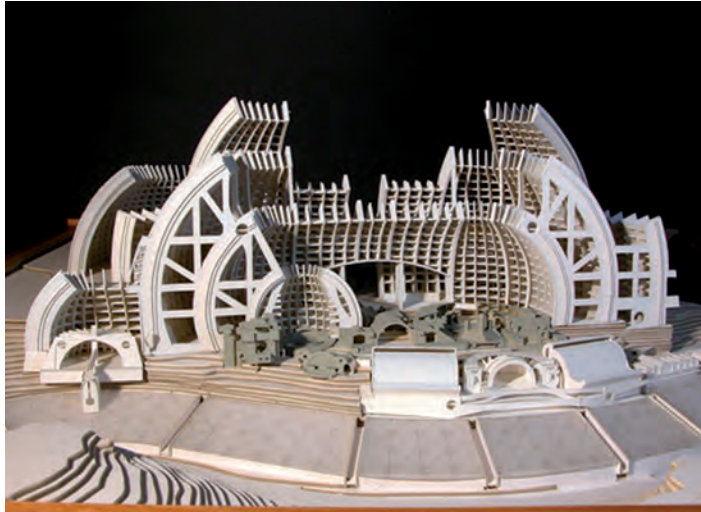


Figure 1.8 - Model of Arcosanti, the dark gray part of which is already built





Figure 1.9 – Aerial view of Arcosanti

In general, this large city planning incorporates the elimination of the automobile, by making use of sophisticated construction systems to enable a high density and therefore, a significant reduction in CO<sub>2</sub> emissions (Fig. 1.8).

From an architectural point of view, the design incorporates the principles of passive solar architecture and makes use of elements such as greenhouses and solar panels, thereby reducing energy consumption by about 20%. The rainwater is stored for later use, as is the recycling of water.

In any event, this experiment is far from reaching the dimensions devised by Soleri (Fig. 1.9).

The intention of this first Part was to address issues related to the evolution of thought and human behavior in relation to the world around us, and especially to our relationship with the Biosphere.

Lima de Freitas eloquently portrays the evolution of thought in the last sixty years “the planetary conflict began in 1939: suddenly everything changed. A great fear invaded the world. The destruction

of Hiroshima and Nagasaki put an end to two centuries of terrible illusions about a bright future made possible by science and technology, because now the scientific achievements brandished the scariest threat suffered by humanity. At the same time, we realized that the dizzying impression Faustian power inspired by the colossal machines and the gigantic technological achievements gave little by little place in the soul, the ‘civilized’, the feeling of an unspoken but profound crisis eroding inherited beliefs in scientific optimism and ‘progress’ of the last century. Awareness of ecological threat by the application of scientific methods arose”<sup>21</sup>.

It is further the Enlightenment / Rationalist thought that as we tried to illustrate, is the basis of a valid intellectual framework, which exceeded. It is also the basis for a kind of economic activity that is based on the extraction, exploitation and devastation. Environmental threats which appear are undeniable. Hence, the development of new business models are also needed to achieve the desired sustainability.

Therefore, “rational understanding of the world we live in has, over time, for us to perceive that the mechanistic rationalism, founded on the idea of exclusive man’s dominion over nature, was nothing more than a social construction of longevity weak”<sup>22</sup>. In this sense, we came to the conclusion that the amount and complexity of interdependent relationships that take place at the level of Biosphere justify the need for decompartmentalisation of knowledge.

The state of the art in terms of international agreements worldwide have contributed to a more rational management of the resources of the planet, which reveals the significance that they have - or may have - in terms of land planning, urbanism and architecture.

In 1780, in the development of a new scientific and philosophical methodology - what we called the intellectual framework of cataloging and the Enlightenment - Adam Smith wrote:

Reinforcing the importance of establishing a new intellectual

framework, this book intends to make a contribution to the theory of sustainable architecture and planning, applied to the North Drainage Basin Abrantes.

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<sup>11</sup> Lovelock J. (1991) Gaia a Prática Científica da Medicina Planetar, Instituto Piaget, p. 239.  
<sup>12</sup> Brundtland (1991) Nosso Futuro Comum / Comissão Mundial sobre Ambiente e Desenvolvimento. - 2 ed. - Rio de Janeiro: Editora de Fundação Getulio Vargas, 430 p.  
<sup>13</sup> Brundtland (1991) Nosso Futuro Comum / Comissão Mundial sobre Ambiente e Desenvolvimento. - 2 ed. - Rio de Janeiro: Editora de Fundação Getulio Vargas, 430 p.  
<sup>14</sup> Documento “Agenda 21 das Nações Unidas” da Conferência das Nações Unidas para o Meio Ambiente e o Desenvolvimento (CNUMAD), Rio de Janeiro, Junho de 1992.  
<sup>15</sup> Documento “Protocolo de Quioto” da Conferência sobre as Mudanças no Clima, Quioto, 1998.  
<sup>16</sup> Documento “Protocolo de Quioto” da Conferência sobre as Mudanças no Clima, Quioto, 1998 (disponível em [http://unfccc.int/essential\\_background/kyoto\\_protocol/items/1678.php](http://unfccc.int/essential_background/kyoto_protocol/items/1678.php); 23 de Agosto de 2009).  
<sup>17</sup> Ministério da Ciência e Tecnologia (disponível em <http://www.mct.gov.br>; 15 de Junho de 2008).  
<sup>18</sup> Ministério da Ciência e Tecnologia, Idem, ibid.  
<sup>19</sup> Parsons K. C. et al. (2002) City To Green City: The Legacy Of Ebenezer Howard, The Johns Hopkins University Press, Baltimore, MD, p. 205.  
<sup>20</sup> Lima A. (2000) Soleri Architecture as Human Ecology, The Monacelli Press, New York, p. 231.  
<sup>21</sup> Lima de Freitas J. (2005) Um Caminho Secreto Ensaios Inéditos, Hugin Editores, Lisboa, p.122.  
<sup>22</sup> Fadigas L. (2007) Fundamentos ambientais do ordenamento do território e da paisagem, Edições Sílabo, Lisboa

## Evaluation of the emission and absorption of CO<sub>2</sub> in DBNA

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### Introduction

Our Global Society is fragmented with respect to land use, to social structure, and to knowledge. Fragmentation is the result of the reductionism of the 18th Century Age of Enlightenment intellectual framework. Reductionism has achieved great advances in solving innumerable mechanistic problems, but since World War 2, the hyper-acceleration of human endeavour has exploded in all fields, and this has also resulted in excessive anthropogenic pressures on the Biosphere, observed at all levels of all ecosystems, verifiable through the pollution effects at all levels.

We, therefore, need to develop a new intellectual framework based on holistic principles and transdisciplinarity to provide a solid foundation for re-educating architects and planners, and to achieve true community sustainability. For this, we need an indicator tool for analysis and accounting and for sustainable planning of territories and their functions. In the following chapter we present a study case to illustrate the methodology developed for accounting CO<sub>2</sub> in a Drainage Basin north of the city of Abrantes, Portugal. This tool/indicator being the area's capacity to absorb/emit Carbon Dioxide (CO<sub>2</sub>). The dangers of emissions of greenhouse gases (GHG) and CO<sub>2</sub> in particular are universally accepted to convey the severity of anthropogenic pressures. Architects and planners have a duty and a responsibility to expand their understanding of what true sustainability means. They must create a holistic, transdisciplinary framework for both building design and for assuring a positive/symbiotic relationship between urban places and their corresponding drainage basins.

In general, Portuguese urban planners have been out detached with the issues that arise from complex interrelationships, such as those that make up the Biosphere. Consequently, they have failed to see and to design appropriate responses to planning issues from a holistic point of view, especially those that have to deal with truly sustainable planning.

In fact, these professionals have not yet understood that this is a task for which they ought to be responsible. Because in their job description, the urban planner is still considered to be a professional who works in the field of land planning with the purpose of making the use of a community's land and infrastructures more efficient. From this commonly accepted and reductionist definition, it becomes clear that this “job description“ is insufficient, and that it is necessary to develop the above mentioned intellectual framework and the tools which will enable them to overcome fragmentation.

Therefore, it is important for the urban planner to claim his role and responsibility in rethinking sustainability. For this to happen, he will have to resort to his inherent qualifications - those that differentiate him from other professions. This being the ability to visualize complex problems, and the interpretation of multileveled and interconnected issues.

Indeed, for an urban planner it is essential to foresee and plan the “future“. In order to plan for a sustainable future

it is also important to be imaginative, which is precisely the ability to imagine the future - a trait that characterizes the urban planner.

### 2.1 A brief overview on the theme of urban and territorial sustainability

*“In a holistic, regenerative, complex ecological system its autopoiesis or self-organizing characteristics serve to trim off the superfluous from that system”.*<sup>1</sup>

Phil B.Hawes, architect of the Biosphere 2

The Biosphere 2 project - in Arizona, USA - was a catalyst in the process of understanding the complexities of incorporating man-made environments into the natural world. Therefore, it is a prime example of an approach that corresponds to the concepts of transdisciplinarity and serves as a guide to understanding Earth's complex life support systems.

On the other hand, its architecture, organization, and interdependence of systems make it into an apparatus that goes beyond one or two

decades of useful research. Indeed, the presentation of this project - of its underlying concepts, and its operational systems - is intend to provide a specific example of both, the practical point of view (the importance of accounting and the mixture of atmospheric gases) and theoretical point of view (the understanding of an existing building that is based in a holistic intellectual framework).

As a testimony of the relevance of the atmospheric gases Linda Leigh, one of the scientists inside Biosphere 2, wrote (in 1992) in her logbook “In Biosphere 2 we have created an economy of carefully measured atoms: carbon, nitrogen, oxygen were the currency. Instead of rushing to a computer to view the Dow Jones or to my doorstep to retrieve the Wall Street Journal, I began my day by rushing to the computer screen to view updated graphs of carbon dioxide in the atmosphere and nitrates in the ocean inside Biosphere 2”<sup>2</sup>. Indeed, carbon was the major currency inside of Biosphere 2. In this small replica of the planet, the carbon dioxide in the atmosphere indicated if the system was operating in the red or in the black on a daily basis. Deficits and profits compound daily. This small world depended on careful daily measurements and management of all elements affecting the atmosphere.

One of the lessons learned from the Biosphere 2 project - that has a correlation with planning and design - is that CO<sub>2</sub> can be seen and used as a currency. In fact, the Kyoto Protocol (1995) is clearly based on this idea.

Indeed, the concepts and solutions developed for this project have many applications in both urban planning and architecture. Biosphere 2 features paradigmatic solutions that are synonymous with a transdisciplinary project. This project can also be seen as a contribution to the development of the much needed holistic intellectual framework, mentioned above.

This book also aims to contribute to the search of “specific solutions” in order to develop corresponding guidelines and tools that will allow planners and designers to better visualize and understand our Biosphere. In this sense, the idea of CO<sub>2</sub>, as an indicator and



Figure 2.1: The Biosphere 2 Project - Arizona, USA (Architect - Phil Hawes)



a design tool, is introduced to assess the sustainability of a given territory (DBNA).

For example, the relevance to the concept of the oneness of the ecosystems (or biomes as intended in the Biosphere 2 project) can be translated in terms of regional planning into an area defined as a drainage basin. The division of the land ought to be based on a holistic

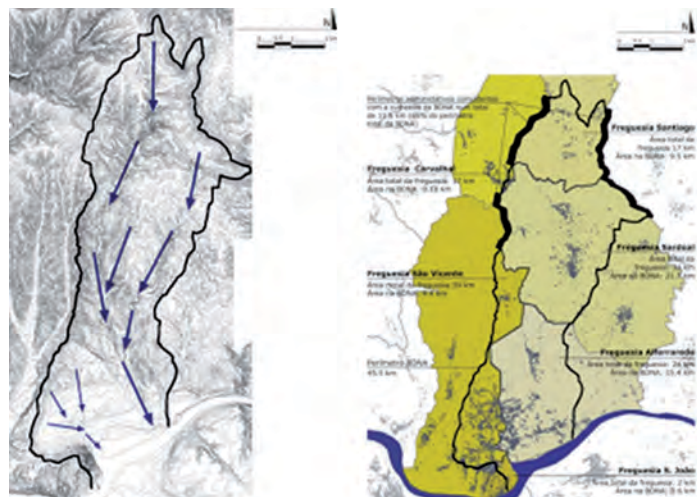


Figure 2.2 - The Drainage Basin North of the city of Abrantes (DBNA), Portugal (The black line represents the ridge, the blue arrows the water flow lines). The map of the administrative limits of the parishes that make up the DBNA

logic, and not on randomly or politically defined borders. Therefore, we argue for an integrated management, and an enhanced administrative system based on the territorial unit such as the drainage basin.

Thus, an area of 5 662 hectares corresponding to the Drainage Basin North of the city of Abrantes, which drains into the river Tagus, was selected as the study area for the implementation of some of the above mentioned concepts<sup>3</sup>.

In the process of research, it became apparent that current legislation - in terms of territorial and urban planning - does not take into account fundamental aspects for ensuring the sustainability of a given territory.

For example, it does not take into account the balance of CO<sub>2</sub> emissions within this territory. As one of the results, the planning of the territory will remain fragmented and dysfunctional with negative consequences for the environment.

In general, local authorities manage the territory without the vision or the necessary tools to ensure its sustainability, and in particular without a real understanding of the value of the territory in terms of CO<sub>2</sub> absorption.

We believe that taking into consideration the emissions and absorption of CO<sub>2</sub> on a given territory will add a holistic and transdisciplinary approach to the planning process. Thus enabling municipalities to plan and manage their territory in a more sustainable way.

*“...because it is not known how much we can perturb the natural ecological balance of the earth without serious consequences. It is not known how much CO<sub>2</sub> or thermal pollution can be released without causing irreversible changes in the earth's climate, or how much radioactivity, lead, mercury, or pesticide can be absorbed by plants, fish, or human beings before the vital processes are severely interrupted.*

*This ignorance about the limits of the earth's ability to absorb pollutants should be reason enough for caution in the release of polluting substances. The danger of reaching those limits is especially great because there is typically a long delay between the release of a pollutant into the environment and the appearance of its negative effect on the ecosystem”<sup>4</sup>.*

D.L. Meadows

*“In this paleotechnic world the realities were money,*

*prices, capital and shares: the environment itself, like most of human existence, was treated as an abstraction. Air and sunlight, because of their deplorable lack of value in exchange, had no reality at all”<sup>5</sup>.*  
Lewis Mumford

It is interesting that both these quotations are more than forty years old, however their contents are as actual today as they were then.

## 2.2 Evaluation of the emission and absorption of CO<sub>2</sub> in DBNA

This chapter intends to establish a base and a dynamic in order to account for the emissions of CO<sub>2</sub> in Drainage Basin north of Abrantes

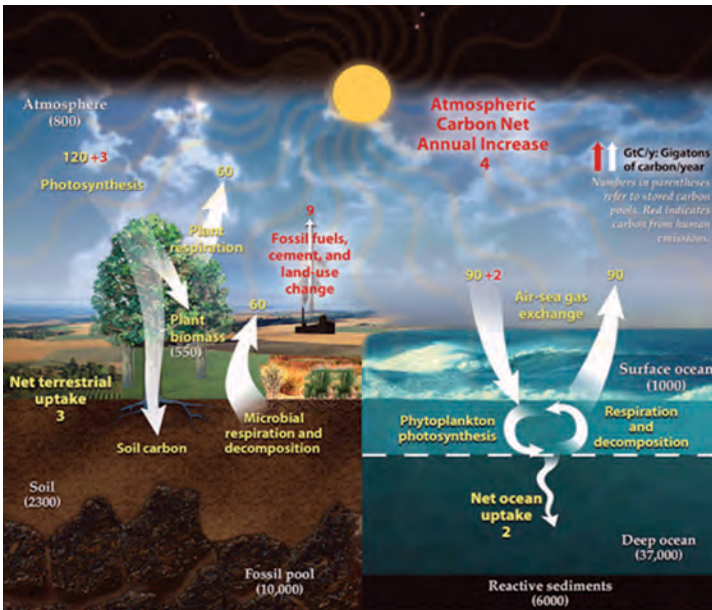


Figure 2.3 - The Carbon Cycle

(DBNA). Its objective is to verify the impact of its inhabitants in terms of CO<sub>2</sub> emissions larger to the area of the drainage basin itself.

In a succinct form, the cycle of carbon has the following components (fig. 2.3):

The natural CO<sub>2</sub> sinks, such as oceans, plants and other organisms from the process of photosynthesis, absorb CO<sub>2</sub> from the atmosphere, incorporating it in their biomass and releasing oxygen into the atmosphere. But the levels of CO<sub>2</sub> have been increasing and the sinks have not demonstrated the ability to maintain the same constant levels.

Research presented by the Science Magazine in June 2009, carried out by scientists at the Lamont-Doherty Earth Observatory of Columbia University - this observatory was also responsible for scientific research on Biosphere 2 - have shown that highest levels of CO<sub>2</sub> in the last 2.1 million years were on average 280 parts per million.

“However, current CO<sub>2</sub> levels are 385 parts per million, i.e. 37.5% higher than the above mentioned number. This means that in order for researchers to have an idea of the effects of this rise on the biosphere they have to go back even further in time to be able to find analogies with the corresponding levels to present climatic changes.

The reconstitution of the levels of CO<sub>2</sub> through the analysis of single-celled plankton shells buried in the Atlantic Ocean on the African coasts. The dating of this shells and measuring the percentage of boron isotopes allow us to estimate the CO<sub>2</sub> levels in the atmosphere back when this plankton was alive.

In any case, it is well acknowledged and there is no doubt regarding the seriousness of the situation of finding valid solutions to reduce the emission of greenhouse gases. It is, therefore, urgent to analyse and account for the damage that continues to occur.

## 2.3 Calculation Methods of CO<sub>2</sub> emission

The Protocol of Greenhouse Gases is the first tool for calculating and

accounting greenhouse gas (GHG) emissions.

The Greenhouse Gas Protocol (GHG Protocol) aims to develop a model of calculation and disclosure of greenhouse gas (GHG) emissions in the industrial sector, in the production of energy and other institutions. It is the most widely used and internationally accepted method of accounting of this type of gases. This method was developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD).

*The Kyoto Protocol lists six greenhouse gases:*

- “the carbon dioxide (CO<sub>2</sub>);
- the methane (CH<sub>4</sub>);
- nitrous oxide (N<sub>2</sub>O);
- perfluorocarbons (PFCs);
- the sulphur hexafluoride (SF<sub>6</sub>);
- the hydro fluorocarbons (HFC)”<sup>6</sup>.

In general terms, the Greenhouse Gas Protocol (Corporate Standard) has been proposing standards and guidelines for companies.

Table 2.1  
Tools for measuring the Greenhouse Gas Protocol  
for the Industrial Sector in 2009

Calculation Tool	Version of document
GHG emissions from stationary combustion	4.0 (Feb 2009)
GHG emissions from Purchased Electricity, Heat, or Steam	2.1 (Jun 2009)
GHG emissions from transport or mobile sources	1.3 (Jun 2009)
Emissions from employee commutes	2.0 (Jun 2006)
Measurement and Estimation Uncertainty of GHG Emissions	1.0 (Sep 2003)
Allocation of Emissions from a Combined Heat and Power (CHP) Plant	1.0 (Sep 2006)

Table 2.2  
Specific Tools of the Greenhouse Gas Protocol

Calculation Tool	Version of document
GHG emissions from the production of aluminium	2.0 (Mar 2008)
CO <sub>2</sub> emissions from the production of cement (US EPA)	1.0 (Aug 2002)
CO <sub>2</sub> emissions from the production of iron and steel	2.0 (Mar 2008)
CO <sub>2</sub> emissions from the production of lime	2.0 (Mar 2008)
CO <sub>2</sub> emissions from the production of ammonia	2.0 (Mar 2008)
CO <sub>2</sub> emissions from the production of cement (CSI)	2.0 (Jun 2005)
N <sub>2</sub> O emissions from the production of nitric acid	2.0 (Mar 2008)
HFC-23 emissions from the production of HCFC-22	2.0 (Mar 2008)
GHG emissions from pulp and paper mills	1.3 (Dec 2008)
N <sub>2</sub> O emissions from the production of adipic acid	2.0 (Mar 2008)

This protocol can also be applied to other types of organizations such as non-governmental organizations, government institutions, and universities.

In the tables below we can see the GHG Protocol tools that are used to account for these emissions in the industrial sector and in other specific situations.

In order to facilitate the process of quantifying and accounting emissions the following rules intend to:  
“1 Assist companies during the preparation of the GHG inventory that can represent a real and fair estimation of their emissions, through using similar principles and standardized approaches.  
2 Seek to simplify and reduce the costs of elaborating system of inventory of GHG.  
3 Provide companies with the necessary information, thus enabling them to develop an effective strategy in terms of managing and

reducing GHG emissions.  
4. Provide information to facilitate participation in voluntary and mandatory GHG programs  
5 Increase the rationality and transparency in GHG accounting and reporting among various companies and GHG programs”<sup>7</sup>.

Hundreds of companies all over the world use these guidelines and tools to manage their GHG footprint, develop new products and improve their energy efficiency.

In any case, the methodology which is proposed here divides emissions in three areas (or scopes) (fig. 2.4):

“Scope 1: Direct GHG emissions

Direct GHG emissions are from sources that are owned or controlled by the company; for example, combustion emissions from boilers, furnaces, vehicles of the company or subsidiaries, etc., as well as, emissions from the chemical production process equipment that belong to or are controlled by the company.

Scope 2: Indirect GHG emissions from electricity

The scope 2 accounts for GHG emissions from the generation of purchased electricity and its consumption by the company. The purchased electricity is defined as electricity that is purchased or brought from outside of company territory.

Scope 3: Other indirect GHG emissions

Scope 3 is an optional reporting category, which allows indicating all other indirect emissions. Scope 3 emissions are consequences of the activities of the company but occur from different sources that don’t belong or are controlled by it. Some examples of scope 3 activities are extraction and production of purchased materials, transportation of purchased fuels, and the use of the products and services that have been sold.

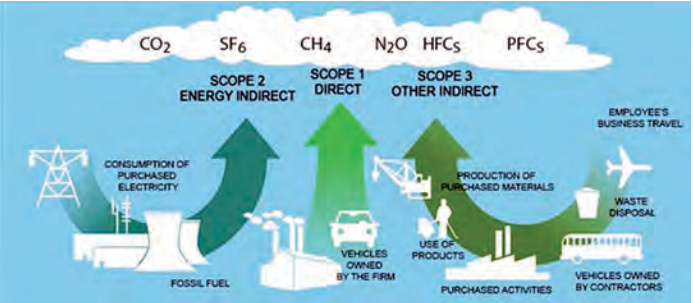


Figure 2.4 - Overview of scopes and emissions along the value chain.

Together, these three scopes provide a reference framework of comprehensive records, to manage and reduce direct and indirect emissions. Figure 2.2 offers a global view of the relationship between the areas and activities that generate direct and indirect emissions along the value chain of the company”<sup>8</sup>.

As we can see from the above mentioned, the Greenhouse Gas Protocol and corresponding tools, that are used for accounting for GHG emissions in highly complex situations (particularly in cities) lacks feasibility.

Another approach was presented by Comhar (December 2008), The Sustainable Development Council, Ireland, in their report. It suggests simultaneously combating the problem of climate change and high oil consumption. This should be done through a system of individual quotas of carbon ‘cap-and-share’, which proposes bounds and CO<sub>2</sub> quotas. This system can be implemented at regional, national or global levels.

The listed ideas and proposals reveal concerns not only regarding climate change/GHG emissions, but also the importance of conducting an intense research regarding practices and fair solutions to this problem.

In the table below (fig. 2.5) - published in the same report - you can see various accounting schemes for developing policies



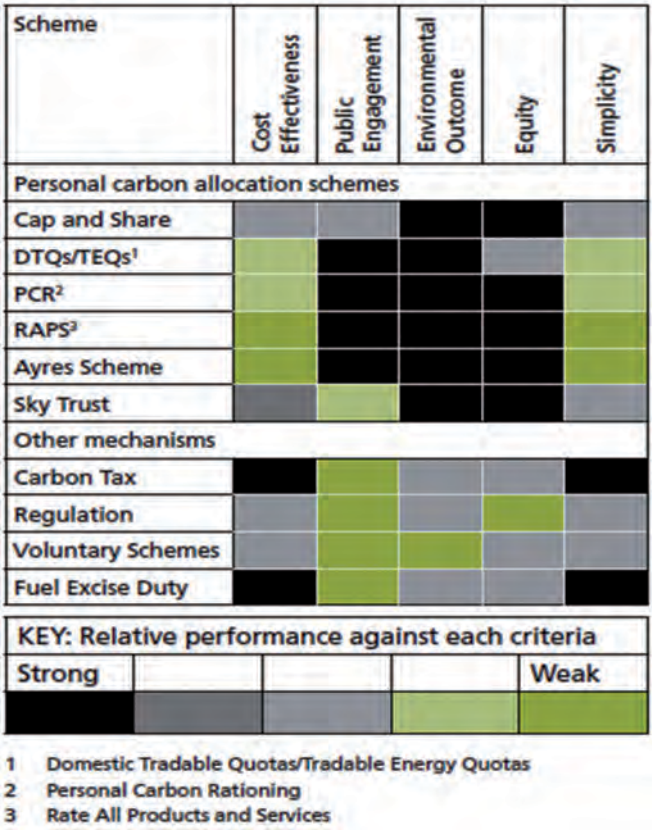


Figure 2.5 - Multiple accounting schemes of policy options that aim to reduce GHG emissions

that aim to reduce GHG emissions. These options vary from the assignment of personal carbon credits and taxes to the regulation aspects.

The methods are identified and assessed as to compare the merits of each method. It is interesting to see which five categories are

used to evaluate the methodology:

- 1 “Cost efficiency,
- 2 Public engagement,
- 3 Environmental outcomes,
- 4 Equity,
- 5 Simplicity”<sup>9</sup>.

These five categories could also be used to assess other GHG accounting methods (linked to planning/architecture), such as the method for measuring the ecological footprint, method that will be later discussed in this chapter. There are more methods for the calculation and accounting of CO<sub>2</sub> emissions (light and heavy automobiles and airplanes)<sup>10, 11, 12, 13</sup>, however, this methods do not give us a complete overviews of situations of great complexity (in particular cities and surrounding areas: or in the division of the territory into drainage basins).

In any case, in the following chapter, we will discuss the development of an accounting system that can contribute in a simplified and fast way, to verify the balance between emissions and CO<sub>2</sub> absorption in Drainage Basin North of Abrantes (DBNA). Thus seeking to promote greater sustainability in the use of resources and territory.

2.4 CO<sub>2</sub> Emissions in the DBNA (see pag. 18)

The problem of climate change must be understood as a transdisciplinary concern, origins of which can be traced in the consumption/ resource utilisation, thus being fundamental in accounting for emissions and evaluation of DBNA area. As we have already mentioned, the increase in the temperature of Earth’s atmosphere comes from increased concentrations of so-called greenhouse gases; in namely carbon dioxide (CO<sub>2</sub>) (fig. 2.6), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and Chlorofluorocarbons (CFCs).

The anthropogenic causes of CO<sub>2</sub> emissions are largely attributed to the use of the automobile and urban and domestic energy

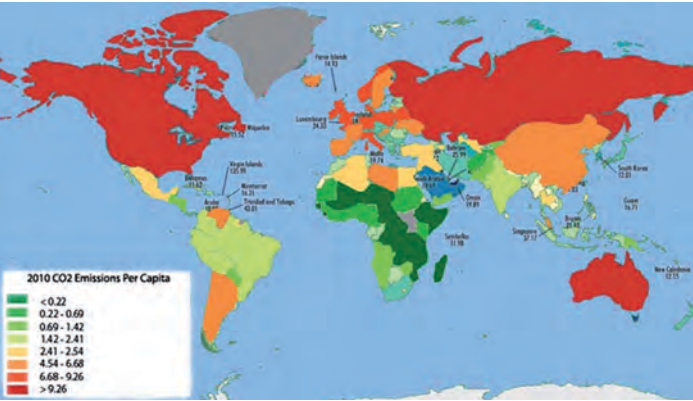


Figure 2.6 Map of the world in terms of CO<sub>2</sub> emissions

Table 2.3  
Carbon dioxide (CO<sub>2</sub>)  
in the world in 2000-2004

CO <sub>2</sub> EMISSIONS IN TONS PER CAPITA (UNFCC) <sup>14</sup>					
Years	2000	2001	2002	2003	2004
Germany	10,8	10,9	10,7	10,8	10,7
Hungary	5,8	5,9	5,8	6,1	5,9
Japan	9,9	9,7	10	10,1	10,1
Netherlands	10,6	10,9	10,8	11	11,1
Portugal	6,2	6,3	6,7	6,2	6,3
Romania	4,3	4,5	4,9	5,2	5,4
Spain	7,6	7,6	8	7,9	8,3
USA	20,8	20,3	20,2	20,2	20,4

Table 2.4  
Carbon dioxide (CO<sub>2</sub>)  
in the world in 2005-2012

CO <sub>2</sub> EMISSIONS IN TONS PER CAPITA (UNFCC) <sup>15</sup>								
Years	2005	2006	2007	2008	2009	2010	2011	2012
Germany	10.3	10.4	10.2	10.2	9.4	10.0	9.8	9.9
Hungary	5.9	5.9	5.8	5.6	5.1	5.2	5.0	4.6
Japan	10.1	9.9	10.2	9.5	9.0	9.4	9.7	10.0
Neatherlands	10.8	10.5	10.5	10.6	10.3	10.9	10.1	9.9
Portugal	6.6	6.1	5.9	5.7	5.4	5.0	4.8	4.8
Romania	4.5	4.7	4.7	4.5	3.8	3.7	3.9	3.9
Spain	8.4	8.1	8.1	7.4	6.4	6.1	6.0	5.9
USA	20.2	19.8	19.9	19.1	17.5	18.1	17.5	16.7

consumption, i.e. the efficiency of planning and architecture (in terms of energy).

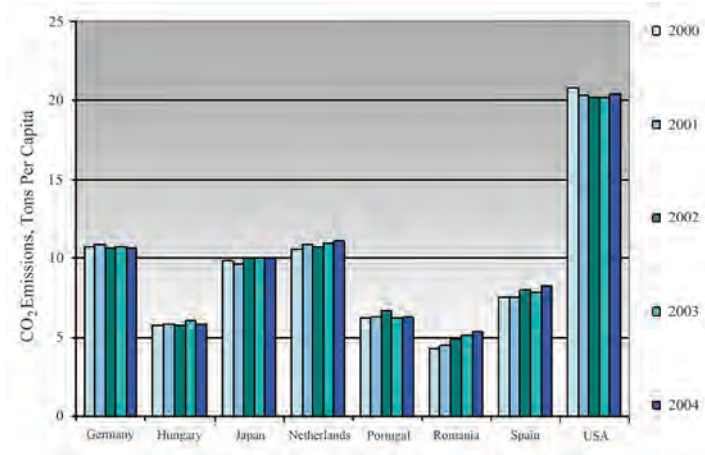
According to the paper written by A.S. & Korovin G.N. , Atmospheric Studies Program in Russia, the molecule of CO<sub>2</sub> remains in the atmosphere for two and a half years, later being absorbed by terrestrial or marine ecosystems.

In any case, on a global scale the numbers are undeniable and prove the seriousness and the size of the emission of carbon dioxide (CO<sub>2</sub>) (tab. 2.3, chart 2.1).

It is interesting to verify that in the span of 12 years (2000-2012) all 8 countries mentioned in these tables have maintained or lowered their CO<sub>2</sub> emission rates.

Chart 2.1

Carbon dioxide emissions between the years of 2000 and 2004 (per capita in tons per year)



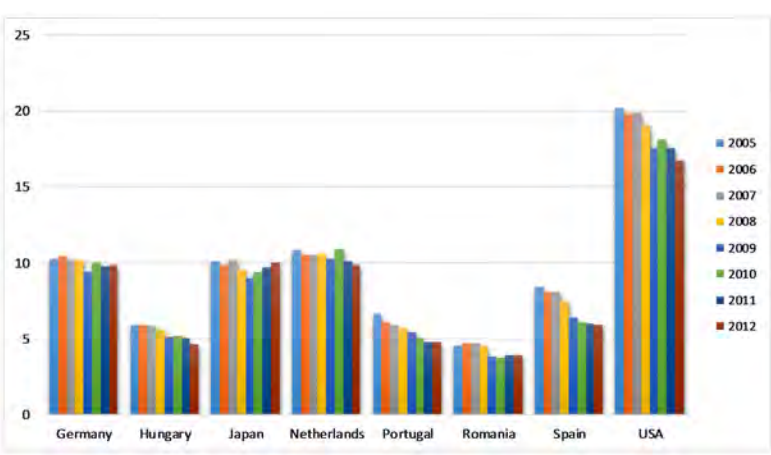
When combining Charts 2.1 and Chart 2.2 it is clear that countries that have had the most significant decreases in CO<sub>2</sub> emissions between 2000 and 2012 are:

- Portugal 23% less CO<sub>2</sub>
- Spain 22 % less CO<sub>2</sub>
- USA 20% less CO<sub>2</sub>.

In any case, in 2006, the figures and numbers which were presented in the Monthly Summary Statistics, a study prepared in August 2006 by the Office of Strategy and Studies of the Ministry of Economy and Innovation of Portugal, pointed out the release of 5.73 tons of CO<sub>2</sub> emissions per capita, a number that is close to the number presented on table 2.3 which in 2004 was approximately 6.3 tons of CO<sub>2</sub>.

Chart 2.2

Carbon dioxide emissions between the years of 2005 and 2012 (per capita in tons per year)



In DBNA the CO<sub>2</sub> emissions of major impact come from:

1 - Natural causes:

- Forest fires;
- Decomposition of biomass;
- Respiration.

2 - Human activities:

- From energy production;
- Use of internal combustion vehicles.

In calculation process of CO<sub>2</sub> emissions in the DBNA area above-mentioned factors were selected due to the fact that they are the biggest contributors to higher levels of emissions.

2.4.1 Forest Fires

To start with the issue of fires in Portugal: thousands of hectares of forests are burned each year. On satellite image shown below (fig. 2.7), August 2003, it is important to note the magnitude and dispersion (marked red) of the forest fires in the municipalities of Abrantes, Sardoal and Adjacent. Indeed, this year marked the record number of 14 053 hectares of burned forest in Abrantes region. Note the grey smoke caused by fires covering a large area north of these municipalities (fig. 2.7).

Forest fires have different origins; however, Paulo Almeida believes that in Portugal “If the forest is managed negligently, therefore it is not surprising that the main cause of the fires is the same negligence”.

This neglect manifests itself at various levels, and both the Report of the Municipal Plan (PDM) of Abrantes and the regulations, refer to forest as an area for wood production and not as a fundamental and complex ecosystem supporting human activities.

Indeed in Chapter 4 of Municipal Plan of Abrantes, it points out that one of the objectives of planning “is just to define possibilities of different types and species of trees in the county of Abrantes”. This is a deeply reductive perspective of the importance of forest ecosystems. Quoting from the same report:

“Ecological vector:

- *Natural soil resources.*
- *Soil capacities.*
- *Ecological values.*
- *Risks of erosion.*
- *Slopes”.*

From this list it appears that the issues that are relate to:

- the forest fires or its prevention;

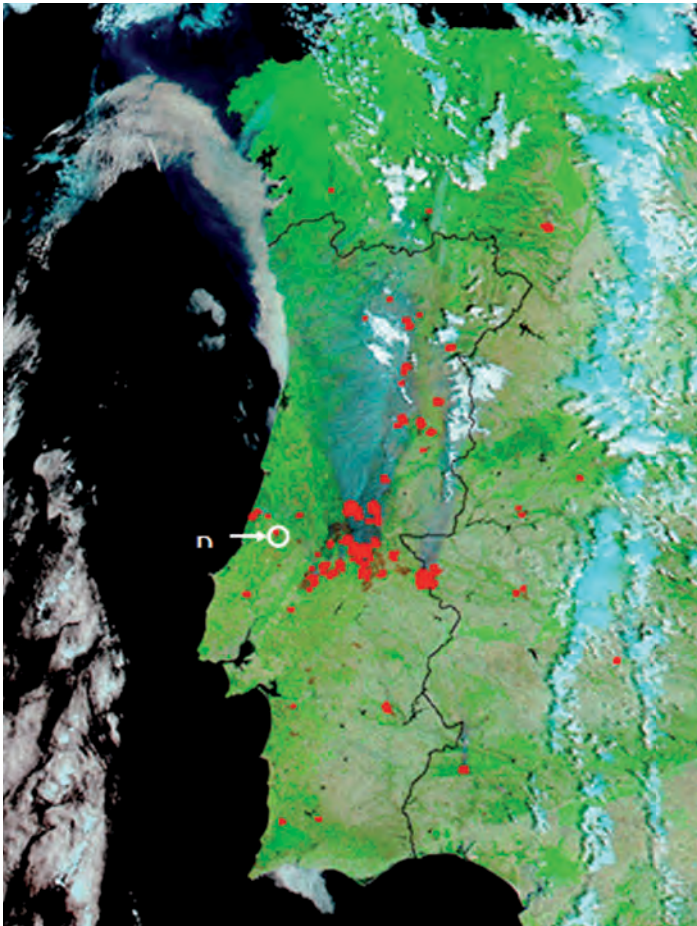


Figure 2.7 - Forest fires in Portugal, August 2003



- the specifics and the relevance of the ecosystems;
  - the importance or accounting of forest areas as CO<sub>2</sub> sinks;
  - problems related to the pollution of forests and the water lines or;
  - the landscape scenic interest of the forested areas
- do not deserve any attention in this report.

The above-mentioned Agro-Forestry Planning Proposal adds two definitions of forest areas:

1 “Area of Forest Production (MPA) is an area occupied with eucalyptus and pine trees, in soils of the sub-classes of ability Ds, Eh, Es (low quality soils)”

2 “Protected Forested Area that consists mainly of cork oak”.

This confirms that the PDM (Plano Diretor Municipal) - The Magna Carta of administration and territorial management - also shows negligence for not implying a more holistic and integrated management of the territory, particularly in regards with forest areas. The DBNA wildfires have had severe impact, not only from an economic point of view but also on the environment.

In the picture of DBNA, August 2003 (fig. 2.8), you can see the size of the cloud of smoke caused from combustion of forest biomass, during one of the fires that hit this area.

In the picture (fig. 2.9) you can see consequences from the fire shown in the picture. Results are massive, leaving behind only the trunks of trees, since all the undergrowth was destroyed.

The Cork Oak (fig. 2.10) - as long as cork/bark isn’t removed - has the ability to resist high temperatures that occur during forest fires. Indeed, the insulating qualities of the cork of the tree in the Figure 2.10 allowed it to have survived the fire. The cork oak tree in this image is resuscitating after having suffered the above mentioned forest fire.



Figure 2.8 - DBNA photo view from the Castle of Abrantes



Figure 2.9 - Image of devastation in August 2003



Figure 2.10 - Photo taken on the Ridge West of DBNA

On Fig. 2.11 in red we can see the areas burned down in last ten years in DBNA and surrounding areas.

In the following table (tab. 2.5) we can see that the number of fire

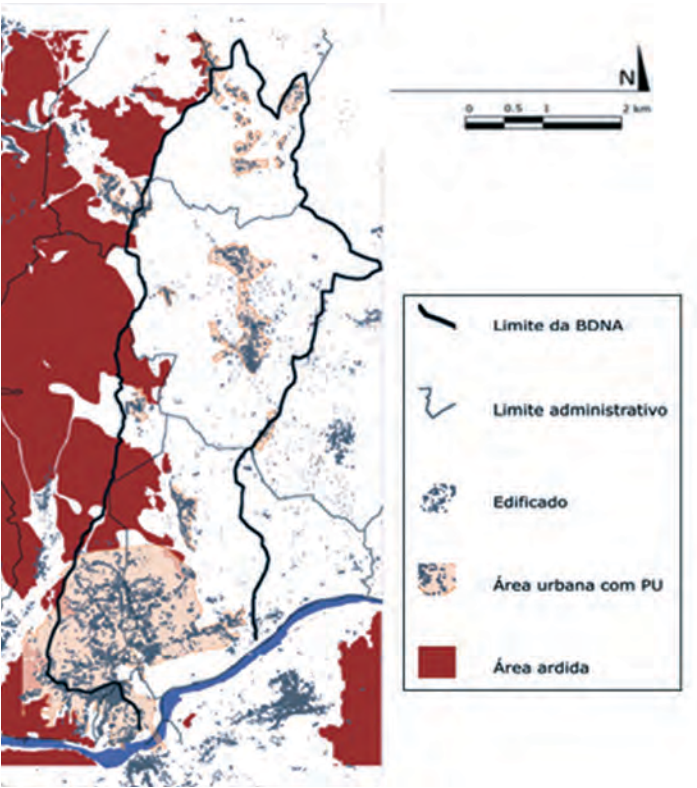


Figure 2.11 - Map is created using data provided by the Civil Protection of Abrantes

occurrences is not necessarily related to the number of hectares burned; for example, in 2003 there were 72 fires that resulted in 14 053 Ha of burned areas, where as in 2000 twice as many occurrences resulted only in 850 Ha of burnt areas (chart 2.3). In order to account for the degree of natural CO<sub>2</sub> emissions, we need to consider the following parameters:

1 - In an area of 10 m<sup>2</sup> (3.3 m x 3.3 m) of Mediterranean forest



Table 2.5  
Summary Table of the Burnt Areas  
in the Municipality of Abrantes  
(Abrantes Civil Protection)

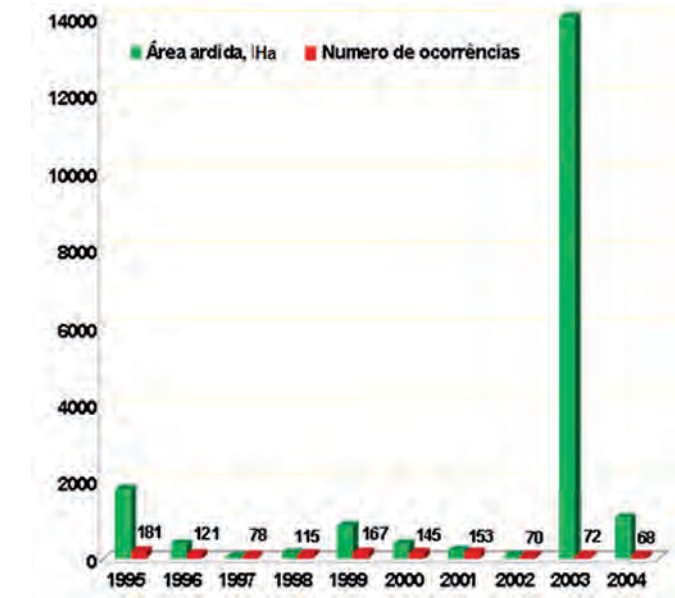
Year	Burned Area (Ha)	Nº of occurrences
1995	1 800	181
1996	382	121
1997	66	78
1998	147	115
1999	850	167
2000	381	145
2001	218	153
2002	83	70
2003	14 053	72
2004	1 069	68
<b>TOTAL</b>	<b>19 049</b>	<b>1 170</b>

approximately 50 kg of biomass will be burnt; 1 kg biomass corresponds to emissions of 1.83 kg of CO<sub>2</sub>. Thus, in this type of Mediterranean forest a forest fire would, approximately, consume 50 000 kg of biomass which corresponds, in average, to the emission of:

50 000 kg/Ha x 1.83 kg de CO<sub>2</sub> =  
91 500 kg CO<sub>2</sub>/Ha = 91.5 tons of CO<sub>2</sub>/Ha.

2 - The sum of the areas consumed by forest fires in the municipality of Abrantes in the last 10 years totals 19 049 Ha. We calculated that during this time, on average, 1 905 Ha were burnt per year. This corresponds to the emission of 1 743 075 tons of CO<sub>2</sub> per year.

Chart 2.3  
Evaluation of burnt areas  
(1995 - 2004)

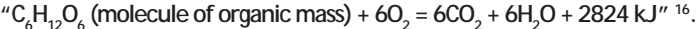


1 905 Ha x 50 000 kg/Ha x 1.83 kg de CO<sub>2</sub> =  
= 1 743 075 tons of CO<sub>2</sub> per year.

At the same time, the area burned within the perimeter of the DBNA, is in the order of 170 hectares of forest per year, which corresponds to approximately 15 555 tons of CO<sub>2</sub>/year.

170 Ha x 50 000 kg/Ha x 1,83 kg de CO<sub>2</sub> =  
= 15 555 tons of CO<sub>2</sub> per year.

We chose not to count the amount of CO<sub>2</sub> emissions caused by decomposition of biomass from other natural causes. However, this value can be calculated by the following formula:



In addition to the combustion of biomass in forest fires, we also need to consider the use of wood for domestic heating. In DBNA the use of firewood is remarkable. However, in this case “(...) firewood is different from fossil fuels, such as, oil and gas, because these processes are naturally balanced. The term ‘renewable’ refers to the fact that trees recycle CO<sub>2</sub>. During its growth, the tree uses the CO<sub>2</sub> present in the atmosphere as a carbon source to build its structure. This carbon is about half the weight of the wood. When wood is burned the CO<sub>2</sub> is released back into the atmosphere. However, a similar amount of CO<sub>2</sub> would be slowly released if the tree dies and is rotting in the forest ground.

As a result, the heat produced by burning wood in fireplaces does not significantly contribute to the problem of climate change, unlike when using oil. Consequently, wood is a renewable fuel if it is reproduced through sustainable forestry practices”<sup>17</sup>.

2.4.2 Value of CO<sub>2</sub> Emissions from Human Respiration

“CO<sub>2</sub> emissions caused by human respiration correspond to 619.4 kg of CO<sub>2</sub> per capita/year, which is equivalent to 316 m<sup>3</sup> per capita/year CO<sub>2</sub> “. Whereas the DBNA has 14 000 inhabitants, the corresponding CO<sub>2</sub> emissions are:

14 000 x 619.4 kg = 8 671 600 kg CO<sub>2</sub>/year =  
= 8 672 tons of CO<sub>2</sub>/year.  
1 (m<sup>3</sup> of CO<sub>2</sub>) x 1.96 \* (kg/m<sup>3</sup>) = 1 kg of CO<sub>2</sub>.  
316 m<sup>3</sup> of CO<sub>2</sub> x 1.96 kg/m<sup>3</sup> = 619.4 kg of CO<sub>2</sub>.  
14 000 x 316 m<sup>3</sup> = 4 424 000 m<sup>3</sup> of CO<sub>2</sub>/year.

(\* “whereas the density of Carbon dioxide is 1.96 (kg/m<sup>3</sup>)”).

Note: “through respiration process a human consumes 368 m<sup>3</sup> of oxygen

per year, which is equal to 525 kg of oxygen per year”, the corresponding formula follows:

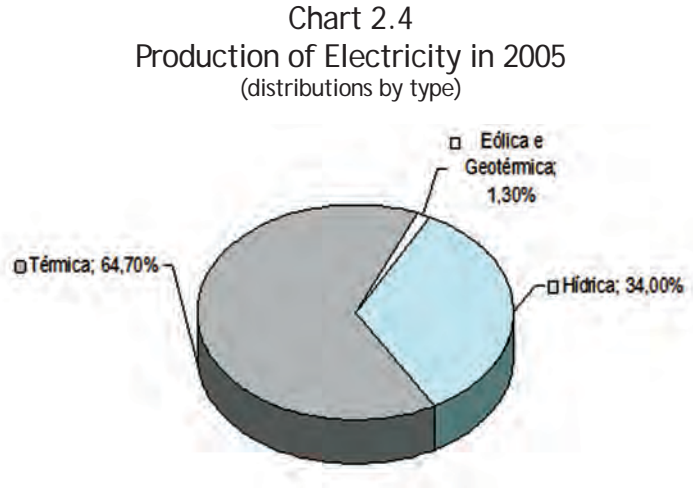
1 (m<sup>3</sup> of O<sub>2</sub>) x 1.427 \* (kg/m<sup>3</sup>) = 1 kg O<sub>2</sub>.  
368 m<sup>3</sup> of O<sub>2</sub> x 1.427 \* kg/m<sup>3</sup> = 525 kg O<sub>2</sub>.  
14 000 x 525 kg O<sub>2</sub> = 7 350 tons of O<sub>2</sub>/year.  
(\* “whereas the density of oxygen is 1.427 (kg/m<sup>3</sup>)”<sup>18</sup>).

2.4.3 CO<sub>2</sub> Emissions Caused by Human Activity in DBNA

According to the pie chart 2.4, in 2005 electricity production in Portugal had the following distribution:

“65% Thermal (Thermal power stations);  
34% Water (Hydroelectric Dams);  
1% Wind and geothermal energy (Renewable energy)”.

In the year of 2005, 65% of the electricity in Portugal was produced from burning coal in thermal power stations, especially in the Central area of the Abrantes municipality, in the district of Santarém.



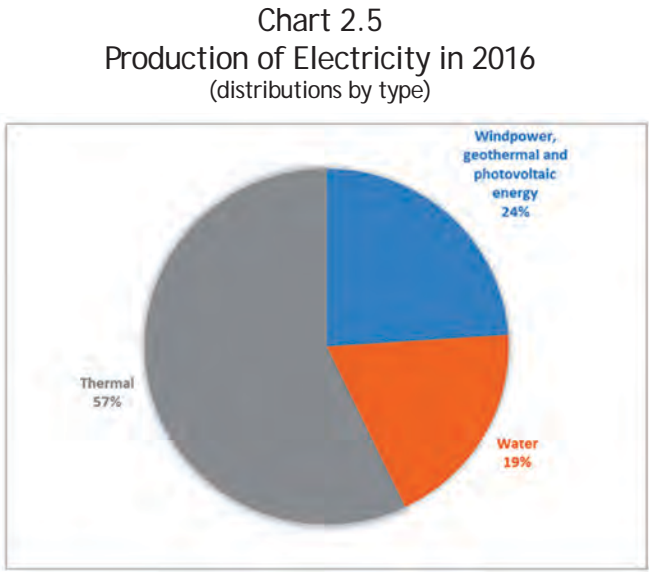


In any case, according to the pie chart 2.5, in 2016 electricity production in Portugal had the following distribution:

“57% Thermal (Thermal power stations);  
19% Water (Hydroelectric Dams);  
24% Wind, geothermal and photovoltaic energy (Renewable energy)”.

This 9% increase in the renewable energy sources is a very positive indicator and is the reason for the drop in CO<sub>2</sub> emissions per capita in Portugal, which in 2004 was 6.3 tons per capita (table 2.3.) and in 2012 was 4.8 tons per capita. However, for the purpose of the following calculations we shall use the 2005 data.

Using this data we can calculate CO<sub>2</sub> emissions corresponding to the electric consumption in DBNA.



The Greenhouse Gas Protocol (GHG Protocol) suggests the methodology for CO<sub>2</sub> accounting related to the emissions from thermal power stations (stationary combustion emissions, table 2.1).

“Calculation methods require compilation of:  
a) Information about company’s activities, in particular in regards to the quantity of fuel consumed for the purpose of combustion.  
b) Information regarding emissions, in particular the type and characteristics of fuel used and the efficiency of the process of oxidation”<sup>19</sup>.

In order to calculate the CO<sub>2</sub> emissions using the amount of fuel consumed and the emission factor, we can use following equations (2.1 and 2.2):

Equation 2.1  
Method of calculation, equation to account  
for CO<sub>2</sub> emissions

$E = A_{fs} \cdot F_{cs} \cdot F_{as} \cdot (44/12)$ or $E = A_{fms} \cdot F_{cms} \cdot F_{as} \cdot (44/12)$ or $E = A_{fsh} \cdot F_{csh} \cdot F_{as} \cdot (44/12)$	
Where,	
$E$ =	Mass emissions of CO <sub>2</sub> (short tons or metric tons)
$A_{fs}$ =	Volume of fuel consumed (e.g., L, gallons, ft <sup>3</sup> , m <sup>3</sup> )
$A_{fms}$ =	Mass of fuel consumed (e.g., short tons or metric tons)
$A_{fsh}$ =	Heat content of fuel consumed (GJ or million Btu)
$F_{cs}$ =	Carbon content of fuel on a volume basis (e.g., short tons C/gallon or metric tons C/m <sup>3</sup> )
$F_{cms}$ =	Carbon content of fuel on a mass basis (e.g., short tons C/short ton or metric tons C/metric ton)
$F_{csh}$ =	Carbon content of fuel on a heating value basis (e.g., short tons C/million Btu or metric tons C/GJ)
$F_{as}$ =	Oxidation factor to account for fraction of carbon in fuel that remains as soot or ash
$(44/12)$ =	The ratio of the molecular weight of CO <sub>2</sub> to that of carbon

Equation 2.2  
Calculating the heat contained in consumed fuel

$A_{fsh} = A_{fs} H_v$ or $A_{fsh} = A_{fms} H_m$	
Where,	
$A_{fsh}$ =	Heat content of fuel consumed (GJ or million Btu)
$A_{fs}$ =	Volume of fuel consumed (e.g., L, gallons, ft <sup>3</sup> , m <sup>3</sup> )
$A_{fms}$ =	Mass of fuel consumed (e.g., short tons or metric tons)
$H_v$ =	Caloric value (i.e., heat content) of fuel on a volume basis (e.g., million Btu/ft <sup>3</sup> or GJ/L)
$H_m$ =	Caloric value (i.e., heat content) of fuel on a mass basis (e.g., million Btu/short ton or GJ/metric ton)

As it can be seen from the accounting methodology and the equations presented, direct application of this methodology to the greenhouse gas emissions in cities or urban areas is not easily done. Because, this methodology requires high accuracy in order to ensure justice in the process of “purchase and sale” of carbon quotas (carbon permits), making it’s aplication difficult in highly complexity environments.

For accounting the CO<sub>2</sub> emissions from the production of electricity in DBNA, we used the method that combines DBNA specific factors and factors proposed in the GHG Protocol. This way the accounting of CO<sub>2</sub> in high complexity environments and human activities can be applicable.

Table 2.6  
Accounting for electricity consumption in the municipality  
of Abrantes and DBNA (energy consumption by sector of activity  
according to the Direção Geral de Energia- Statistics Division)

ELECTRICAL CONSUMPTION IN THE MUNICIPALITY OF ABRANTES FROM 1995 TO 2004				
Year	High Voltage kWh	Low Voltage kWh	Total kWh	Domestic Use kWh
1995	53552596	51716902	105269498	29269498
1996	45398434	53891024	99295458	30868739
1997	43851445	55482607	99334052	31936968
1998	44167581	59040262	103207043	33270207
1999	47924288	63722021	111646309	36146203
2000	47170486	67047333	114217819	37999494
2001	48098036	72804859	120902895	40454226
2002	49107157	72472519	121587176	40797203
2003	51909145	76939756	128856401	42615633
2004	55673372	80958575	136 639 447	45522151

Having into account the values of electrical consumption (in kWh) (table 2.6), by the population in the municipality of Abrantes, which in 2001 was 42 000 inhabitants, will be equal to 120 902 895 kWh. Thus, in 2001, the total per capita consumption was 2 879 kWh. But if we consider only the domestic consumption, this value decreases to 963 kWh per capita.

Total consumption per capita =  
total Consumption (table 2.6) / Population.

Total = 120 902 895 per capita consumption (kWh) / 42 000 =  
2 879 kWh per capita.

Domestic consumption per capita =  
= Domestic consumption (table 2.6) / Population.

Domestic consumption per capita = 40 454 226 (kWh) / 42 000 =  
= 963 kWh per capita.

In any case, for a more modern approach in terms of electricity consumption, we can say that in the municipality of Abrantes population growth from 2001 to 2004 was minimum or even negative, but despite this, during the same period, the electric consumption has increase by 13%. This has the following readings and values (see table 2.6):

Total consumption per capita = 136,639,447 (kWh) / 42 000 =  
= 3 253 kWh per capita

Domestic consumption per capita = 45522151 (kWh) / 42 000 =  
= 1 084 kWh per capita

Therefore, electrical consumption in the municipality of Abrantes in the year 2004 was:

3 253 kWh - total consumption per capita;  
1 084 kWh - domestic consumption per capita.

On the other hand, according to the Census of 1991 “the resident population in the municipality of Abrantes was of 45 697. Already in 2001 the value for the total population residing in that municipality was reduced to 42 436, this shows a loss of 3 261 residents (7.1%)”<sup>20</sup>.

Having these ratios as being coherent with the realities of electric consumption in the area corresponding to the DBNA, we can say that for a population of 14 000 inhabitants, the total consumption values shall be following:

- . Electrical consumption in the year 2004 in DBNA:  
  
Total consumption = Population of DBNA x total Consumption per capita  
= 14 000 x 3 253 = 45 542 000 kWh.
- . Domestic consumption =  
Population of DBNA x domestic Consumption per capita
- . Domestic consumption = 14 000 x 1 084 = 15 176 000 kWh

We can then assume that 65% of 45 542 0000 kWh-consumed in DBNA- were produced from burning coal, which equals to 29 602 300 kWh \* (according to Direcção Geral de Energia).

\* The energy used for the transportation of fuel/coal has not been included in this value.

In the municipality of Abrantes secondary sector is the largest high voltage electricity consumer. This includes, manufacturing and metallurgical industries. Since this energy is used to generate wealth and to boost local economy, it is considered that these emissions should be included in the per capita equation.

You can see that there is only one year-1995 to 1996 - that showed a fall in the consumption by 15%. However, in this ten years period, the high voltage electric consumption has increased by only 4% (chart 2.6).

Domestic consumption has not experienced any decrease, in just ten years period domestic consumption has increased by 56% (chart 2.7).

Chart 2.6  
High Voltage Electric Consumption

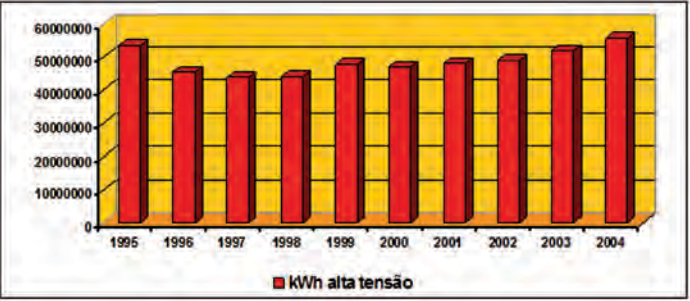
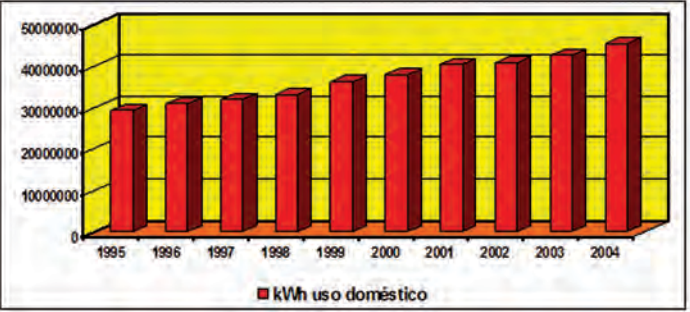


Chart 2.7  
Household Electric Consumption



As for the total power consumption (agricultural, commercial, industrial and domestic), we can observe an increase of 30% over the same time period (chart 2.8).

Chart 2.8  
Comparative Table of Electric Consumption  
in the Municipality of Abrantes

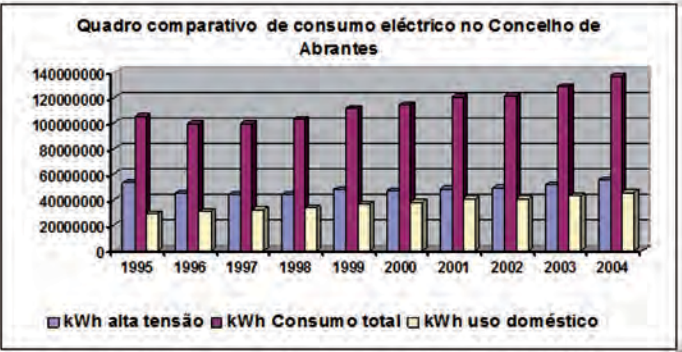


Figure 2.12 – Power Station of PEGO, view from the Castle of Abrantes

According to the information of the power station of PEGO in Abrantes (PEGO, (fig. 2.12)) “to produce 300 MWh (megawatts/hour) this power plant burns 110 tons of coal”<sup>21</sup>, which means that, in order to produce 1 kWh of electricity they uses 0,37 kg of coal, (“1 kg of coal is approximately 2.7 kWh of electric energy”<sup>22</sup>).

“Burning 1 kg of coal results in emissions of, approximately, 3 kg of CO<sub>2</sub>”<sup>23, 24, 25</sup>, and “the formula used to calculate CO<sub>2</sub> emissions caused by the burning of coal follows”<sup>26, 27, 28</sup>:

Coal + Oxygen = carbon dioxide + Q (quantity of heat).

Considering that the DBNA consumes 29 602 300 kWh of electricity per year (total electric consumption in 2004 from the burning coal, for 14 000 inhabitants in DBNA), this value will be equivalent to 10 953 tons of coal. Burning 1 ton of coal emits 3 tons of CO<sub>2</sub> into the atmosphere, which is equivalent to 32 859 tons of CO<sub>2</sub> emissions per year, this translates in 2.35 tons of CO<sub>2</sub> emissions per capita.

Burning coal for electricity production in DBNA per year:

0.37 kg of charcoal per kW x 29 602 300 kWh = 10 952 851 tons of coal.

CO<sub>2</sub> emissions corresponding to the production of electricity in DBNA per year:

10 953 tons of coal x 3 tons of CO<sub>2</sub> per ton of coal =  
= 32 859 tons of CO<sub>2</sub> (see table 2.10).

CO<sub>2</sub> emissions corresponding to the electric power production in DBNA per year per capita:

32 859 tons of CO<sub>2</sub> / 14 000 = 2.35 tons of CO<sub>2</sub> emissions per capita.

In any case, the energy output from burning coal and other fossil fuels is one of the largest emitters of CO<sub>2</sub> to the atmosphere. “With an idea of reducing greenhouse gas emissions produced by the industrial sector, a new technology for carbon capture and storage (CCS) is beeing developed (Figure 2.13).

Regarding this, the European Commission introduced two instruments to facilitate the use of carbon capture and storage systems (CCS).



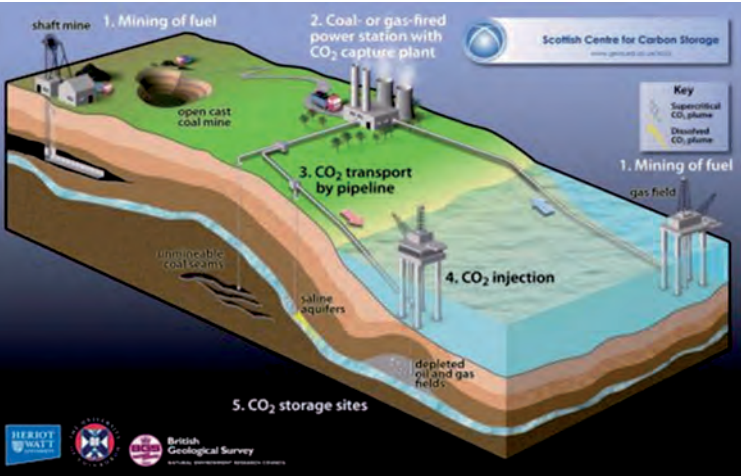


Figure 2.13 - Scheme of carbon capture and storage. (Point 2 corresponds to the CO<sub>2</sub> capture, points 3 and 4 – transportation and storage of CO<sub>2</sub>)

1. The emission trading scheme (EU ETS)<sup>29</sup>, which provides incentives for industry to invest in this type of technology and filters, encouraging them to use CCS.
2. The directive providing measures and methodology for geological storage of CO<sub>2</sub>, taking into consideration the safety of the population and of the environment.

Technology for the carbon capture and storage (CCS) consists of three phases:

1. Capture of CO<sub>2</sub>.
2. Transportation of CO<sub>2</sub>.
3. Sequestration/Storage of CO<sub>2</sub>.

The capture of CO<sub>2</sub> is applicable to stationary sources, such as, thermal power stations and industrial plants, where CO<sub>2</sub> can be separated

from the combustion gases.

The captured CO<sub>2</sub> is transported in a tanker or through a pipeline. However, the source of CO<sub>2</sub> and the place of storage are rarely on the same territory, which implies the need for a safe means of transportation of the captured CO<sub>2</sub>. It will be therefore necessary to plan a controlled risk management system.

In the case of the power station PEGO and DBNA, where CO<sub>2</sub> storage will be done away from the power station, its transportation entails serious risk for the environment and human health.

In order for this technology to be useful for climate change monitoring, the storage of CO<sub>2</sub> must be thought through. This way, the geological storage of CO<sub>2</sub> in geological formations may be of various models; in sedimentary basins, in exhausted oil or gas fields, or even in the coal mines.

Indeed, the logic behind choosing the appropriate location of a power plant must follow these basic principles: easy access to water and fuel, as well as, consideration of CO<sub>2</sub> emissions. Due to this problem it is necessary to manage information regarding:

- Topography and existing infrastructure along the proposed routes for CO<sub>2</sub> transportation;
- Geotechnical surveys;
- Seismic activities;
- Urban areas;
- Environmental impact studies.

Indeed, the production of electrical energy and its side effects need to be viewed from a holistic standpoint – designed to respond not only to the aspects of cost and the production of energy, but also to aspects related to polluting emissions – which goes towards the assumption of the need for a new intellectual framework, that has also been proposed in this book.

Table 2.7  
Structure of the toxic components of internal combustion vehicle emissions (equivalent to 1 kg of fuel)

Components of the gaseous emissions	Grams	%
CO <sub>2</sub>	225	73,8
NOx	55	18,1
CmHn	20	6,6
SOx	2	0,7
Algecide	1	0,3
Dust	1,5	0,5
Total	304,5	100

2.4.4 Accounting of CO<sub>2</sub> Emissions Caused by the Use of Internal Combustion Vehicles

Although carbon dioxide is the gas which is often used as an indicator of pollution from the internal combustion vehicles, the complete structure of their toxic emissions is represented below (table 2.7).

Issues of mobility are essential for urban planning, in terms of traffic routes, efficiency or energy output. However, we should add to these, the issues of CO<sub>2</sub> emissions.

Two methodologies to calculate and account for the emissions are presented in the Greenhouse Gas Protocol.

“The first is based on the use of fuels, where fuel consumption is multiplied by the CO<sub>2</sub> emission factor for each type of fuel. This emission factor is based on the heat concentration of the

fuel and the fraction of carbon that is oxidized (usually about 99%, but here it is assumed to be 100%), as well as, the coefficient level of carbon. This methodology is quite simple and requires only two steps:

Step 1: Obtaining data regarding fuel of consumption by type.

***Fuel Use = Distance x Fuel Economy Factor***

**Note: the units for the fuel economy factor will depend on the type of distance traveled activity data known (e.g., gallons per ton-mile if ton-miles given).**

Step 2: Converting the asstimation of CO<sub>2</sub> of the fuel and multiplying it by the results of step 1.

***CO<sub>2</sub> Emissions = Fuel Used x Heating Value x Emission factor***

The second methodology is based on distances covered by vehicles. Emissions then are calculated by using the data for the distance travelled and the type of fuel used.

Step 1: Collect information regarding distances travelled per vehicle and fuel type.

Step 2: Convert the distance traveled in order to account for the emissions of CO<sub>2</sub> and by multiplying the results of step 1 by the distance based on emissions factor.

***CO<sub>2</sub> Emissions = Distance Traveled x Emission factor***

The methodology based on the use of fuels is more accurate (first method), since the data on fuel is generally more reliable. The methodology based on the distance covered should only be used as a last resort.

In any case, all the methodologies which are used for this matter are similar to those outlined above. However, we came to the conclusion

that the methodology which is based on the type and weight of fuel is more reliable

To account for the emissions corresponding to the existing automobiles in DBNA, we decided to establish 3 starting points:

- Number of existing cars in the municipality of Abrantes;
- Average estimation of CO<sub>2</sub> emissions per vehicle \*;
- Average estimation of kilometres travelled per year per vehicle.

**\*Note:** “different types and brands of automobiles have different behaviour for both, fuel consumption and emission of gases. For example, Jaguar 3,2 L emits 290 grams of CO<sub>2</sub> per km, Fiat Bravo emits 177 grams of CO<sub>2</sub> per km, and Renault Clio emits 144 grams of CO<sub>2</sub> per km”.

While researching information regarding the number for the automobiles in the municipality of Abrantes, we faced some difficulties. Because this data is obtained from the sale of the car stamps. It is processed by the tax office and isn’t shared with the city of Abrantes.

However, the data provided in 2004 by this division stated the existence of 14 000 light vehicles and 4 000 heavy trucks in the municipality of Abrantes. In 2006, this number corresponded to an average of 3 inhabitants per light vehicles and 10.5 inhabitants per heavy trucks.

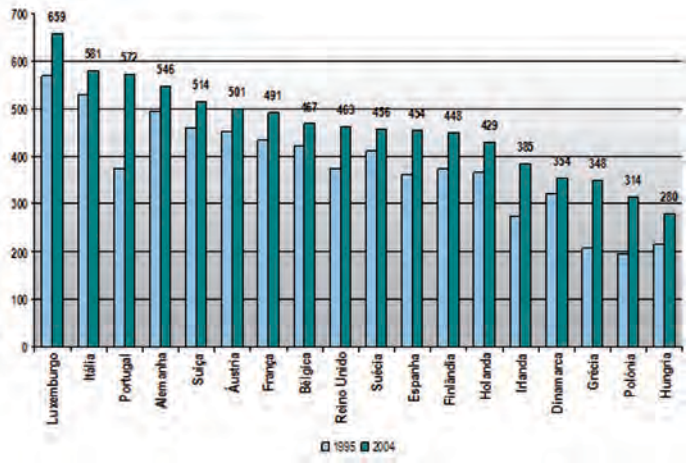
Number of cars per capita in the municipality of Abrantes:

Population in the municipality of Abrantes/number of cars.  
42 000 / 14 000 = 3 inhabitants per vehicle.

Number of Heavy trucks per capita in the municipality of Abrantes:

Population in the municipality of Abrantes/Number of heavy trucks  
42 000 / 4 000 = 10,5 truck per capita

Chart 2.9  
Vehicles per 1000 inhabitants



If we calculate this ratio for the DBNA, we will have 4 667 vehicles and 1 333 heavy trucks.

Number of vehicles in DBNA:

DBNA population / number of cars per capita  
14 000 / 3 = 4 667 vehicles in DBNA.

Number of heavy tracks in DBNA:

Population in DBNA / number of heavy tracks per capita  
14 000 / 10,5 = 1 333 heavy trucks in DBNA.

In any case, according to 2004 data, released by Eurostat, Portugal was the third country in the European Union with the highest number of cars per inhabitant (572 vehicles per 1 000 inhabitants), Italy is on the second place (581) and Luxembourg is on the first

Table 2.8  
Summary table of emissions  
by kilometres travelled

Number of vehicles	4 667 vehicles	1 333 heavy
Emissions of CO <sub>2</sub>	190 g CO <sub>2</sub> /km	770 g CO <sub>2</sub> /km
Kilometres travelled	13 500 km/year	28 000 km/year
Sub–Total (km/year)	4 667x13 500 = = 63 004 500 km/year	1 333x28 000 = = 37 324 000 km/year
Total emissions (g CO <sub>2</sub> /km)	63 004 500x190= =11 970 855 000 g CO <sub>2</sub> /year	37 324 000x770= =28 739 480 000 g CO <sub>2</sub> /year
Total emissions (tons)	11 971 tons CO <sub>2</sub> /year	28 739 tons CO <sub>2</sub> /year
Total kilometres travelled in DBNA		100 328 500 km/year
Total emissions of CO <sub>2</sub> in DBNA		40 710 tons CO <sub>2</sub> /year

(659) (chart 2.9). This means that in Portugal the ration in 2004 was 1.8 inhabitants per vehicle; however, this number goes up to 3 inhabitants per vehicle in DBNA.

The data shows that in Portugal “carbon dioxide emissions from these cars, given the prevalence of low car engine size (smaller engine displacement), are on average 190 grams of CO<sub>2</sub> per kilometre. The calculation of emissions from heavy trucks gives us the value of 770 g/km”.

Bearing in mind that, in Portugal “the average of kilometres travelled is quite high, reaching about 13 500 km/year/vehicle and 28 000 km/year/heavy vehicle”. This means that the inhabitants of DBNA travelled total of about 100 328 500 km in the year of 2004, resulting in 40 710 tons of CO<sub>2</sub> emissions (see table 2.8) - which is the equivalent of almost 300 trips from Earth to the Moon.

Table 2.9  
Fuel  
Consumption

Fuel weight	Passenger cars	Heavy vehicles
	63 004 500 (km/year) /10 (l/km) = = 6 300 450 litres	37 324 000 km/year /30 (l/km) = = 11 197 200 litres
0,900***	6 300 450 litres x 0,900 = = 5 670 405 kg	11 197 200 litres x 0,900 = = 10 077 480 kg
Total emissions (g)	5 670 405 kg x 1 900 g CO <sub>2</sub> /kg of fuel = 10 773 769 500 g CO <sub>2</sub>	10 077 480 kg x 3140 g CO <sub>2</sub> /kg of fuel = 31 643 287 200 g CO <sub>2</sub>
Total emissions (tons)	10 774 tons CO <sub>2</sub>	31 643 tons CO <sub>2</sub>
Total fuel consumed		15 747 885 kg/year
Total emissions of CO <sub>2</sub> in DBNA		42 417 tons CO <sub>2</sub> /year

However, this value can be calculated differently, the alternative value considers the amount of CO<sub>2</sub> emissions from consumed fuel (table 2.9).

Assuming that the travelled kilometres by the inhabitants of DBNA correspond to the use of 5 670 405 kg \* fuel for cars and 10 077 480 kg \*\* for heavy vehicles (table 2.9), then combustion from 1 kg of oil can be quantified with the following formula <sup>30, 31, 32, 33</sup>:



\* Assuming a consumption of 10 litres per 100 km.  
\*\* Assuming a consumption of 30 litres per 100 km.  
\*\*\* 1 litres of gasoline weighs approximately 0.900 kg.



So “the combustion of 1 kg of diesel results in the emission of 3.14 kg of CO<sub>2</sub> for heavy vehicles and 1.9 kg of CO<sub>2</sub> for vehicles”<sup>34, 35, 36</sup>.

If CO<sub>2</sub> emissions from cars are equal to 10 774 tons and that value for heavy vehicles, is 31 643 tons of CO<sub>2</sub>, totalling 42 417 tons of CO<sub>2</sub> (see table 2.10). This is higher than the previously calculated value of 40 710 tons of CO<sub>2</sub>/year (see table 2.8). This difference (approximately 4%) comes from the fact that originally calculated value is based on 190 g CO<sub>2</sub> emissions per kilometre, while the second calculation is based on laboratory results. Perhaps this may be more accurate and therefore more properly applicable calculation, due to the fact that car engine does not burn the fuel up to 100%. On the other hand, the value of 190 g/km of CO<sub>2</sub> is valid for low/medium size (displacement) cars in tests that were done by the automakers. It is also important to consider that as the engines age their efficiency is also reduced. As such this can be considered a more proper methodology of accounting for CO<sub>2</sub> emissions.

In order to reduce CO<sub>2</sub> emissions in new cars, the legislation from the European Commission (EC), no 443/2009, set the goal for manufacturers to produce cars that emit only 120 g CO<sub>2</sub>/km, this value should be reduced till 95 g CO<sub>2</sub>/km by the year of 2020. However, there was an amendment to this legislation in 2014 that proposes: “Regulation (EC) No 443/2009 with a view to establishing CO<sub>2</sub> emission targets for new passenger cars beyond 2020, including the possible setting of a realistic and achievable target for 2025, based on a comprehensive impact assessment that will consider the continued competitiveness of the car industry and its dependent industries, while maintaining a clear emissions-reduction trajectory comparable to that achieved in the period up to 2020.”<sup>37</sup>

Failure of manufacturers to follow these directives will result in penalties and fines will correspond to 5€ for the first g. CO<sub>2</sub>/km, 15€ for the second g. CO<sub>2</sub>/km, 25€ for the third, and 95€ for every following gram of CO<sub>2</sub>.

Not commenting on the feasibility of the proposed objectives, or the values of the fines mentioned, it is important to say that such penalties may also be applied to urban areas, or even on territories that have been defined by the concept of drainage basin limits/boarders. This

idea corresponds to the principle of ‘polluter pays’ and implies the concept of “think globally act locally”.

2.4.5 Accounting for emissions of CO<sub>2</sub> from using liquid gas

In addition to what we discussed previously, there is also the need to account for the CO<sub>2</sub> emissions due to the usage of liquid gas (in particular the propane and butane). According to the figures presented in the Monthly Summary Statistics, a study prepared in October 2005 by the Office of Strategy and Studies of the Ministry of Economy, pointed to “the fact that consumption of this type of gas is 69.4 kg per capita”. The formulas to calculate “the value of CO<sub>2</sub> emissions corresponding to the burning of liquid gases”<sup>38, 39, 40, 41</sup> are following:

Methane: CH<sub>4</sub> + 2O<sub>2</sub> = CO<sub>2</sub> + 2 H<sub>2</sub>O +Q,

Propane: C<sub>3</sub>H<sub>8</sub> + 5O<sub>2</sub> = 3CO<sub>2</sub> + 4H<sub>2</sub>O +Q,

Butane: 2C<sub>4</sub>H<sub>10</sub> + 13O<sub>2</sub> = 8CO<sub>2</sub> + 10H<sub>2</sub>O +Q.

Thus, we come to the conclusion that in DBNA, in 2004, the total amount of CO<sub>2</sub> emissions was 4 117 tons, which corresponds to 294 kg of CO<sub>2</sub> emissions per capita for the existing 14 000 inhabitants.

CO<sub>2</sub> emissions from the use of liquid gas per year per capita:

Gas consumption x CO<sub>2</sub> emissions from burning 1 kg of liquid gas.  
96.4 kg per capita x 3.05 kg CO<sub>2</sub> per kg of gas = 294 kg CO<sub>2</sub> per capita.

“The emission of CO<sub>2</sub> from combustion of 1 kg of liquid gas is 3.05 kg of CO<sub>2</sub> per kg of gas”<sup>42, 43, 44</sup>.

Total amount of CO<sub>2</sub> emissions from burning liquid gas per year in DBNA:

CO<sub>2</sub> emissions per year per capita x DBNA population.  
294 kg CO<sub>2</sub> per capita x 14 000 = 4 117 tons of CO<sub>2</sub> (table 2.10).

Table 2.10  
Total Balance of CO<sub>2</sub>  
Emissions in DBNA

15 555	tons of CO <sub>2</sub> /year caused by forest fires
8 672	tons of CO <sub>2</sub> /year due to human respiration
32 859	tons of CO <sub>2</sub> /year due to the production of electricity
42 417	tons of CO <sub>2</sub> /year due to the use of automobiles
4 117	tons of CO <sub>2</sub> /year due to the use of liquid gas
103 620	tons of CO <sub>2</sub> /year of total emissions in DBNA

Table 2.11  
CO<sub>2</sub> emission per capita per year  
in tons in DBNA

Number of inhabitants in DBNA	Total emission of CO <sub>2</sub> , tons	CO <sub>2</sub> emission per capita per year in tons in DBNA
14 000	103 620	7,4

With the help of this accounting system for CO<sub>2</sub> emissions (table 2.10), we came to the conclusion that the value of CO<sub>2</sub> emission recorded in the DBNA (103 620 tons of CO<sub>2</sub>/year) “corresponds to the average of per capita value recorded in Portugal (+/-7 tons/CO<sub>2</sub>/per capita)”.

Therefore, the value of per capita emissions in DBNA is 7.40 tons of CO<sub>2</sub> (table 2.11).

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CO<sub>2</sub> Absorption in DBNA

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Introduction

The absorption/capture of CO<sub>2</sub> is mainly done by forests, agricultural areas and, in the case of DBNA, by the water surface of the Tagus River. On figure 3.1 you can see the areas of urban perimeter, agriculture and forest in DBNA.

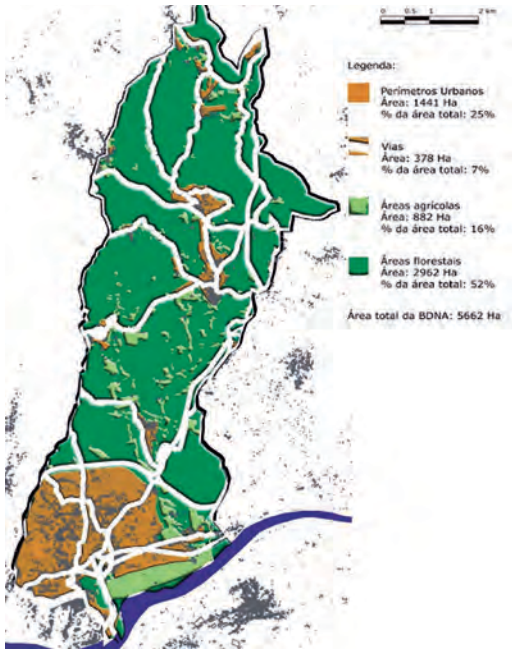


Figure 3.1 - Land use in DBNA

3.1 CO<sub>2</sub> Absorption by Forests and Agricultural areas

“The formula used to estimate the amount of CO<sub>2</sub> absorption by a tree is done through measurement of the weight of its dry wood, which is then divided by the value and weight of other elements, including hydrogen and oxygen”<sup>1</sup>.

In any case, the same source indicates that “a growing forest with 100 000 hectares, has capacity to absorb two million tons of CO<sub>2</sub>, which corresponds to the absorption of 20 tons of CO<sub>2</sub> per hectare per year”<sup>2</sup>.

Absorption capacity for a forest area by year:  
2 000 000 tons of CO<sub>2</sub> / 100 000 hectares of forest =  
= 20 tons of CO<sub>2</sub> per hectare.

However, the sources are not unanimous in presenting the values of CO<sub>2</sub> absorption. For example, Sucss Mj, Crastford J.R. indicate that “one hectare of forest absorbs on average 91.3 tons of CO<sub>2</sub> per year (or 46 600 m<sup>3</sup> of CO<sub>2</sub>) and in the process emits 73 tons on oxygen (corresponding to 51 200 m<sup>3</sup> of O<sub>2</sub>)”, but the website of the Organization for the Protection of Tropical Forests indicates that “the CO<sub>2</sub> absorption of a rainforest is 5 to 10 tons of CO<sub>2</sub> per hectare per year”<sup>3</sup>. As for agricultural areas, the CO<sub>2</sub> absorption is 2.2 tons per hectare according to Weinstein L.H. and McCune D. C.<sup>4</sup>. Considering then, Mediterranean forest in DBNA, because of its characteristics, will have a capacity to absorb about 20 tons of CO<sub>2</sub> per hectare of forest.

Forest areas take up to 52% of total are of DBNA. This equals to an area of 2 962 ha and, consequently, has the following CO<sub>2</sub> absorption capacity:

2 962 ha x 20 tons of CO<sub>2</sub>/ha<sup>5</sup> =  
= 59 240 tons of CO<sub>2</sub> absorbed per year (see table 3.1).

Note 1: It is also relevant to point out the fact that “a hectare of forest absorbs from 32 up to 63 kg/year of airborne particles”<sup>6, 7, 8, 9</sup>.

Note 2: “Every minute, 12 hectares of forest is destroyed in the world”<sup>10</sup>.

- Agricultural areas take up 16% of total area of DBNA. This equals to 882 Ha and, therefore, will have the following CO<sub>2</sub> absorption capacity:

882 ha x 2.2 tons of CO<sub>2</sub>/ha<sup>11</sup> =  
= 1 940 tons of CO<sub>2</sub> absorbed per year (see table 2.12).

In addition to the CO<sub>2</sub> sinks already mentioned, there is a technique and a research that entails burying biomass in the state of charcoal. Indeed, “new biomass furnaces are developed that produce carbon negative energy. Because, they produce more coal than the bio-fuels. If this coal, rather than being burned as vegetable charcoal, is buried then the sequestration is permanently done at a low cost”<sup>12</sup>.

Unlike CO<sub>2</sub> storage technology at great depth, which is temporary and expensive, when buried, carbon is preserved in the soil (in the form of charcoal) for hundreds of millions of years. Another advantage of this method is the process of improving soil fertility. This method was used by the Indians of the Amazon to enrich and fertilize the soil more than 500 years ago. They called it terra preta”<sup>13</sup>.

In addition to the benefits of increased productivity of the soil, this is also a quick, cheap and long-lasting affect for carbon storage.

There is 2 to 4 times more carbon stored in the soil than in living biomass on Earth, but this sink is not recognized by the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, or the Clean Development Mechanism (CDM).

Indeed, “the advantages of soil as carbon sink are superior to the trees since it has greater capacity and is more durable”<sup>14</sup>.

2.2 CO<sub>2</sub> Absorption by the Water Area in DBNA

The sources also are not unanimous regarding the CO<sub>2</sub> absorption by water surface of the Tagus River (Figure 3.2), due to the fact that this process depends on multiple variables.



Figure 3.2 - View of the city of Abrantes from the Tagus River margins

“The ‘levels’ of absorption of CO<sub>2</sub> in water are difficult to measure and depend on uncontrollable factors, such as the contact surface or the temperature. But there are several other factors, such as, current speed of river, temperature differences between the air and water, the depth of the water, the wind velocity and the concentration gradient between the air and water”<sup>15</sup>.

“The carbon dioxide (CO<sub>2</sub>) is more soluble in fresh water than in salt water, its solvency in fresh water is represented by the following formula α<sub>o 2</sub> = 0,878m<sup>3</sup> of gas per cubic meter of water at 20°C temperature”<sup>16</sup>. To account for the Tagus river area corresponding

to the DBNA territory, a digital cartographic base was used, thus accounting for an area of 1 300 027 m<sup>2</sup>, as shown in Figure 2.14. The average depth of the River in that area is 1.5 m.

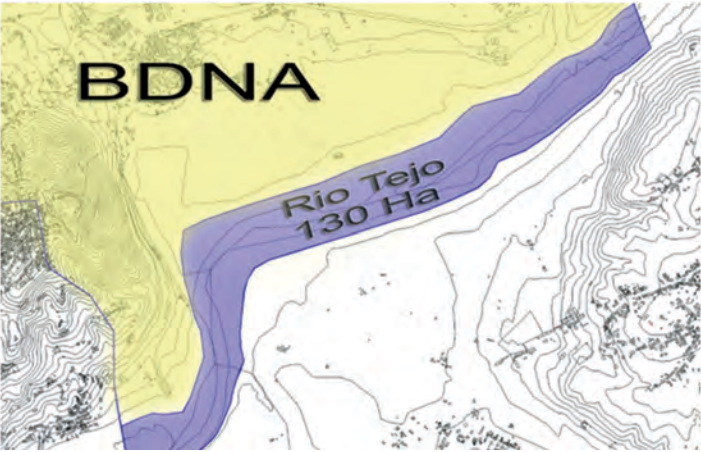


Figure 3.3 - Image of the Tagus river area corresponding to the territory of DBNA

Considering that the amount of water in the area of DBNA is:  
1 300 027 m<sup>2</sup> x 1,5 m = 1 950 040 m<sup>3</sup>.

To calculate absorption of CO<sup>2</sup> by this volume of water the following method was used<sup>17</sup>:

1 - Calculate partial pressure of CO<sup>2</sup> in the air.  
As it has been emphasized, the air we breathe is composed of a mixture of gases. To calculate partial pressure of the components present in the air it is necessary to use Dalton's law.

*"In chemistry and physics, Dalton's law (also called Dalton's law of Partial Pressures) states that in a mixture of non-reacting gases, the total pressure exerted is equal to the sum of the partial pressures of the individual gases"*<sup>18</sup>. This law was empirically observed by John Dalton in 1801.

Mathematically, the pressure of a mixture of gases can be defined as a sum of:

$$P_{\text{total}} = \sum_{i=1}^n p_i \text{ or } P_{\text{total}} = p_1 + p_2 + p_3 + \dots + p_n,$$

where p<sub>1</sub>, p<sub>2</sub>, p<sub>n</sub> represents the partial pressure of each component<sup>19</sup>.

*"The partial pressure of one of the components in a mixture of gases (as in air) is the pressure which the gas would have if it was to occupy the volume alone"*<sup>20</sup>.

It is assumed that the gases do not react with each other.  
p<sub>i</sub> = P<sub>total</sub> x X<sub>i</sub>,

where X<sub>i</sub> is equal to the mole fraction of the total mix of components.

"The mole fraction is the ratio between the amount of solute and the amount of material present in the solution. If we have a mixture of two components, solute A and solvent B, then the mole fraction is:

$$x_A = \frac{n_A}{n_A + n_B} \text{ "21.}$$

Therefore, we can calculate the partial pressure of CO<sub>2</sub> in the air using the following formula:

$$p_{\text{CO}_2} = P_{\text{total}} \times X_{\text{CO}_2} \text{ "22, "23, "24,}$$

where P<sub>total</sub> - total pressure, Pa;  
P<sub>total</sub> - atmospheric pressure which is 101 325 Pa<sup>25</sup>;  
x<sub>CO<sub>2</sub></sub> - mole fraction of CO<sub>2</sub>;  
x<sub>CO<sub>2</sub></sub> = 0,00038 (380 ppm (parts per million)/1 000 000)<sup>26, 27, 28,</sup>

p<sub>CO<sub>2</sub></sub> - partial pressure of CO<sub>2</sub> in the air.  
p<sub>CO<sub>2</sub></sub> = 101 325 Pa x 0,00038 = 38,50 Pa.

2 - Calculate the amount of CO<sub>2</sub> absorbed in aqueous areas (such as river/water surface).

The amount of CO<sub>2</sub> absorbed by water in the river can be calculated using the following formula:

- 1 - Calculate the concentration of CO<sub>2</sub> in aqueous area.
- 2 - Calculate the volume of water in the river for a year in the area of DBNA.
- 3 - Calculate the volume of CO<sub>2</sub> that is absorbed by the fluvial/ river water.

For the calculation of the concentration of CO<sub>2</sub>/quantification in aqueous area, we now need to use Henry's law (formulated by the British chemist William Henry in 1803) which states that:

*"At a constant temperature, the amount of a given gas dissolved in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid"*<sup>29</sup>.

The partial pressure of a gas is a measure of thermodynamic activity of the gas molecules. The gaseous flow always occurs from a region of higher partial pressure to a region of lower partial pressure; the greater is the difference, the faster will be the flow.

*"The gases dissolve, diffuse and react according to their partial pressures and not necessarily according to its concentration in a gas mixture"*<sup>30</sup>.

Henry's law can be applied in mathematical terms (at constant temperature):

$$p_i = k_H \times c_i \text{ "31, "32,}$$

where p<sub>i</sub> - the partial pressure of the liquid,  
c<sub>i</sub> - the concentration of the liquid;  
k<sub>H</sub> - a constant pressure measures divided by the concentration.

The constant, known as the Henry's law constant, depends on the liquid, solvent and temperature.

Consequently, the concentration of CO<sub>2</sub> can be calculated with the following formula:

$$c_{\text{CO}_2} = p_{\text{CO}_2} / k_H.$$

(The concentration of CO<sub>2</sub> = Partial Pressure of CO<sub>2</sub>/ Henry's constant)

$$c_{\text{CO}_2} = 38,50 \text{ (Pa)} / 29,41 \text{ (L x atm/mol)} = 1,29 \times 10^{-5} \text{ mol/L,}$$

$$\text{where } k_H = 29,41 \text{ (L x atm/mol)} \text{ "33, "34.}$$

To calculate the volume of CO<sub>2</sub> that is absorbed by the water of the river, it is necessary to convert carbon dioxide concentration of mole \*/L for

$$\frac{m^3 \text{ CO}_2}{m^3 \text{ H}_2\text{O}} \text{ and "with conversion coefficient of } \frac{m^3 \text{ CO}_2}{m^3 \text{ H}_2\text{O}}$$

" 35, 36, 37, 38.

$$c_{\text{CO}_2} = 1,29 \times 10^{-5} \text{ mol/L} \times \frac{8,31 \cdot 10^3 \cdot 293}{101325} = 0,000315 \frac{m^3 \text{ CO}_2}{m^3 \text{ H}_2\text{O}}.$$

\* *"The unit of quantity in the international system is the mole, which corresponds to 6,023 x 10<sup>23</sup> units. The volume in the international system is measured in cubic meters; the concentration unit in the international system is the mol/m<sup>3</sup>. However, the cubic meter is a very large unit for laboratory applications for everyday life, so is the volume of solution in litres or cubic decimetres (1L = 1dm<sup>3</sup>), so the more concentration unit used the most is mol/L or mol/dm<sup>3</sup>"*<sup>39</sup>.

Assuming that the water flow (Vágua) in DBNA is *"on average 300 m<sup>3</sup> per second"*<sup>40</sup> which corresponds to a volume of 9 460 800 000 m<sup>3</sup>/year.



300 m<sup>3</sup>/second x 60 seconds x 60 minutes x 24 hours x 365 days =  
= 9 460 800 000 m<sup>3</sup> H<sub>2</sub>O/year.

The total volume of CO<sub>2</sub> absorbed per year will be following:

$$V_{\text{water}} \text{ m}^3/\text{year} \times c_{\text{CO}_2} = 9\,460\,800\,000 \text{ m}^3\text{H}_2\text{O}/\text{year} \times 0,000315 = 2\,980\,152 \text{ m}^3\text{CO}_2/\text{year}.$$

$$2\,980\,152 \text{ m}^3 \text{CO}_2/\text{year} \times 1,96 \text{ kg}/\text{m}^3 = 5\,841\,097 \text{ kg CO}_2/\text{year} = 5\,841 \text{ ton CO}_2/\text{year} \text{ (see table 2.12)}.$$

(“Whereas, the CO<sub>2</sub> density is 1.96 kg /m<sup>3</sup>”<sup>41</sup>).

So the amount of absorption by the river water in DBNA will be 5 841 tons of CO<sub>2</sub> per year.

3.3 Analysis of the Results of the Emission and its Absorption in DBNA

Taking into account above discussed figures (table 3.1), the total amount of CO<sub>2</sub> absorbed by the DBNA sinks will be 67 021 tons per year, but if we consider that the amount of CO<sub>2</sub> emitted on this territory is 103 620 tons/year (table 2.10), then we will have a negative balance of 36 599 tons of CO<sub>2</sub>/year in DBNA.

Table 3.1  
Total Balance of CO<sub>2</sub> absorption in DBNA

59 240	tons of CO <sub>2</sub> absorbed by forest areas per year
1 940	tons of CO <sub>2</sub> absorbed by the agricultural areas per year
5 841	tons of CO <sub>2</sub> absorbed by the freshwater areas per year
67 021	Total tons of CO <sub>2</sub> absorbed in DBNA per year

59 240	tons of CO <sub>2</sub> absorbed by forest areas per year
1 940	tons of CO <sub>2</sub> absorbed by the agricultural areas per year
5 841	tons of CO <sub>2</sub> absorbed by the freshwater areas per year
67 021	Total tons of CO <sub>2</sub> absorbed in DBNA per year

Taking into consideration the hypothesis that “a hectare of forest has the ability to intake 20 tons of CO<sub>2</sub>/year”<sup>42</sup>, to absorb the 103 620 tons of CO<sub>2</sub>/year, which corresponds to DBNA’s total emissions (see table 2.10), 5 181 hectares of forest would be required (which corresponds to 0.37 hectares or 3 700 m<sup>2</sup> per capita of forest).

The forest area required to absorb the total CO<sub>2</sub> emissions in DBNA.

103 620 tons of CO<sub>2</sub> emissions/20 tons of CO<sub>2</sub> per hectare =  
= 5 181 hectares of forest to the absorption of the total emissions.

5 181 hectares of forest / 14 000 inhabitants =  
= 0.37 hectares or 3 700 m<sup>2</sup> of forest per capita in DBNA.

Therefore, to absorb the remaining CO<sub>2</sub> emissions deficit in DBNA (36 599 tons) 1 830 hectares of forest would be needed.

Forest area needed to absorb remaining CO<sub>2</sub> emissions in DBNA.

36 599 tons of CO<sub>2</sub> emissions / 20 tons of CO<sub>2</sub> / hectare =  
= 1 830 hectares of forest to the absorb emission deficit.

To analyse CO<sub>2</sub> emissions corresponding to the energy sector (not counting the emissions relating to forest fires and human respiration), two different methodologies can be used:

1<sup>st</sup> methodology - takes into account only “the ratio of 20 tons of CO<sub>2</sub> absorbed per hectare of forest per year”<sup>43</sup>.

2<sup>nd</sup> methodology - takes into account not only the absorption of CO<sub>2</sub> but also the replacement of the energy consumed; which means

that “1 hectare of forest accumulates energy during a year and absorbs CO<sub>2</sub> emissions produced by the consumption of 100 GJ fossil fuels (land-for-energy ratio amounts to 100 GJ of biomass energy per hectare per year)”<sup>44</sup>.

In any case, not accounting for the human respiration and forest fires emissions of CO<sub>2</sub>, and only the value of the emissions from fossil fuel (burning coal emits 32 859 tons of CO<sub>2</sub>/year, burning of diesel and gasoline 42 417 tons of CO<sub>2</sub>/year, liquid gas 4 117 tons of CO<sub>2</sub>/year, see table 2.10) we will have the value of 79 393 tons of CO<sub>2</sub> emitted in DBNA.

1<sup>st</sup> Methodology:

Forest area needed to absorb CO<sub>2</sub> emissions from the burning fuel in DBNA

79 393 tons of CO<sub>2</sub> emissions per year / 20 tons of CO<sub>2</sub> per hectare =  
= 3 970 hectares of forest to absorb CO<sub>2</sub> per year.

2<sup>nd</sup> Methodology:

To sequester CO<sub>2</sub> emissions corresponding to the energy sector (79 393 tons of CO<sub>2</sub>) and to restore that same energy conversion of fossil fuel (kg) used in DBNA into energy will be needed (Gigajoules).

In DBNA 15 747 885 kg of diesel fuel and gasoline is consumed every year (point 2.2.4 and table 2.10), and “the calorific value of 1 kg of petrol corresponds to 44 MJ of energy”<sup>45, 46</sup>:

$$15\,747\,885 \text{ kg of oil} \times 44 \text{ MJ} = 692\,906\,940 \text{ MJ} = 692\,907 \text{ GJ}.$$

In DBNA 10 952 851 kg of charcoal is consumed every year (section 1.2.3), and “1 kg of coal calorific value corresponds to 31 MJ of energy”<sup>47, 48, 49</sup>:

$$10\,952\,851 \text{ kg of coal} \times 31 \text{ MJ} = 339\,538\,381 \text{ MJ} = 339\,539 \text{ GJ}.$$

In DBNA 1 349 600 kg of liquid gas is consumed every year (1.2.5),

and “the calorific value of 1 kg of liquid gas corresponds to 50 MJ of energy”<sup>50, 51, 52</sup>.

$$1\,349\,600 \text{ kg of liquid gas} \times 50 \text{ MJ} = 67\,480\,000 \text{ MJ} = 67\,480 \text{ GJ}.$$

The total energy used in DBNA from fossil fuels:  
692 907 GJ + 339 539 GJ + 67 480 GJ = 1 099 926 GJ

Forest area needed to absorb CO<sub>2</sub> emissions and to accumulate the energy spent on burning of fuels in DBNA  
1 099 926 GJ / 100 GJ per hectare =  
= 11 000 hectares of forest per year.

In other words, difference between these two methodologies is:

1<sup>st</sup> methodology: 3 970 hectares of forest per year  
3 970 hectares of forest per year/14 000 inhabitants =  
0.28 ha per capita.

2<sup>nd</sup> methodology: 11 000 hectares of forest per year  
11 000 hectares of forest per year/14 000 inhabitants =  
0.8 ha per capita.

The area of forest in the second methodology is 2.8 times higher than the calculated area in the first methodology. These two methodologies reflect two different perspectives, first one considers only the present equilibrium (CO<sub>2</sub> emitted <-> CO<sub>2</sub> absorbed) and the second advocates that a society is not sustainable if your present economy depends on the exhaustion of the natural recourses, while compromising needs of future society.

The second approach - to restore what is consumed - recognizes that equity between generations is a prerequisite for sustainability.

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Table 3.1 – Total Balance of CO2 absorption in DBNA. By Antonio Castelbranco.

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Calculation methods of ecological footprint

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Introduction

The idea underlying the ecological footprint concept is to represent the consumption of energy and resources in terms of area per capita, measured in hectares. There are various methods to calculate the ecological footprint for example, the “Carbon Calculator” method that uses the following parameters:

“Human Factor:

- Number of people per dwelling.
- Number of rooms per dwelling.
- Food and drink
- Clothes, textiles and shoes.

Energy Factor:

- Fuel for heating.
- Duration of the heating season.
- Value of the energy bill.
- Duration of the electric bill.
- Total electric bill.
- Bi-hourly rate.

Transportation Factor:

- Number of cars.
- Km/year travelled by car.
- Km/year travelled by train.
- Km/year travelled by bus.
- Type of car.
- Type of train.
- Air travel”<sup>1</sup>.

However, the method that seems to be the most adequate - from the perspective of land planning - is an adaptation of the method designed by Mathis Wackernagel and William Rees in their book Our Ecological Footprint<sup>2</sup>.

4.1 The ecological footprint in Biosphere 2

Due to its complexity and energy use Biosphere 2 (fig. 4.1) has two different areas in terms of ecological footprint.

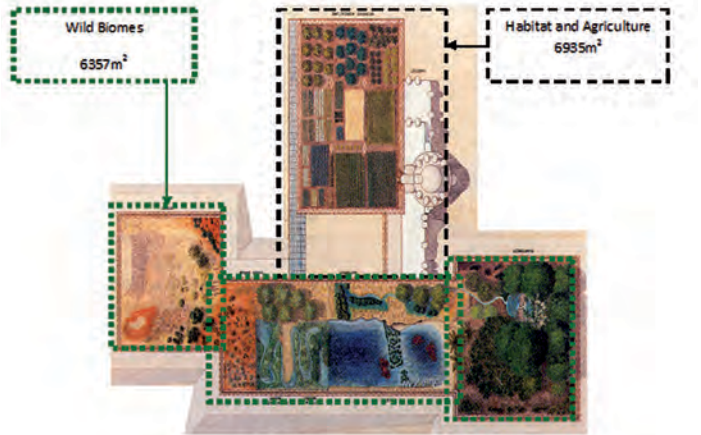


Figure 4.1 -General Plan of Biosphere 2

The accounting of ecological footprint of its eight residents, during the first experiment - which began in September 1991 and lasted until September 1993 - is a relatively simplified calculation, due to the fact that it is a building which is sealed from the outside.

However, to calculate the ecological footprint of the eight Biosphere 2 residents, the building’s total area must be accounted for, thus from a functional a perspective the building is divided into two large areas: the human habitat and wilderness biomes (table 4.1).

Table 4.1  
Areas and functions in Biosphere 2

“Human Habitat Area”	“Wild Biomes Area”		
	Area, m²		Area, m²
Residential area	577	Forest	1 936
Laboratories and workshop areas	500	Savannah	1 665
The technosphere (incl. the south and west Lungs)	3 644	Ocean	855
Agricultural Biome	2 214	Marshes	532
		Desert	1 369
Total Area, m²	6 935	Total Area, m²	6 357

Indicator 1 - Forest, Agricultural Area  
and Human Habitat (Urban Area)

The area devoted for agriculture in Biosphere 2 was 2 214 m² for 8 people, thus it accounted to the 280 m² per person (or 0.028 hectare per person for agricultural purposes).

However, the ecological footprint is the sum of all the areas within the Biosphere 2 (forest, agricultural area and human Habitat must also be accounted due to the fact that they all worked

together and gave support to 8 residents (see table 4.1)):

$$6\,935\text{ m}^2 + 6\,357\text{ m}^2 = 13\,292\text{ m}^2.$$
$$13\,292\text{ m}^2/8 = 1\,662\text{ m}^2\text{ per capita (or 0.17 Ha per capita).}$$

Indicator 2 - Energy

According to Bill Dempster, - engineer responsible for the maintenance of the Biosphere 2 project - if we calculate the amount of energy used in mechanical cooling and heating systems, electronic systems, control systems, etc., all the elements that are necessary for the proper functioning of Biosphere 2, the ecological footprint has the following dimension (total amount of energy consumed per year was on average 2 Mega Watts (MWh), 2 MWh = 2 000 000 kWh / 8 inhabitants = 250 000 kWh / per capita).

$$\frac{250\,000\text{ kWh}}{278\text{ kWh}} = 899.3\text{ GJ per capita,}$$
$$\frac{1\text{ GJ}}{1\text{ GJ}}$$

(“Whereas 1GJ = 278 kWh”<sup>3, 4</sup>).

According to Mathis Wackernagel and William Rees, “the conversion ratio of territory to energy is 100 GJ/ha/year”<sup>5</sup>, i.e.:

$$899.3\text{ GJ per capita per year}/100\text{ GJ/ha/year} = 8.99\text{ ha per capita.}$$

Thus, the ecological footprint of each of the eight residents of the Biosphere 2 equals to:

$$0.17\text{ hectares per capita} + 8.99\text{ hectares per capita} = 9.7\text{ hectares per capita.}$$

4.2 The ecological footprint in Canada

In their book Our Ecological Footprint<sup>6</sup>, Wackernagel and Rees have presented several case studies concerning the ecological footprint concept. At the same time, they established the methodology

for its accounting, but referring in particular to Canadian citizens per capita in 1991. In this sense, various indicators are presented:

1<sup>st</sup> - Energy Indicator

The methodology starts by establishing the fossil energy consumption per capita per year. Based on the assumption of the World Resource Institute that, “the total energy consumption in Canada is 8 779 Peta Joules (1 PJ = 1 x 10<sup>15</sup>J), out of this, 926 PJ are produced from nuclear power plants and 1 111 PJ from hydroelectric dams.

Thus, total fossil energy consumption in Canada is:

8 779PJ - 926PJ - 1 111PJ = 6 742 PJ.

Considering that the population in Canada is 27 000 000 inhabitants, per capita consumption accounts for:

6 742 PJ / 27 000 000 inhabitants = 250 GJ per capita per year.

This value does not exactly correspond to the official statistics of Canada, pointing to a 234 GJ/capita per year. In order to avoid errors, the authors have chosen to use this value as an indicator to determine the ecological footprint. Assuming, as said above, that for every 100 GJ of fossil fuel energy burned we need 1 hectare of sink area to absorb the CO<sub>2</sub> produced:

$$\frac{234 \text{ GJ/per capita/per year}}{100 \text{ GJ/hectare/year}} = 2,34 \text{ hectares/per capita.}$$

Therefore, an area of 2.34 hectares will be required per capita per year for each Canadian.

Indicator 2 - Forest

Here, the authors intended to account for the forest area required to produce timber, paper pulp and other forest products for

every Canadian. Considering, therefore, a 244 kg consumption of wood/capita/per year, it was accounted that, “to produce a ton of paper it is required 1.8 m<sup>3</sup> of wood and that one hectare produces 2.3 m<sup>3</sup> per year”<sup>7</sup>.

$$\frac{244 \text{ (kg/cap/year)} \cdot 1,8 \text{ (m}^3 \text{/ton)}}{1000 \text{ (kg/ton)} \cdot 2,3 \text{ (m}^3 \text{ Ha/year)}} = 0,19 \text{ Ha per capita.}$$

Taking into consideration that much of the construction in Canada uses wood, this value is still adding up to 0.40 Ha of wood. It means that 0.59 hectares of forest area per capita per year will be needed.

Indicator 3 - Urban Use

To determine this indicator we need to account for areas occupied by buildings, roads, industrial areas, etc. The World Resource Institute stated that “in Canada the total hectares of these type of areas corresponds to 5 500 000 Ha”<sup>8</sup>. Which is equivalent to:

$$\frac{5\,500\,000 \text{ hectares}}{27\,000\,000 \text{ habitantes}} = 0,20 \text{ hectares per capita.}$$

Thus, the area devoted to urban use and road systems will be around 0.20 hectares per capita.

Indicator 4 - Agricultural Use

To determine this indicator we need to consider the areas occupied by:

- gardens 0,02ha
  - crops 0,66ha
  - pastures 0,46ha
- 1,14ha

Thus the area dedicated to agricultural use will be 1.14 hectares per capita.

The sum of all above indicators in Canada is:

Indicator:

1 - energy	2,34 hectares
2 - forest	0,59 hectares
3 - urban use	0,20 hectares
4 - agricultural use	1,14 hectares
Total	4,27 hectares

According to the presented calculations, the ecological footprint of a Canadian citizen in 1991 was 4.27 hectares per capita.

Note: the areas for agricultural use, were introduced in 1972 by the Club of Rome and indicated different numbers. The report mentioned that “*to feed the worlds growing population 0.4 hectares per capita is enough. To feed the entire population of the world with the existing standards of the United States, it would take 0.9 hectares per person*”<sup>9</sup>.

4.3 Ecological footprint in the Netherlands

Mathis Wackernagel and William Rees<sup>10</sup> also feature case study for a European country, the Netherlands. Following the same methodology, the authors make an analysis of the ecological footprint for a Dutch citizen. It is interesting to note that, while in Canada the urban usage indicator is 0.20 ha/per capita in Holland this value is five times lower, being 0.04 ha/per capita.

This difference is, undoubtedly, the result of an urban planning system. Both, Canada and the United States, heavily depend on automobiles. In many North American cities within the urban perimeter, the area of urban land dedicated to automobile use exceeds 55% of the total urban area.

In any case, the sum of all the indicators in the Netherlands is:

Indicator:

1 - energy	2.10 hectares
2 - forest	0.47 hectares
3 - urban use	0.04 hectares
4 - agricultural use	0.71 hectares
Total	3.32 hectares

4.4 The ecological footprint in DBNA

Applying the same methodology to the DBNA area we can calculate the ecological footprint per capita for its inhabitants. However, the numbers presented here do not include CO<sub>2</sub> emissions from the usage of cement, and according to Prof. Aires Camões: “*the production of each ton of Portland cement entails the release of about a tone of CO<sub>2</sub>. Thus, the cement industry contributes to about 7% of the total emissions into the atmosphere. With the aim of reducing CO<sub>2</sub> levels associated with the cement production, it is urgent to reduce consumption of this material*”<sup>11</sup>.

Indicator 1 - Energy

As it already has been calculated, to absorb CO<sub>2</sub> emissions in DBNA 11 000 hectares of forest will be required, which corresponds to 0.8 hectares per capita (section 2.3.3 of this chapter).

11 000 hectares / 14 000 inhabitants = 0.8 hectares per capita.

Indicator 2 - Forest

According to CELPA, Paper Industry Association, paper consumption in Portugal, “in the year of 2005 was 120 kg per capita”<sup>12</sup>, using the formula:

$$\frac{120 \text{ (kg/cap/year)} \times 1,8 \text{ (m}^3 \text{/ton)} *}{1\,000 \text{ (kg/ton)} \times 2,3 \text{ (m}^3 \text{/hectare/year)} **} = 0.095 \approx 0.1 \text{ hectares/per capita.}$$



“\* It requires 1.8 m<sup>3</sup> of wood to produce a ton of paper.  
\*\* In the production of wood one hectare of forest produces about 2.3 m<sup>3</sup>”<sup>13</sup>.

The ecological footprint on the consumption of wood for other uses in Portugal is “of 0.4 hectare per capita per year”<sup>14</sup>. Therefore, the sum of these two factors is 0.5 hectares per capita per year.

Indicator 3 - Urban Use

The sum of the areas dedicated to urban perimeters and the roads (see fig. 2.12) is 1 441 and 378 ha.

1 441 ha + 378 ha = 1 819 hectares.  
1 819 hectares / 14 000 inhabitants = 0.13 hectares per capita.

Indicator 4 - Agricultural Use

The agricultural area of DBNA is insufficient to feed its population of 14 000 inhabitants and imported food flows are significant. We decided to use the ratio presented for the population of the Netherlands, equivalent to 0.71 hectares of agricultural area per capita.

The sum of the indicators to calculate ecological footprint in DBNA is:

Indicators:

1 - energy	0.80 hectares
2 - forest	0.50 hectares
3 - urban use	0.13 hectares
4 - agricultural use	0.71 hectares
Total	2.14 hectares.

4.5 Ecological Footprint in Comparative Terms

Following the same methodology, the authors, Mathis Wackernagel and William Rees, presented the ecological footprints of inhabitants in the United States of America, India, and calculated the world average in 1991, on the chart 1.10. Added to this is the average-sized ecological footprint of DBNA and Biosphere 2 - with the energy use component (Bio-2 (2)) and without the component of energy expenditure (Bio-2 (1)):

“United States of America	5.1 hectares;
India	0.4 hectares;
World average	1.8 hectares” <sup>15</sup> .

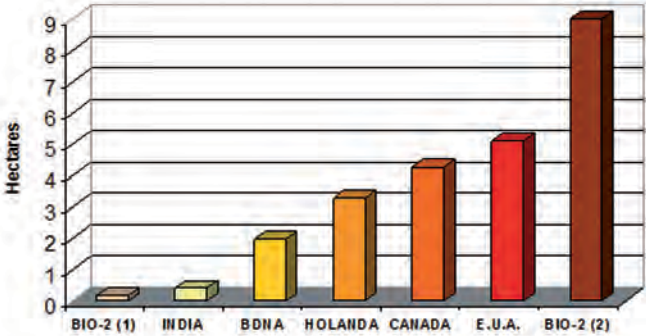


Chart 4.1 - Values of ecological footprint in India, the Netherlands, Canada, USA, and in Biosphere 2 (with and without energy use) and in DBNA

The difference in ecological footprint between the DBNA and the Netherlands is justified with two reasons: first one is that the Dutch gross domestic product per capita (GDP) is 60% higher than the GDP for Portugal; the second one is that the climate of the Netherlands is substantially colder than the moderate climate of Portugal, resulting in greater energy use for heating the buildings.

As can be verifies from the table 4.2 and chart 4.1, the ecological footprint area is clearly related to the gross domestic product per capita of each country:

Table 4.2  
Gross Domestic Product per capita  
in US dollars in 2015<sup>16</sup>.

United States of America	56 115
Canada	43 315
Netherlands	44 290
Portugal	19 222
India	1 593

In any case, it is interesting to note that in almost all countries, the ecological footprint gradually increased until 2006, but it has started to level out or has decreased, except for India and the World’s average. (Chart 4.2).

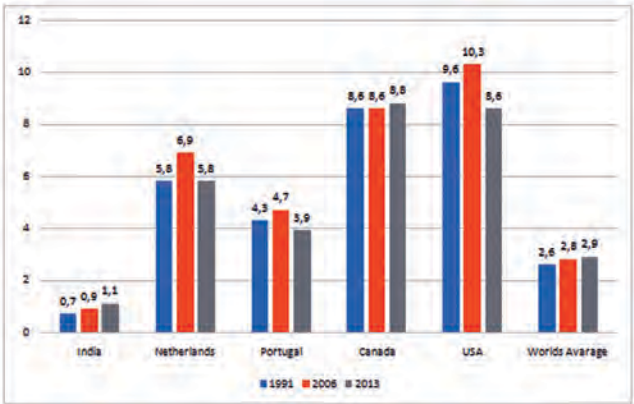


Chart 4.2 - Evolution of ecological footprint in the last 22 years

It is assumed that the difference between the ecological footprint accounted for DBNA and Portugal is due not only to the fact that the municipality of Abrantes and Sardoal County have lower gross domestic product (GDP) per capita than the national average, but also due to the fact that the calculation method used by Global Footprint Network is based on parameters other than those used here.

As there were several schemes and methodologies to account for Green House Gases, as presented at the beginning of this chapter, there are also other methods for accounting/measuring the environmental impact of human activities. In the following example, presented by Esther Higuera at the Higher Technical School of Architecture of Madrid, the author points out the methodology that covers some of the same parameters that were analysed above. Such as, the accounting of the territory in environmental terms, and the accounting of energy consumption. “In Madrid’s case, in 1956, the land occupied by indirect urban use, dams, embankments, roads and mining was equal to 10%, compared to 23% in the year of 1980. From 1960 to 1968 the per capita energy consumption in the region doubled”.

Consumption of goods resulting in waste:

“Daily consumption of goods per person in urban area of the city of Madrid in 1983 was estimated to be:

- 2.6 kg of oil;
- 252 litres of water;
- 2 kg of food and beverages;
- 8 kg of construction materials;
- 214 litres of waste water;
- 1/4 generation of sludge in wastewater treatment;
- 5 kg of atmospheric discharges;
- 6 kg of inert waste, rubbish;
- 1 kg of industrial waste (1/5 of which toxic or dangerous);
- 1 kg of solid urban waste (USW).

These figures show that the urban areas consume huge

*amounts of non-renewable resources and generate large quantities of wastes that cannot be recycled”<sup>17</sup>.*

In this chapter we presented several ways to account for the human impact on the Biosphere, based on the different priorities and approaches. These differences are, partly, due to the fact that this topic is relatively new, but on the other hand, the intellectual framework that serves as a support is not yet developed. Therefore a broad consensus in regard of primary elements that should be the basis of the methodologies are not yet familiar or do not exist.

CONCLUSION

Michael Fay says that *“ the Earth has approximately 200 million years of accumulated carbon (in various forms), however in the last 60 to 80 years we (humans) already have consumed/burned the equivalent of 100 million years of accumulated carbon”<sup>18</sup>.*

The result of accelerated carbon consumption starts to have visible effects on the environment and the scientific community points that in average the temperature of the planet is increasing with approximately 0.4 Celsius each year - along with the increased concentration of CO<sub>2</sub> in the atmosphere. In any case, the increased concentration of other gases, such as methane (CH4) and chlorofluorocarbons (CFCs) also contribute to the greenhouse effect. The combined effect of such substances can cause an increase in global temperature, which is estimated to be between 2 to 6 °c in the next 100 years. Furthermore, a warming of this magnitude will change the global climate, and will contribute to the rise of ocean level by approximately 30 cm and will affect lives of millions of people living in coastal areas.

The Kyoto Protocol intends to serve as an instrument, a willingness to reduce greenhouse gases. The Kyoto Protocol was endorsed in Bonn, Germany, in July 2001, where the targets set earlier were softened. Because it was argued the possibility to promote and increase the areas of “carbon sinks”. According to this proposal,

countries that had large forested areas, which naturally absorb CO<sub>2</sub>, could make use of these forests as credit for emissions trading.

In any case, the need of more detailed studies on the amount of carbon that a forest is actually able to absorb is needed, in order to not overestimate or underestimate the of amounts paid through carbon credits.

*“ The second commitment period of the Kyoto Protocol began on 1 January 2013 and will end in 2020. 38 developed countries, including the EU and its 28 member states, are participating. This second period is covered by the Doha amendment, under which participating countries have committed to reducing emissions by at least 18% below 1990 levels. The EU has committed to reducing emissions in this period to 20% below 1990 levels.*

*The main weakness of the Kyoto Protocol is that it only requires developed countries to take action. As the United States has never signed up to the Kyoto Protocol, Canada pulled out before the end of the first commitment period and Russia, Japan and New Zealand are not taking part in the second commitment period, it also only now applies to around 14% of the world’s emissions. However, more than 70 developing and developed countries have made various non-binding commitments to reduce or limit their greenhouse gas emissions”<sup>19</sup>.*

On the other hand, experience with industrial emission trading scheme is already quite developed. For example, every company, as a source of emissions holds a ‘ license ‘ fixed limit of CO<sub>2</sub> emission. This value is defined on the basis of the national plans for each participating country and will be reduced over time.

“If a company intends to issue more emissions than the limit set in the permit, they have to buy ‘carbon credit ‘ of another company that have emissions below their fixed amount. This way, companies that invest in reducing emissions can sell their surplus credit and generate revenue. In the first year, 362 million tons of CO<sub>2</sub> credits

were sold, worth 7.2 billion euro”<sup>20</sup>. Comparing the experience of industrial emissions trading scheme with the cities and territories, we came to the conclusion that there is not yet a consensus regarding the methodological priorities what may become the criteria for accounting for CO<sub>2</sub> emissions.

With the overview of the situations - throughout this Chapter- we developed a viable methodology for the accounting for an environmental impact originated from the population living in the Drainage Basin North of Abrantes (DBNA), in order to verify the sustainability of this area.

Therefore, we contributed to the development of a new intellectual framework for the CO<sub>2</sub> indicator, while analysing tools for its accounting.

As calculated, DBNA emits 103 620 tons of CO<sub>2</sub>/year for a population of 14 000 inhabitants, corresponding to 7.4 tons of CO<sub>2</sub>/year per capita. This value is consistent with the values of emissions proposed by the Kyoto Protocol *“of 84 608 000 tons of CO<sub>2</sub> for Portugal, which with a population of about 10.6 million corresponds to an average of 7.9 tons of CO<sub>2</sub>/year per capita”<sup>21</sup>.*

The difference between these two values (7.4 and 7.9 tons of CO<sub>2</sub>) is only ~ 6%, proving the accuracy of the method that was proposed here, and allows us to use it for the environmental accounting of sustainability for territorial and urban planning.

Regarding CO<sub>2</sub> absorption, we came to the conclusion that the areas of sink (2 962 Ha of forest areas, 882 Ha agricultural areas, and 130 Ha of river Tagus) present in DBNA are insufficient to absorb 103 620 tons of CO<sub>2</sub> that are emitted by its inhabitants per year. The causes underlying CO<sub>2</sub> emissions (as specified in table 4.1) arise from the use of the automobile (42 417 tons), the production of electrical energy (32 859 tons), forest fires (15 555 tons), human respiration (8 672 tons) and by the use of liquid gases (4 117 tons).

Table 4.3  
Total balance of CO<sub>2</sub> emissions in DBNA

15 555	tons of CO <sub>2</sub> /year caused by forest fires
8 672	tons of CO <sub>2</sub> /year due to human respiration
32 859	tons of CO <sub>2</sub> /year due to production of electric energy
42 417	tons of CO <sub>2</sub> /year by the use of automobiles
4 117	tons of CO <sub>2</sub> /year by the use of liquid gases
103 620	tons of CO <sub>2</sub> /year of total emissions in DBNA

The absorption capacity of the sinks present in DBNA adds up to just 67 021 tons per year(as shown in table 4.4). Which shows that there is a deficit in the absorption of CO<sub>2</sub> of 36 599 tons per year.

Table 4.4  
Total balance of CO<sub>2</sub> absorption in DBNA

59 240	Tons of CO <sub>2</sub> absorbed by forest areas per year
1 940	Tons of CO <sub>2</sub> absorbed by the agricultural areas per year
5 841	Tons of CO <sub>2</sub> absorbed by the freshwater volume per year
67 021	Total tons of CO <sub>2</sub> absorbed in DBNA per year

This chapter has also presented an analysis of the absorption of CO<sub>2</sub> emissions from the energy sector (not counting the emissions related to forest fires and human respiration) with two different methodologies:

1<sup>st</sup> methodology - takes into account only the absorption;

2<sup>nd</sup> methodology - takes into account not only the absorption of CO<sub>2</sub> but the replacement of the energy consumed.

When you analyse not only the absorption of CO<sub>2</sub> but also replacement of the energy consumed, so the area of forest equivalent to the energy



consumed goes from 0.28 hectares per capita to 0.8 hectares per capita (2.8 times higher than the calculated area in the first methodology).

In any case, the idea of restoring what has been consumed – recognizes fairness/justice between generations and therefore is a prerequisite for sustainability.

This chapter has also presented the method for calculating the ecological footprint. These calculations pointed out that the area of DBNA (5 662 hectares) is insufficient for the environmental impact generated by its inhabitants. On the figure 4.2 the red rectangle with 29 960 hectares (299.6 km²) corresponds to the impact of the ecological footprint. On the Figure 4.3, the same area divided by indicators (forest/agriculture/energy/urban area) allows a graphic visualization/verification of these areas, and has the same graphic scale as the DBNA boundaries. This proves the existence of a deficit in area for the resident population of DBNA.

14 000 inhabitants x \* 2.14 ha/per capita = 29 960 hectares.  
(\* Ecological footprint in DBNA).

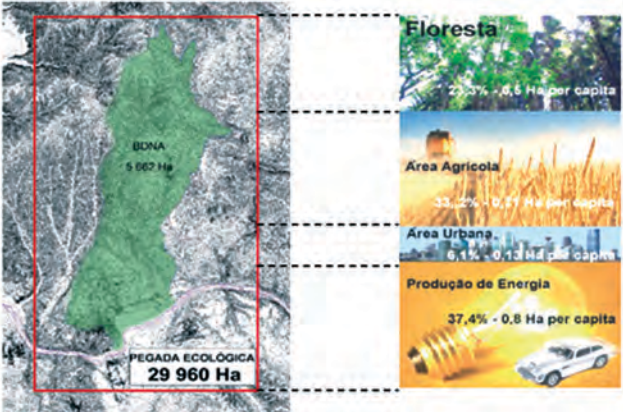


Figure 4.2 - DBNA area versus ecological footprint area (red rectangle)

Figure 4.3 - Distribution of the ecological footprint for indicators in DBNA

If we use the same value to calculate the ecological footprint of the Portuguese population, it appears that, the area of our ecological footprint (226 820 km²) is 60% higher than the area of the national territory (92 090 km²):

10 599 095 \* x 2.14 ha/per capita = 22 682 063 Ha = 226 820 km².  
\* “Population residing in Portugal 10 599 095 inhabitants”<sup>17</sup>.

The intention of this chapter was to contribute to the development of a new intellectual framework, based on the division of the territory into drainage basins and accounting for CO<sub>2</sub> emissions. Thus, being a useful tool for easily assessing the sustainability of a particular area.

In the development of this new intellectual framework, it will also be necessary to develop an emissions trading scheme that will be applicable to the territory in its wholeness (urban areas, agricultural areas, forests) and to encourage the search for a wider sustainability in terms of planning and architecture.

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NOTES

<sup>1</sup> - Carbon calculator (disponível em [www.carboncalculator.co.uk](http://www.carboncalculator.co.uk); 2 de Agosto de 2009).

<sup>2</sup> - Wackernagel M., Rees W. (1996) Our Ecological Footprint, Gabriolalsland, New Society Publishers, p. 36.

<sup>3</sup> - Instituto Nacional de Estatística (disponível em <http://www.ine.pt>; 20 de Março de 2007).

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<sup>5</sup> - Wackernagel M., Rees W. (1996) Our Ecological Footprint, Gabriolalsland, New Society Publishers, p. 75.

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<sup>14</sup> - Wackernagel M., Rees W. (1996) Our Ecological Footprint, Gabriolalsland, New Society Publishers, p. 97.

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<sup>17</sup> - Fay M. et.al. (2005) The Last Place on Earth, National Geographic Society, p. 135.


<sup>18</sup> - European Council of European Union, International Agreements on Climate Action <http://www.consilium.europa.eu/en/policies/climate-change/international-agreements-climate-action/>

<sup>19</sup> - Europa: 50 passos em frente. Comércio de emissões (disponível em [http://europa.eu/success50/html/story\\_19\\_pt.html](http://europa.eu/success50/html/story_19_pt.html); 15 de Agosto de 2009).

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# PART 2

## Overview of the Impact of Urban Settlements by the Natural Disasters

### The Issues of Seismic Vulnerability and Risk Assessment Throughout the Urban Territory

## Overview of the Impact of Urban Settlements by the Natural Disasters. The Issues of Seismic Vulnerability and Risk Assesment Throughout the Urban Territory

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### Introduction

The risk always exists when cities are built. The increase of population in cities and urbanization in seismic-prone zones causes the increase of infrastructure. The goal of society is to create infrastructure that is protected from destructive earthquakes and minimize the expected loss. The task is complicated as there is always a deficiency of knowledge about real seismic hazard and infrastructure's vulnerability. The proper assessment of seismic risk is of crucial importance for sustainable economic development of cities and protection of society. We see that rapid urbanization and population growth are continuing to create enormous new challenges for the humanity and pushing us to deal with a strange new urban world. An earthquake can bring hospitals, schools and homes down with tragic consequences. When it comes to the impact of natural disasters, well-run cities can be among the safest places on earth - this has been realized in developed countries. But cities can also be the most dangerous places on earth for those who live in an urban environment where the authorities have little presence and where the will and the resources are lacking to ensure basic social services including respect for building codes". These ideas are supported by the UN Secretary General: strongly urge Member States to join the global initiative Making Cities Resilient 2010-2011: *"My city is getting ready, to increase the resilience of cities and urban areas, in particular by raising the awareness of citizens and local governments of risk reduction options and by mobilizing political commitment and support among local governments to include risk reduction aspects in urban development planning and critical infrastructure investments, such as schools and hospitals"* (United Nations, A/65/388 General Assembly, 22 September 2010).

Due to the high level of natural hazards in many countries it became necessary to work out the international programs and strategies. The World Conference aiming at reducing natural disasters, conducted by the UN in Kobe (prefecture of Hyogo, Japan) in 2005, has adopted Hyogo Framework for Action 2005-2015. The following concept was underlined in this program: *Governmental, municipal, scientific offices involved in problems of development of cities have to include the assessment of natural disasters risk in strategy of urban planning.*

This problem is of vital importance for Tbilisi as it is a big city and capital of Georgia. The city is characterized with the rapid increase of population density, high speed of urbanization and vulnerable infrastructure, which increases seismic hazard. This was confirmed by Tbilisi earthquake of 2002 years. This earthquake is result of seismically active, newly discovered Tbilisi-Mtkvari fault passing through the territory of capital.

### 1.1 Scientific Background in seismic hazard and seismic risk assessment

For more than a century of intensive geological, seismological and other geophysical investigations the enormous factual material, not only on the seismology, but also on geology and environment of the region, has been obtained. These data give possibility to combine fundamental and applied research to investigate the seismic hazard and risk in the South Caucasus region, particularly in Georgia.



It is obvious that till present time the attention of scientists and professionals was paid mostly to assessment of seismic hazard. On the other hand, the objective of earthquake risk assessment and loss estimation studies is to quantitatively assess the natural hazard and consequent risks due to the earthquake. The output of these studies shall be used as a planning tool to execute management and mitigation policies of seismic disasters and damages within an area of interest.

Index of Seismic Risk for Georgia and political districts of Georgia were calculated in the GNSF project 2006 - 2009 “Reducing natural disasters multiple risk: a positive factor for Georgia development”. The distribution of risk index by hazard type is based on the method developed by the Columbia University group during compilation of the Map of Global Natural Disaster Risk Hotspots<sup>1</sup>. This method enables to compare political districts of Georgia by the levels of risk and to evaluate the type of risk, which makes main contribution to total loss. But this method is quite rough for risk estimation inside political districts<sup>2</sup>.

Seismic risk of Tbilisi was calculated for a scenario earthquakes with intensity of 7 and 8 by equation of Sobolev<sup>3,4,5</sup>. Inventory map of buildings was quite rough in this case. Databases contained information only about the number of various type of buildings in each administrative district of the city.

Seismic risk of old part of Tbilisi was calculated taking into account various factors<sup>6</sup>.

Thus, despite the fact that the seismic hazard and risk assessment in this region was subject of several investigations, there are still gaps in this direction. The most vulnerable items in seismic hazard and risk assessment are expressed in the following problems:

- Detail seismotectonic characterization of the area under study (based on classical and modern data analysis procedures) is not done
- Selection of a model for predicting the expected distribution

of ground motions at a site due to possible earthquake (this includes knowledge of propagation path characteristics, also topographical, geological and geotechnical data for site classification and site response analysis models) is not done

- High quality “build environment” inventory map for the territory of Georgia, especially for Tbilisi, is not available.
- Systematic detail data on GDP, economic losses and mortality due to seismic hazards are absent
- Maps of expected damage of building stock in case of (i.e., probabilistic) earthquakes
- GIS-based software package to incorporate and manipulate all the maps mentioned above.

## 1.2 Tectonics and Seismicity of Tbilisi

Tbilisi lies at the eastern end of the Achara-Trialeti fold-thrust belt. The North Achara-Trialeti (ATN) thrust separates the Achara-Trialeti belt from the Georgian block to the north. The South Achara-Trialeti (ATS) thrust separates the Achara-Trialeti belt from the Artvin-Bolnisi block to the south. Tbilisi lies between the eastern terminations of these two thrusts (Fig. 2.2.1). The two thrusts are linked by the NE-dipping Tbilisi-Mtkvari dextral strike-slip with reverse fault (TM), which trends NW-SE<sup>7</sup>.

The Tbilisi area had been considered as a region of relatively low seismicity. Historical seismicity in this area has been recorded since the 13th century and all known strong ( $M > 5$ ) earthquakes in this area are associated with the above mentioned faults. During the historical period, the earthquakes with seismic intensity of VII in MSK scale occurred approximately once per 85 years in this region. Especially important is the earthquakes’ cluster around Mtsketa, 15 km north of Tbilisi (Fig. 1.1) One of these earthquakes probably generated an MSK intensity of VIII<sup>8</sup>. This cluster of earthquakes is related to the junction between the ATN thrust and the Tbilisi-Mtkvari fault. Strong historical seismicity also occurred on the ATS thrust (e.g., the 1896  $M_s = 6.3$  event). A third group of historical earthquakes (1682, 1803, 1804, 1819;  $M_s = 3.5 \div 4.5$ ) is located immediately beneath Tbilisi

and is related to the Tbilisi-Mtkvari fault. The 2002 Tbilisi earthquake demonstrated continued activity on this fault (Fig.1.2.1).

### 1.3 Creation elements of risk inventory databases in GIS system

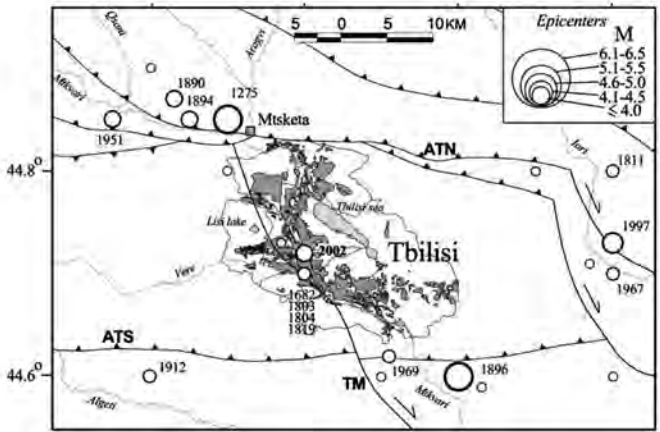


Figure 1.2.1 - ATN - The North Achara-Trialeti thrust fault; ATS - The South Achara-Trialeti thrust fault; TM - Tbilisi-Mtkvari dextral strike-slip with reverse fault.

In the assessment of risk one of the most important parameters is the inventory of elements at risk. In urban area elements at risk are: buildings, lifeline systems, population, socio-economic activities. Extensive and comprehensive collection of element at risk inventories is vital for estimation of losses to elements at risk during the earthquake. The inventories of the built environment (building and lifeline system) was studied and created in GIS system for the following categories:

- *Base map: Buildings, streets (street name and building number), parks, greenery, rivers, lakes, stadiums etc.*
- *Buildings: Building material, number of stories, number of entrances, condition of building, and building period of Tbilisi buildings.*
- *Critical facilities: Educational institutions, health care, religious places, government buildings, sanitary sewer, emergency services*

- *Electric system: Electric power transmission lines, operating stations and centrals*
- *Water aqueducts and supply system: water transmission system, sanitary sewer system, pumping stations, and reservoirs*
- *Transportation system: Highways and bridges, tunnels, metro lines, bus and mini bus stops; each station has information about transport that passes the station*
- *High loss facilities: Natural gas system, gas station, gas transmission system ( point and line layers of major stations and pipes)*
- *Old heating system network: Points and polyline layer of main stations and pipes*
- *Relief of Tbilisi: Digital Elevation Model (Fig. 1.3.1)*
- *Aerial photos of Tbilisi*
- *Election precincts with population: Boundaries or election precincts and number of population in each precinct*

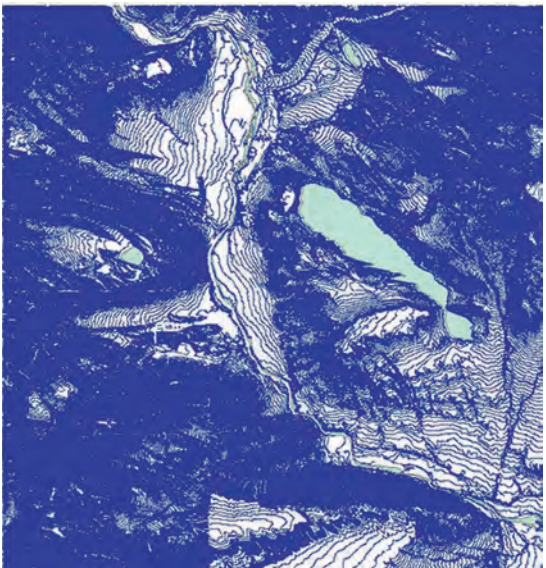


Figure 1.3.1 - Topographic (elevation) map in 10 000 scale



#### 1.4 Local mapping of soil classes

This aspect will deserve major attention since its plays a considerable role in the definition of the seismic impact to be considered in the design and retrofiting of structures. Information about surficial geology and shear velocity either does not exist, varies dramatically in quality, varies spatially), or is not easily accessible. Such maps are available for only a few regions, predominantly in seismically active urban areas of developed countries. For this research we use topographic data of large scale 1:10 000. DEM was calculated from topographic map (Fig. 1.3.1). From DEM the slope map has been calculated. Slope map has been reclassified using correlation with shallow shear-velocity theoretical observations (10) and the corresponding soil map was obtained (Fig. 1.4.1).

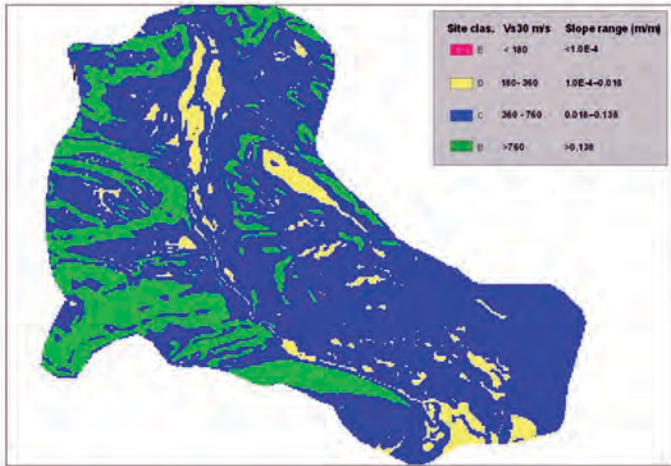


Figure. 1.4.1 - Site classification by slope ranges for subdivided NEHRP Vs30 categories.

Second version of soil classification for Tbilisi was done on the basis of geo engineering map of 1:30 000 scale. It has been reclassified according to Euro code 8 classification (Fig. 1.4.2).

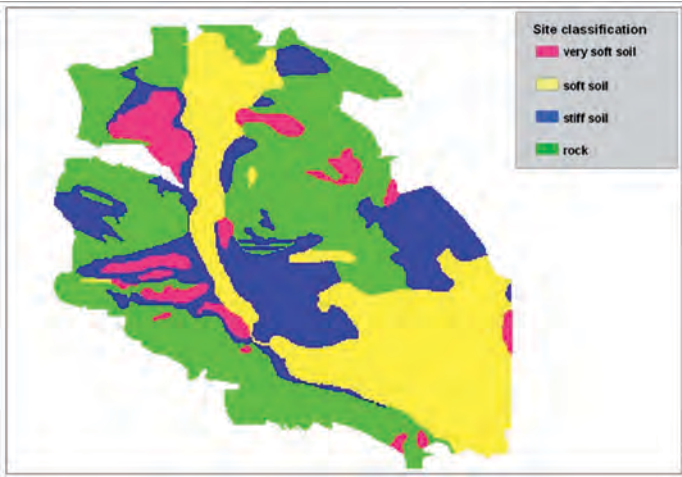


Figure 1.4.2 - Site classification by geo- engineering data of 1:30 000 scale.

#### 1.5 Seismic hazard probabilistic assessment

Delineation of seismic sources is one of the important tasks in seismic hazard assessment. Seismic sources are defined as zones that are characterized with more or less uniform seismicity.

The identification of seismic sources was obtained on the bases of structural geology, parameters of seismicity and seismotectonics. Finally each zone has been defined with the following parameters: geometry, magnitude-frequency relation, maximum magnitude and depth distribution as well as modern dynamical characteristics widely used for complex processes (Fig.1.5.1).

From the engineering point of view investigation of ground motion prediction equation is very significant, but the data is quite poor for South Caucasus, not to mention the local data, which is preferable. Distribution of these data for distance and magnitude for Georgia is shown below (Fig. 5.2). As we see, most of earthquakes near the source (at 20 km, which is the most interesting from the engi-

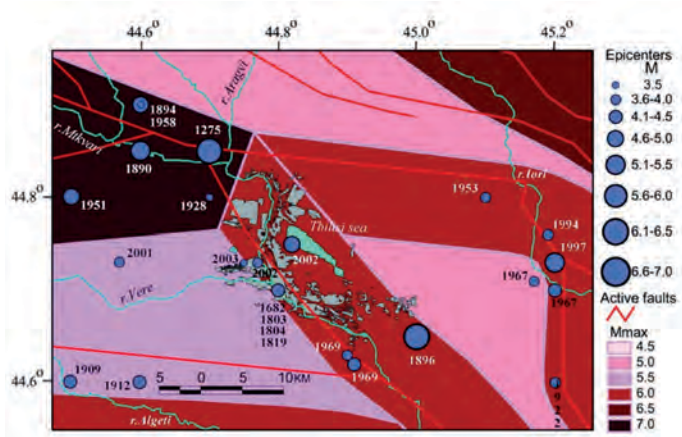


Figure 1.5.1 - Seismic sources zone of Tbilisi and surrounding area.

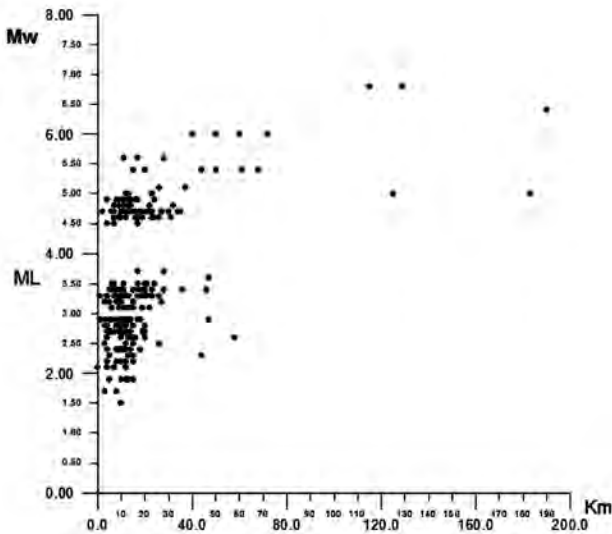


Figure 1.5.2 - Distribution of PGA data by magnitude and distance for Georgia (Most of this data are recorded only on one station).

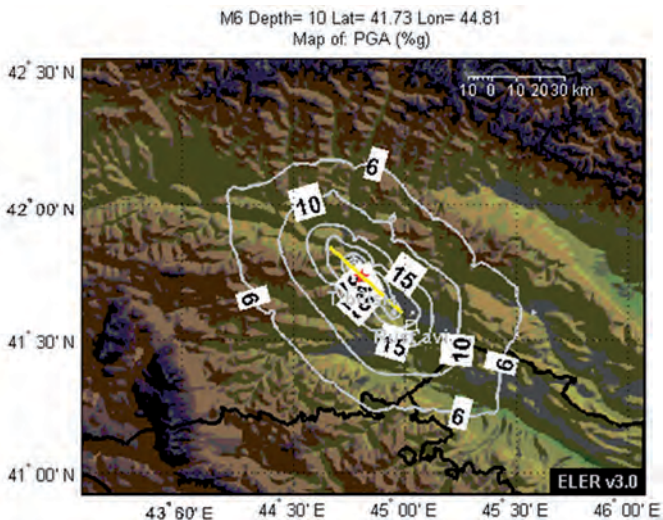


Figure 1.5.3 - Seismic hazard map for Tbilisi scenario earthquake with Ms = 6 in PGA(%g).

neering point of view) are from small to moderate with magnitude of  $M_L < 3.8$  and  $4 \leq M_w \leq 5.5$ . Taking into account that attenuation near source for small to moderate earthquakes is not the same as the attenuation for strong earthquakes and that most of these data is recorded only on one station, the set of data is absolutely insufficient. That means that uncertainty in ground motion prediction equation will be large.

Due to the lack of records from strong earthquakes at short epicentral distances, we considered the model of Boore and Atkinson (2008)  $PGA^9$  and Campbell and Bozorgnia (2008)  $PGA-SA^{10}$  that were derived from the world data including Caucasus. The seismic hazard of Tbilisi region has been computed according to the probabilistic approach. A logic tree was used to take into account different attenuation models.

Deterministic seismic hazard maps of two scenario earthquakes - Tbilisi earthquake with  $M_s = 6$  (Fig.1.5.3) and Mtskheta earthquake



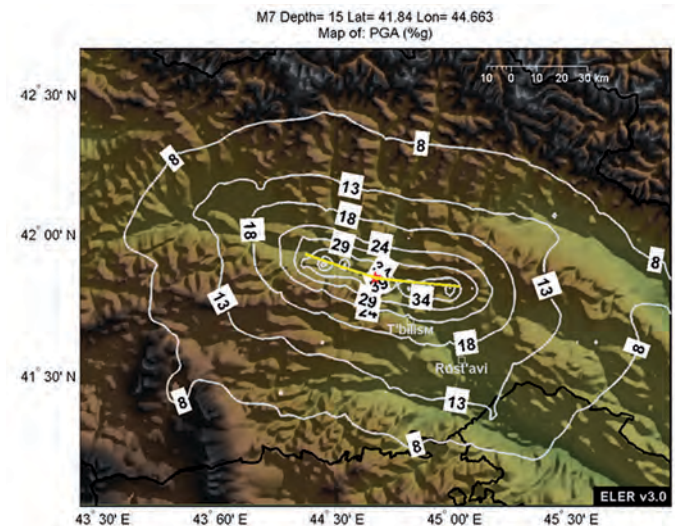


Figure 1.5.4 - Seismic hazard map for Mtskheta scenario earthquake with Ms = 7 in PGA (%g).

with Ms = 7 (Fig. 1.5.4) were estimated using software ELER 3.

### 1.6 Urban Seismic Risk Study and its methodological basis

For integration of seismic aspects into the Tbilisi City General Plan it is necessary to evaluate the seismic vulnerability of all city-forming factors. From this point of view the urban relative seismic risk can be revised as the indicator of the territory seismic hazard influence to the urban factors of seismic vulnerability<sup>11</sup>.

The scheme below shows the methodological basis and objectives of urban Seismic risk study (Fig.1.6.1)

The main regions of Tbilisi were investigated. This gives the possibility to fix significance of urban factors influence into the urban seismic risk reduction across the large territory, manage the construction and planning activities for sustainable development of the city in the most economical way.

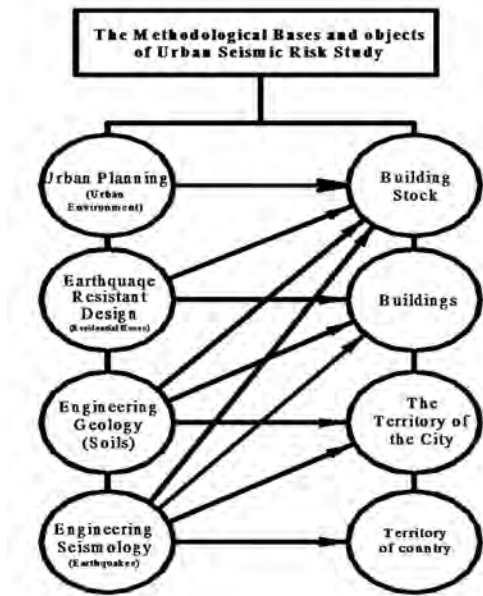


Figure 1.6.1 - Methodological basis and objectives of urban seismic risk study.

According to the limitations and special requirements the urban factors' data were grouped and defined by the level of seismic vulnerability.

Below in the tables are presented the vulnerability evaluation for city roads (Tab.1.6.2), cultural heritage (Tab.1.6.3), building type (Tab. 1.6.4) and other factors.

After this it became possible to unite all urban factors in one system to assess the relative seismic risk for any urban area in whole or separately, for each factor.

Our model of seismic risk assessment, which was transformed in ARC GIS System and farther developed there, gave us possibilities for visual assessment of any urban area according the factors

Table 1.6.1  
Vulnerability Evaluation for Functional Factor

Code	Usage of Object	Level of seismic Vulnerability
A	Unusable objects (Open Spaces, parks, playgrounds)	1
B	Not very usable objects (2-3 story, 1-4 multi-family apartments)	2
C	Very usable objects (Banks, 4-8 multifamily residential, small commercial and office apartments.)	3
D	Highly usable objects (big banks, hotels, schools, fire and police stations, railway and bus stations, theatres, industries, high-rise residential and commercial buildings)	4

Table 1.6.2  
Table 1.6.2 Vulnerability evaluation for city roads

	Type of the Roads/ The level of Vulnerability	Weight Coef- ficient	Width of the Roads m			
A	The Roads of City Sig- nificance and main trunk highways (m)	3	>45	30-45	10-20	<10
B	The Regional Roads (m)	2	>30	25-30	25-15	<15
C	Local Roads (m)	2	>30	25-30	25-15	<15
D	The Roads of trunk communication between cities (m)	1	>65	45-65	30-40	<30

Table 1.6.3  
Vulnerability Evaluation for Historical Heritage

Code	Usage of Object	Level of seismic Vulnerability
A	New Building Stocks	1
B	All buildings in Historical Area (Old Quarters)	2
C	The Monuments of Local Importance	3
D	The Monuments of National Importance	4

Table 1.6.4  
Vulnerability level of Building type and other factors

level of Vulnerability	The Technical Condition of the Buildings	Seismic Hazard of the territory g	The functionality	The Density of Building Stock Sq. m/ha	Density of Population People/ha	Significance of the Roads	Distance from safe area m	The significance of monument
1	D	0.40-0.46	A	0-1094	0-92	D	0-100	A
2	C	0.46-0.48	B	1094-2188	92-184	B,C	100-200	B
3	B	0.48-0.50	C	2188-3281	184-276	A	200-300	C
4	A	0.50-0.53	D	3281-4375	276-367	-	>300	D

separately, in different combinations or in complexity (Fig.1.6.2, 1.6.3, 1.6.4, 1.6.5, 1.6.6). The positive point of GIS methodology is its opportunity of scenarios development, visualization of results, simplification of urban factors seismic risk arrangement, creation of close links between the urban databases and city maps, strong management between city layers. This gives us possibility for quick testing of all urban decisions and visual analyses of its outcomes.

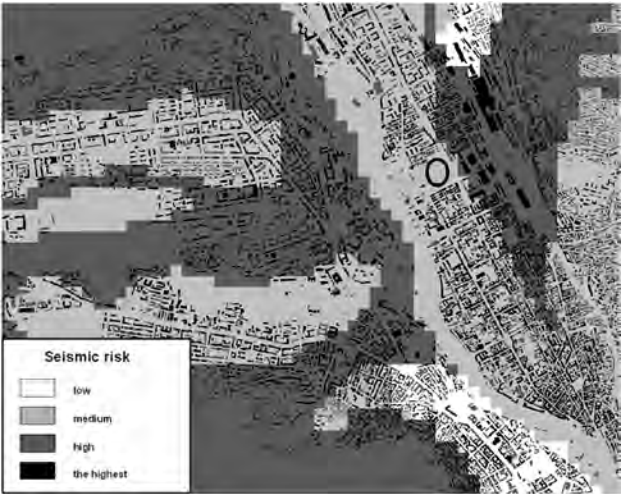


Figure 1.6.2 - The seismic vulnerability of Building type, functionality, building density and seismic hazard.

The seismic risk urban analysis shows the diversity of urban factors nature in different environments, influence of seismic micro-zoning data on seismic risk assessment, impact of urban factors on each other during this assessment.

Thus, the urban seismic risk study results must become the natural undetached part of Tbilisi City General Plan development.

This should give the governmental, private and non-governmental bodies possibility to manage correctly their work and financial activity.

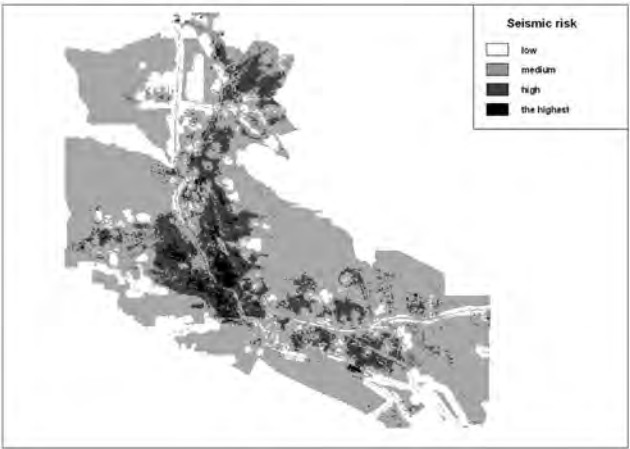


Figure 1.6.3 - The seismic vulnerability of building type, functionality, building density, population density, roads and seismic hazard.

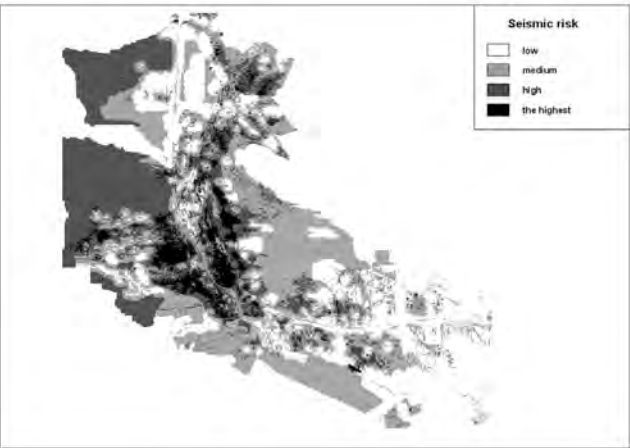


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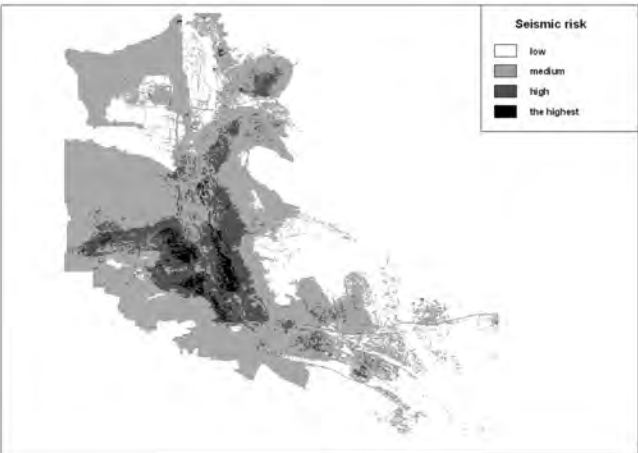


Figure 1.6.5 - The seismic vulnerability of building type+functionality+building density+population density+Road System+distance from safe area+cultural heritage and seismic hazard.

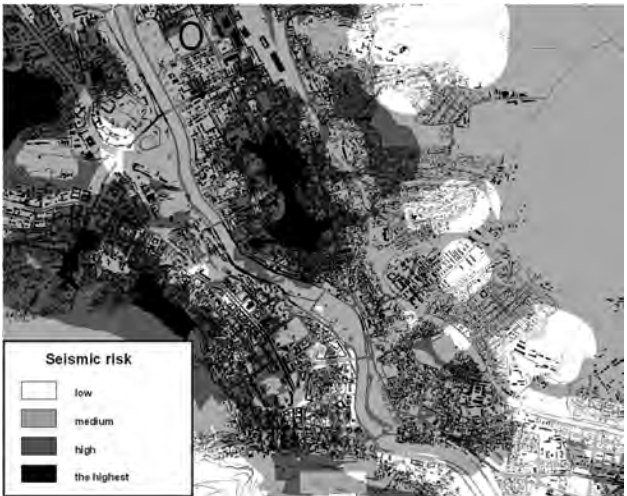


Figure 1.6.6 - Relative seismic risk without seismic hazard will be added.

The urban seismic risk assessment creates good basement for bank and insurance system to be involved into sustainable development of city.

The protection and regulation of the social and functional processes in the cities located in seismic prone areas can be realized by urban planning and seismic risk testing. The concentration and location of urban functions is based on the usual social relations between the inhabitants, their general demands, their work, their ways of relaxation. In order to regulate the seismic risk in the process of the designing and planning it is desirable to follow the recommendations given below:

- > To consider the seismic intensity of the site during the general plan development.
- > To carry out the demolition of heavy damaged buildings in time.
- > The disposition of the buildings of public significance and responsible buildings in convenient territories.
- > Making of parks, green recreational areas in seismic hazard areas.
- > Building of underground garages and parking-lots in order to unload heavy traffic in the center of the city
- > Organization of the movement system in the region - creation of new passages instead of damped buildings by partial opening of ground-floors and deadlocks, which will significantly facilitate the evacuation of population and other salvage operations during the earthquakes, other disasters and their secondary element (fire, flood, landslide etc.).
- > The positive influence of basements on the earthquake resistance of the buildings in case of regulation of underground waters, can be used as additional territories that will safe historical buildings from high rising during the reconstruction process.



Conclusion

Proper solution of the main goal: assessment of seismic risk of Tbilisi strongly depends on the effective cooperation of various scientific institutes and universities, governmental organizations, city authorities, managing/insurance agencies and international trust partners in Georgia. There is a clear and existing synergy between all these partners in the compilation and analysis of the final data. The compilations of earthquake occurrences, fault patterns, inventory maps are individual outcomes on their own that can be used for other purposes too (e.g. hazard assessment, building codes), but they are definitely the pre-requisite for solution of the final task - urban risk management and reduction vulnerability of Tbilisi-city. Establishment of this cooperation can impact further development of efficient national agency. On the basis of this cooperation it is possible to create a system indicating earthquake vulnerability and risk for Georgia and its particular regions/communities also. This will enable the managing agencies to carry out the effective policy of reducing natural disasters risk. The major obstacle in disaster management in Georgia is absence of active and powerful national agencies that will work in systematic manner for assessing/archiving/mapping/monitoring/managing of all catastrophic events. That means that these agencies should be effective not only after disaster, but permanently for carrying out the strategy of prediction and of preparedness to (prevention of) impending hazards. The main gaps in Tbilisi city seismic risk assessments (detail data on site effects, building stock resilience and economic value) are indicated. Creation of such detail dataset will favor developing of effective measures against seismic hazard (city general planning, its development strategy, insurance policy), corresponding to the Hyogo Framework for Action and the global initiative: Making Cities Resilient 2010-2011: My city is getting ready.

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Materials from the Project of Seismic Risk Assessment for Tbilisi

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Materials from the Project of Seismic Risk Assessment for Tbilisi

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# The Ways of Urban Seismic Risk Reduction. Seismic Risk Study for Tbilisi City and Its Historical Center

Authors: Nino Chachava, Zurab Kiknadze, Vladislav Zaalishvili, Sergo Gogmachadze, Nino Tsereteli, Nikoloz Arevadze, Malkhaz Lekveishvili, Tamar Khoshtaria, Igor Timchenko

## 2.1 The ways of Urban Seismic Risk Reduction. Seismic Risk Study for Tbilisi City and its historical Center. Conclusions

Like a heart of human body an urban center organizes movement and functionality of a city, concentrates its treasures and human resources. That is why the seismic disasters are mostly large and significant in case of damages in central quaters.



Location of August 17, 1999 Turkish Earthquake

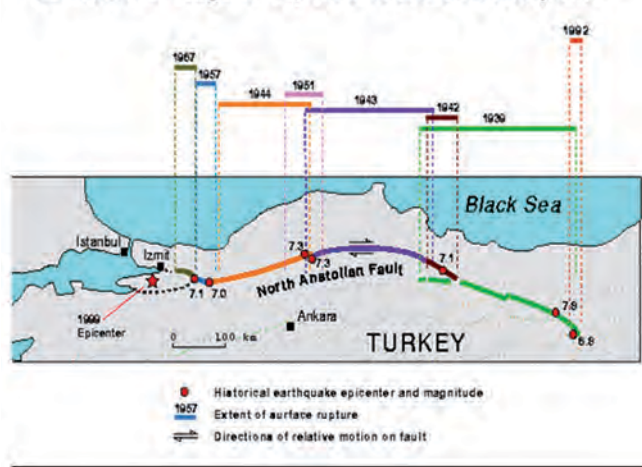


Figure 2.1.1 - Reconstruction of Scopje. Kenzo Tange project. Administration functions were brought out.

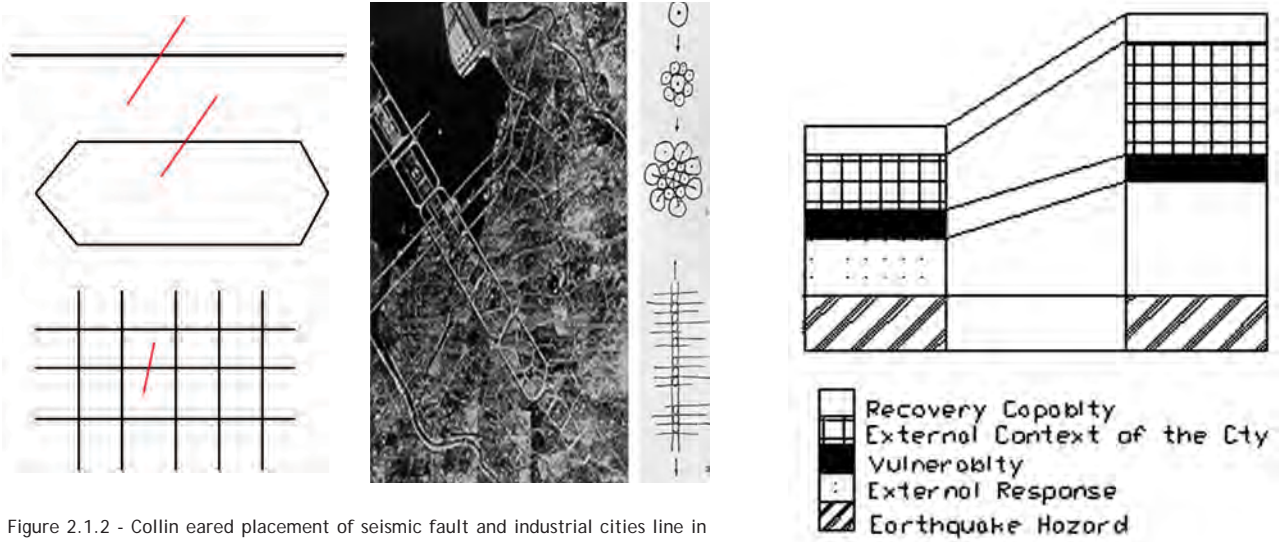


Figure 2.1.2 - Collinear placement of seismic fault and industrial cities line in Turkey. Materials from UIA Summer School 2004. 1-17 July 2004. Izmir - Turkey

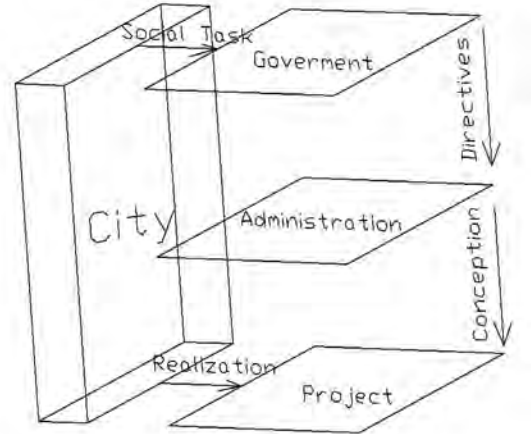


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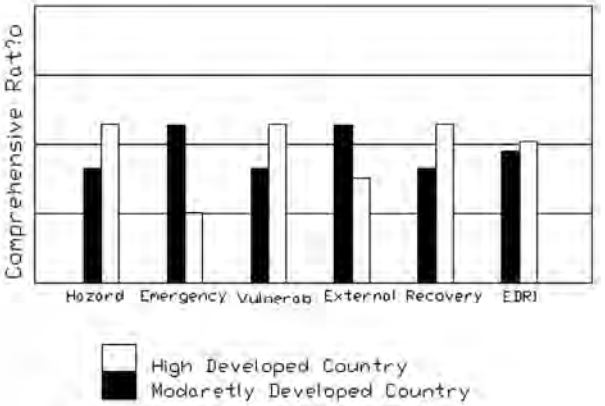


Figure 2.1.4 - Comparison model of San Francisco and Tokyo Earthquake Disaster Risk Indexes (EDRI); b- The comparison model of developed - USA and moderately developed countries.



many buildings were destroyed or how many people were injured, but also uncountable losses like the cultural heritage damages, functionality and some other urban components are. The 20-th century technology and intensive development of seismic sciences created a good methodological basis for urban seismic risk study. Engineering seismology investigations + engineering geology survey gave possibilities for earthquake resistant designing, which was the first very important step in salving people and their houses from earthquakes. For example - In 1923 all Tokyo was stressed, destroyed and burnt by the earthquake, but in 1995 the earthquake influence was much more less. San-Francisco which is located in a seismic prone area does not have any damages like in 1906 any more because of the earthquake resistant designing.

But earthquake resistant designing is not enough because seismic events continue to shock us. In 1995 the Kobe earthquake took more then 5 000 people's life. That is why Japan is seeking new planning ways for seismic risk reduction. In other words we can say that the study of urban seismic risk in Japan and USA is going on very intensively.

The Urban seismic risk is dedicated to study the influence of urban components on its grade separately and in complexity.

The methodologies used for these investigations were mostly based on the mathematical calculations and artificial intelligence.

It is very important to classify the urban factors according to their seismic risk because in different situations they are different. For example priorities of historical and modern centers are different: that is, in historical center the importance of historical heritage is higher, while in modern center its functionality and communications are more important.

According to existing practice we can identify two ways of seismic risk reduction:  
Partial reduction - by means of distribution or reorganization (Fig. 2.1.1).

Total reduction - by means of liquidation. For example in Anchoridge CBD was moved from old city to suburb, and the park was created instead.

The seismic risk reduction of engineering and utility services is possible by creating additional supporting lines (Fig. 2.1.2).

Communication ways can be linear, parallel or like a net. As usual linear and parallel types are used for the cities and regions, nets - for the building stocks. The seismic risk in case of linear connection is very high and it must be reducing by the creation of additional lifelines (Fig. 2.1.2).

The seismic risk must be considered at all stages of urban System (Fig. 2.1.3).

In countries where the links between stages are better and closer the seismic risk is much less. We can see it from the results of RADIUS Project. The comparison of San Francisco and Tokyo Earthquake Disaster Risk Indexes shows that the seismic risk of these two cities in case of hazard and repairing possibilities are the same but the difference is in emergency respond and external context of the city (Fig. 2.1.4). The emergency respond is much better in San Francisco because it is a new city with a high support at all levels, while in Tokyo a lot of problems in historical part creates more difficulties for city organization in whole.

The developed comparison model - USA and moderately developed countries also shows that in spite of high seismic hazard the seismic risk in developed countries is less (Fig 2.1.4).

The urban seismic risk investigations show the importance of urbanists' and urban planners' activities. Especially it is important in Georgian case where the new governmental program of spatial arrangement was expected<sup>1</sup>.

Spatial Structure (Fig.2.1.5), Kars-Ninotsminda-Java, Prospective



Figure 2.1.5 - Spatial Structure of Georgia. Kars-Ninotsminda-Java line.

Connection in Case of Deoccupation.  
In terms of the results of earthquakes it is very important to consider the following recommendations during the urban planning:

- To consider the seismic intensity of the region during the planning of the reconstruction project.
- To remove ruined buildings in time.
- The disposition of the buildings of public significance and important buildings in safe territories.
- Making of parks, green recreational areas in seismic hazard areas, building of underground garages and parking-lots in order to unload heavy traffic in the center of the city
- Organization of the movement system in the region - creation of new passages instead of damped buildings by partial opening of ground-floors and deadlocks, which will significantly facilitate the evacuation of population and other salvage operations during the earthquakes, other disasters and their secondary element (fire, flood, landslide etc.).
- The positive influence of basements on the earthquake resistance of the buildings in case of regulation of underground waters, can be used as additional territories, that will safe historical buildings from high neighborhood.

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<sup>1</sup> - Freedom, Rapid development, Prosperity, theGovernment Program 2016-2020, Spatial Planning, 2016. Presentation of State Spatial Planning Program, Infrastructure Projects to Implement by Government of Georgia, 2016.

# Urban Seismic Risk Reduction and Its Management in Historical City Center

Authors: Nino Chachava, Zurab Kiknadze, Vladislav Zaalishvili, Sergo Gogmachadze, Nino Tsereteli, Nikoloz Arevadze, Malkhaz Lekveishvili, Tamar Khoshtaria, Igor Timchenko

## Introduction

The importance of the City center in urban life is very significant. It represents the heart of the city which defines life of the town in its whole and shows the ways of city development.

The multifunctional nature of the center creates various difficulties during the research process of the behavior of its building stock and it is complicated by the existing historical monuments, as there is a great misbalance between modern life demands and existing old infrastructure with its obsolete old buildings.

Such kind of buildings are under the risk of collapse and become very dangerous for its inhabitants in the seismic area, such as south Caucasus, especially the historical part of Tbilisi, which is the capital of Georgia and a significant geo-political center in the Caucasus.

For these cases it is necessary to study the problems of reconstructions taking into account the seismic hazard of the territory.

The success of the reconstruction of the buildings sited in the seismic zones depend on the definition of the following points and the relationship between them:

1. Risk of building destruction caused by earth quakes;
2. Risk of secondary activities of earthquakes: fire, landslides, floods, stone fall, snowfall, etc.;
3. Analysis of the recent earthquakes and lessons

4. Mechanisms that can implement successful protection of building stocks against earthquakes: governmental policy, legislation, education, insurance and other faces of social - economic aspects;
5. Seismic risk measurements in order to define buildings' vulnerability;
6. Reconstruction as an opportunity of minimizing seismic risk.

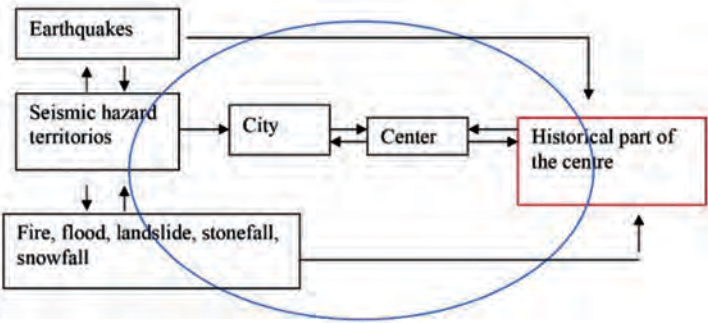


Figure 3.1.1 - Overview of The development of urban seismic risk in Historical Part of the City Center.

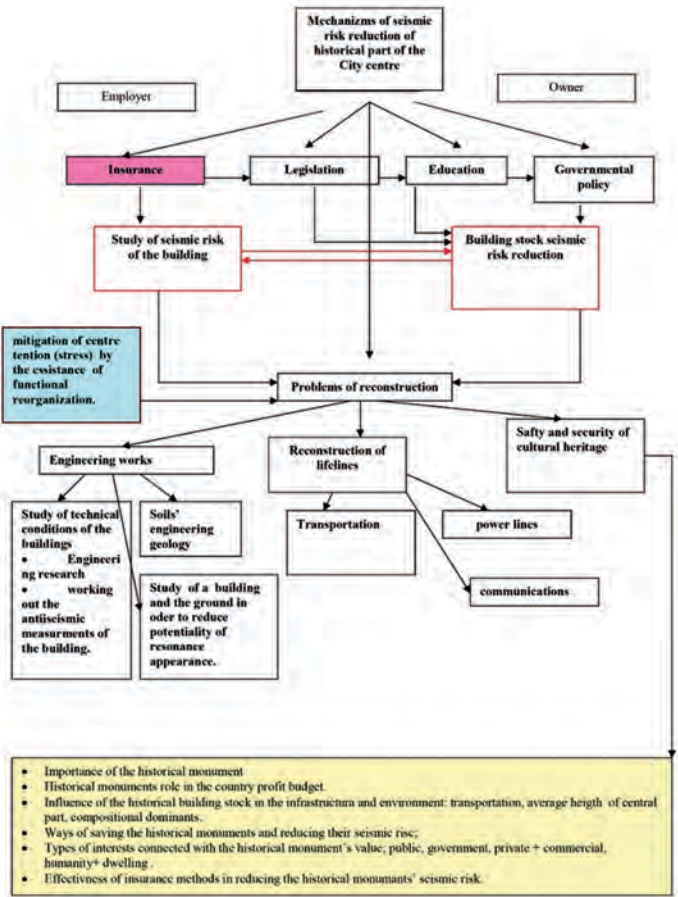


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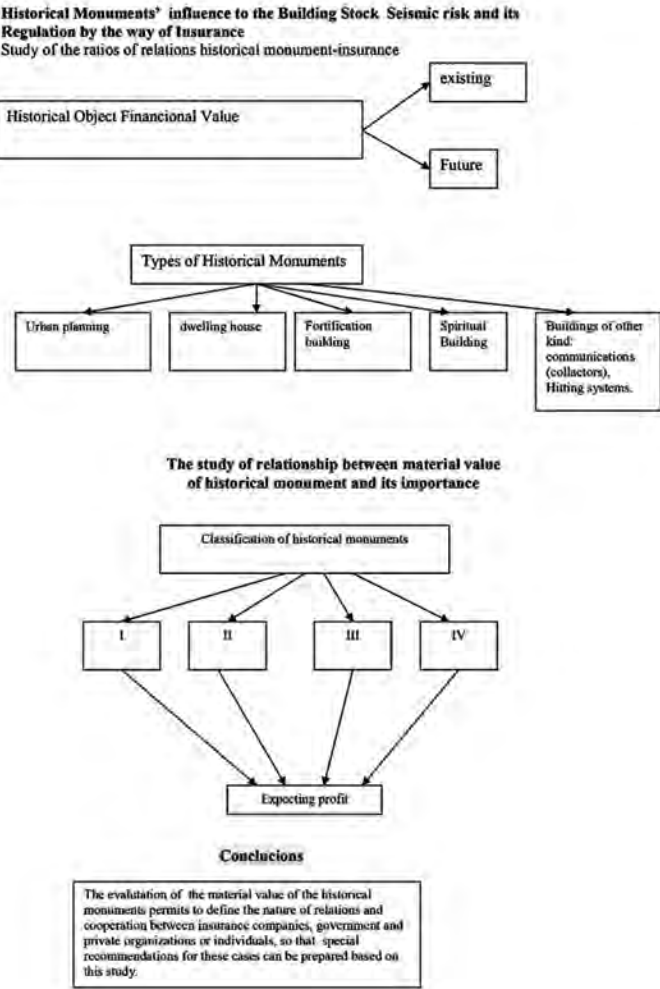


Figure 3.1.3 - Insurance as a Seismic Risk reducing Tool.



3.1 The Process of Studying the Building Stock Seismic Risk Based on the Functional Properties of Buildings

The regulation of the social and functional processes in urban development can be realized by urban planning. The concentration and location of urban functions is based on the usual social relations between the inhabitants, their general demands, their work and their ways of relaxation.

The study of the functional properties which influence the historical building stock seismic risk must be carried out by analyzing several similar objects. Those should be placed in the historical area in modern cities like Tbilisi (Capital of Georgia), Istanbul (capital of Turkey), Skopje (Capital of Macedonia) and Rome (Capital of Italy).

The functional properties' study includes:

- Objective survey of the study area;
- Definition of the functional meanings of the objects;
- Collection of features regarding the technical and economical meanings of study area (building stock);
- Characterizing the building stock according to the level of its seismic risk and the seismic microzonational map of the territory: very high hazard area, high hazard area, moderately low/lowest hazards.

On the basis of above mentioned surveys it is recommended to prepare a scenario of a possible earthquake so that the seismic risk inside the defined area can be studied by alternating some of the functional properties:

- to take away some objects of critical use;
- to designate special function to the historical center like tourism, culture, education or business.

The complexity of this study regarding the functional properties will give us the possibility to make some recommendations of

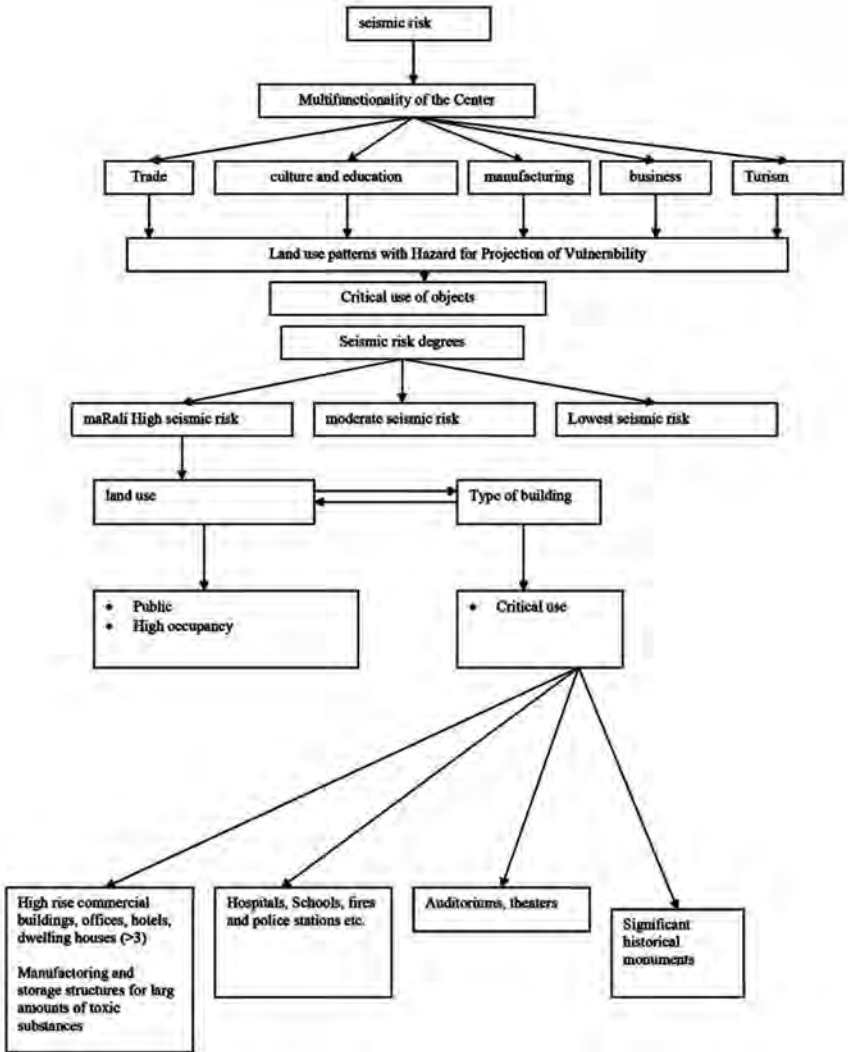


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seismic risk reduction.

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Figure 3.1.3 - Insurance as a Seismic Risk reducing Tool.

Figure 3.1.4 -Overview of Land Use opportunities in Seismic Risk Reducing.

## Reconstruction As a Tool of Seismic Risk Reduction

**Authors:** Nino Chachava, Zurab Kiknadze, Vladislav Zaalishvili, Sergo Gogmachadze, Nino Tsereteli, Nikoloz Arevadze, Malkhaz Lekveishvili, Tamar Khoshtaria, Igor Timchenko

### Reduction Reconstruction as a Tool of Seismic Risk Mitigation

The role of historical center in life of the city is significant. It represents the heart of the city, which defines the ways of the city development. The typical part of the center, its historical quarters creates the individual face of the city. It is not only one of the most crowded and active districts with significant transportation routes, administrative, residential, cultural and business functions, but it is characterized with the high density of building stock and population as well.

The multifunctional nature of the center creates various difficulties during the reconstruction and urban development process. There is a great gap between modern life demands and existing, old infrastructure with its damaged, deteriorated old buildings<sup>1</sup>.

The recent 2000, 2002 earthquakes in Tbilisi have significantly hastened the damage process of old buildings, made all kind of risk unacceptable. The possibility of disaster has become very real and expectable with the high probability. The urban seismic risk mitigation has become necessary for the future sustainable development of Tbilisi.

The complexity of the problem forced the specialists of urban planning, earthquake engineering and engineering geologists to organize the study of seismic risk of historical quarters to find the ways of rehabilitation-preservation policy. In this investigation artificial intelligence has been used as well.

Deteriorated brick buildings constructed at the end of 19-th and in the beginning of 20-th centuries, most part of which is in emergency condition, make approximately 40% of the building stock of Tbilisi and more than 90% in the historical center (Fig. 4.1). Among them there are schools, kindergartens and hospitals.



Figure 4.1.1- Brick buildings in the historical center of Tbilisi.

Typical quarter of historical center with the homogeneous building stock and similar seismic hazard has been investigated using the Expert

System methodology. The territory of the selected quarter was divided into 9 sectors for higher accuracy of results. Sixteen urban factors were considered as a whole<sup>2</sup>. Among them are not only engineering parameters like damage grade, type of soils, soil thickness, but such characteristics as functional destination, density of building stock, density of population, functional usage of streets and roads, distance from the safe area, historical and cultural value etc.

The data bank of the buildings created for this survey was based on the materials of past reconstructions and the special research. Various factors were picked out and formulated for seismic risk mitigation. The parameters of factors were defined and formulated according to their ranges and weight coefficients for quantification of seismic risk level. The urban factors were ranged correspondingly to their contribution to seismic risk increase (risk-physical state, risk-functionality, risk-transportation system etc.).

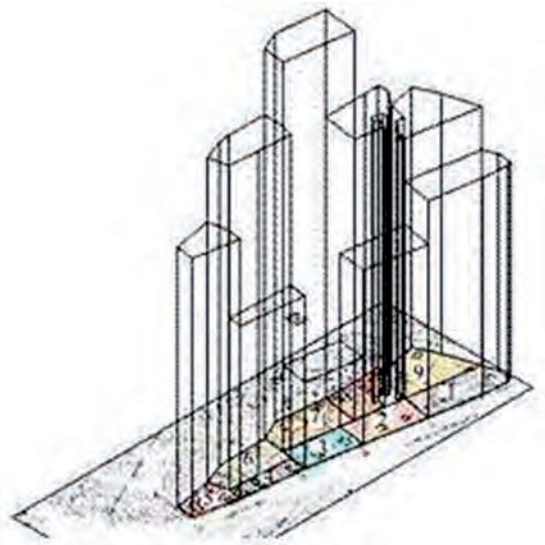


Figure 4.1.2 - Seismic risk level for groups of similar buildings.

From the ratio of the real risk of the building to the maximum one it has become clear that despite the apparent homogeneity of the area under study, values of seismic risk, calculated by Eqn. 4.1.1, vary in different sites of the selected quarter (Fig.4.1.2). It indicates the necessity of the complex estimation and shows the influence of different factors on seismic risk formulation. In an outcome of research the general recommendations on planning and designing, rehabilitation and reinforcement of existing buildings, as well as recommendations for improving engineering-geological conditions of the territory at planning and reconstruction of historical part of the city have been developed<sup>3</sup>. Some of them are presented in Figure 4.1.2.

$$R_j = \frac{\sum_{i \in S} f_i(k_{i,j})}{\sum_{i=1}^n f_i(k_{ij}^{\max})}$$

In Eqn. 1  $R_j$  - value of relative seismic risk of the site;  $f$  - value of a function or modifier which define risk;  $s$  - number of factors which define risk of one element;  $n$ - number of factors which define risk;  $j$  - index of a site.

The recommendations made us to consider and find the further ways of seismic risk regulation (mitigation) in the field of urban planning, architectural design and historical heritage preservation:

- To consider seismic hazard of the region during planning of the reconstruction project.
- To carry out the demolition of heavy damaged buildings and perform reinforcement measures in time.
- The disposition of the buildings of public significance and responsible buildings in convenient territories is recommended.



- Making of parks, green recreational areas in sites with higher seismic hazard is rather expedient.
- To build underground garages and parking places in order to unload the heavy traffic in the center of the city.

Organization of the movement system in the region - creation of the new passages instead of deteriorated buildings by the partial opening of ground-floors and deadlocks, which will significantly facilitate evacuation of the population and other salvage operations during earthquakes, other disasters and their secondary effects (fire, flood, landslide etc.).  
To build underground floors because of their positive influence on the earthquake resistance of buildings (in case of regulation of underground waters), which can be used as additional territories that will safe historical buildings from high rising as well.

Eqn. 1 is more conceptual, than numerical. Product of design parameters and expert modifiers which can be specified by statistical or expert methods, enable to improve and realize in further model that depends on character of the primary information and political demand of objective results. Change of seismic risk in different sites in rather homogeneous deteriorated building specifies importance of town-planning factors in seismic risk formation. In the given example building was in a zone with identical seismic hazard. For sites with different seismicity the results will have the greater dispersion as the factor of seismic hazard has the big importance.

The model, as a matter of fact, represents an earthquake scenario, it results in that, and any reconstruction of buildings in essence does not reduce seismic risk of building. It is caused by influence of other town-planning factors which have not been considered during reconstruction. For example, in case of existence of the adjoining deteriorated buildings there is a danger of damage of the adjoining reconstructed buildings, a blockage of passes in case of destruction of the deteriorated building. The value of a transport infrastructure in historical city specifies increase of

seismic risk in depth of building where time of evacuation depends on the distance from transit highways and squares to the objects.

The concept of liquidation of an earthquake consequences, proposed after the 2002 Tbilisi earthquake<sup>4</sup>, can be considered as a part of the above-stated multifactor approach. It is not based on European documents, includes only engineering aspect - vulnerability level of buildings. The possible strategy is to reinforce damaged buildings up to the level to exclude damages of grade 3 and more in case of the future earthquake of design intensity. This statement can be used for historical center taking into account other engineering and urban factors.

Conclusion

The historical part of the Tbilisi city is experiencing combined and cumulative exposure of regular vibrations due to intensive traffic, periodic earthquakes of intensity 5-6, exposure of the 2002 earthquake of intensity 7 and influence of complex geological conditions worsening with each year. Therefore by performed estimations, buildings of the historical center have high vulnerability level and they can be related to high-risk group with few analogues in the world.

At seismic risk assessment of historical sites not only engineering parameters - vulnerability, damage grade, type of soils, soil thickness - but such urban characteristics as functional destination, density of building stock, density of population, functional usage of streets and roads, distance from the safe area, historical and cultural value etc. should be taken into account. At development of a possible scenario of a future earthquake of designed intensity all the mentioned factors should be taken into account. The intensive implementation of new technologies of injection and reinforcement made possible to accelerate the retrofitting processes in historical centers, allows to keep the safety of decorative elements of external walls, make available the engineers to

work without resettlement of inhabitants. The reconstruction of historical center as the complex of engineering and urban planning procedures is an effective measure for seismic risk mitigation.

Seismic risk mitigation of historical cities, in conditions of its multifactor content, can be reached only by complex town-planning, engineering and volumetric reconstruction. The model of definition of seismic risk can be considered as a part of a technique of a complex town-planning assessment of the territory of the historical city.

CHAPTER 4 LIST OF FIGURES

Figure 4.1.1 - Brick buildings in the historical center of Tbilisi. Photo of N.Chachava, 2003

Figure 4.1.2 - Seismic risk level for groups of similar buildings. Materials from Chachava, N., Lekveishvili, M., Timchenko

NOTES

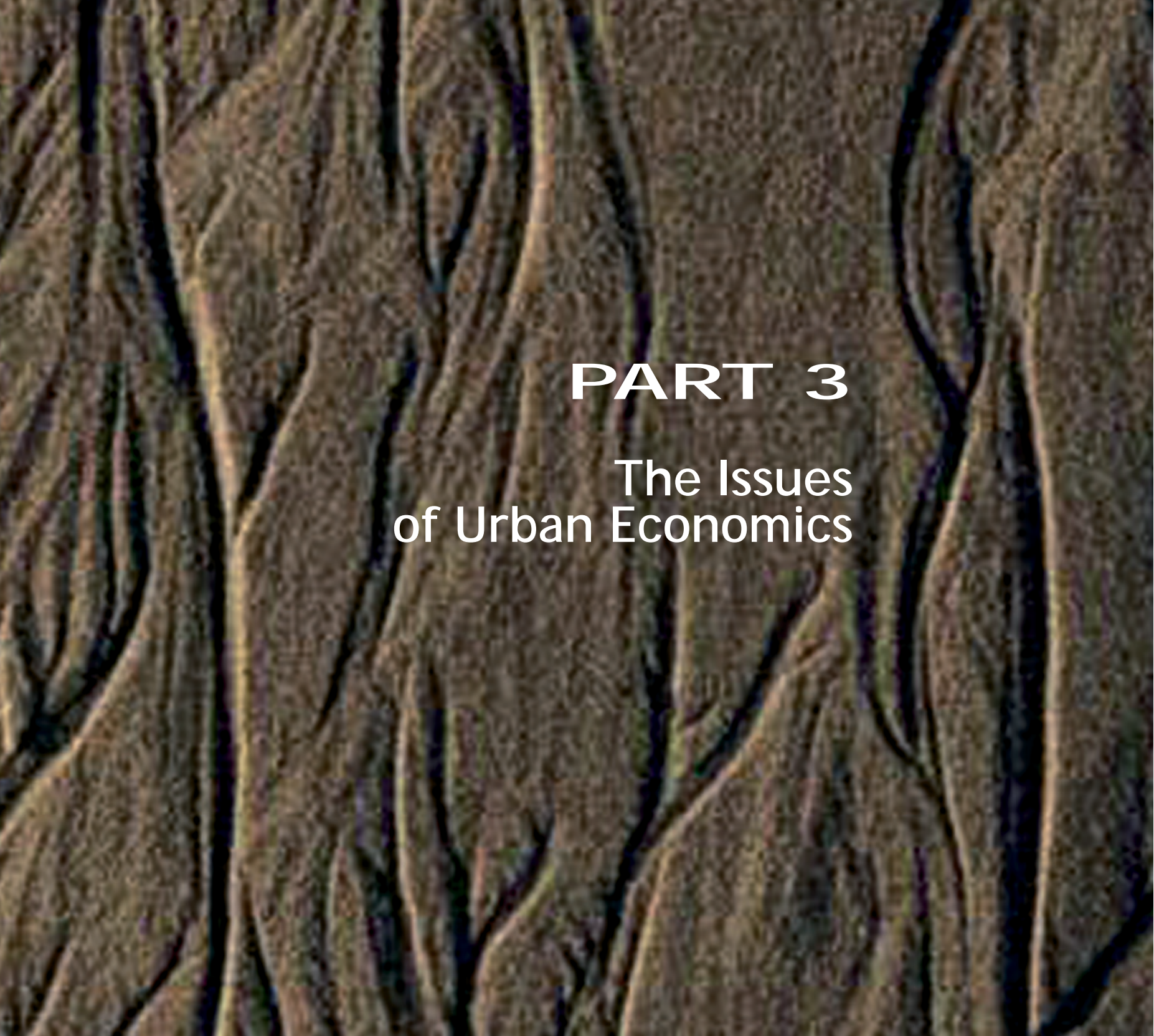
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# PART 3

## The Issues of Urban Economics

### The Analysis of Urban Import-Export Operations

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#### Introduction

Transition to contemporary Economic caused diversity of structures of ownership patterns. Of course there are changes in foreign economy together with transition to market economy. Economic subjects begun working on activities that were taken as prerogative of just government in soviet state. First of all they began to make import transactions independently and after it they organized export of production. The companies assimilated the free niche and are keeping up growth and development. Export and import operations are the most important economic activities for our country, since we depend on import and for reducing negative balance it's important to increase export share. Keywords: Economic development, export operation, foreign economic activity, import operation.

#### 1.1 General Overview of the Problem

The economic development strategy aims to identify structural issue and objective of the urban territory development for the next ten years. At Metropolis, we have identified some problems of territorial limits. That means collectivity of the territory is narrowest than its employment area. We have another problems in business integration for the definition of our economic strategy. Metropolis wish to improve the collectivity wellness by offering the special actions to the companies and other economic players. Another objective is to identify economic development barriers and to solve them. Finally, to allow a sustainable construction involving of public and private sectors, where the collectivity wishes would be

taking into consideration in order to install new economic governance. In this case metropolis have to develop the cooperation in order to work together and solve the common problems. Strategy and prospective mission of Metropolis would be developed according the urban impacts for solving the problems mentioned above.

Externally, the economic activity is one of the most important sectors of the modern economy. With globalization, the operation of export and import steel locomotive and driving force of our economy, despite the fact that our country is an active participant in these processes - there are many problems in this area, to solve these problems an important role is played by the audit. State structures as individuals to make decisions necessary to have reliable and accurate information. Audit FEA-a fairly complex and lengthy process, because range of activities went beyond state borders and the need to take into account both local legislation and international. Based on the data submitted by the audit planned operation on export and import, in turn, affect the growth of the economy. The study of this question a positive impact on our economy<sup>1</sup>.

Foreign economic affairs, specifically export and import operations, are the most important part for our Country's modern economic development, that grounds from early 90th.

#### 1.2 Development of Economic Activities

The term-Foreign Economic Activity (FAC) is used in our country since 20century 70th. From the beginning it meant just trade



between Soviet union and other countries, after gaining independence, Georgia begun forming relations with other countries and deepened trade economic, that's quiet hard and long term process and of course it's not finished yet. The definition of Foreign Economic Activities have been widened lately and right now covers material trading together with other activities: cooperation with foreign companies, international transportation companies, banking, insurance and so on.

Development of Foreign Economic Activities includes development and stability of economic. Privet companies play a major role during this process. For ex: according to National Statistics Office of Georgia-GEOSTAT data, in 2007 the External Trade Turnover was about 6444 mln USD and in 2016 about 9350 mln USD. These figures are main components and parameters of economic development. The validation of this data is too significant, so it defines importance of the audit and monitoring of those activities, equally both for country and for companies that are responsible for this work<sup>2</sup>.

Foreign trading includes import and export of goods and services of different countries. The exchange products are: clothing, shoes, perfume, food and so on. Also it includes trading types such as: selling licenses, franchise and etc. One of the most important part of foreign trading contains customer service, which covers bank services, insurance, international transportation and so on.

The trade deficit of goods improved in 2016. This reversal in trend was driven by a decline in imports by 1 percent (excluding imports of grant-funded hepatitis-C medicine, representing 30 percent of total imports in 2016), although export was slightly down as well (by 4 percent). The trade balance was positively affected by higher export of copper ores, alcohol and unprocessed gold in 2016, while export of used cars, ferroalloys, pharmaceuticals and mineral fertilizers declined. The share of EU countries in total exports declined by 8 ppt to 27 percent of total during 2016. Tourist arrivals increased by 7.6 percent in 2016, Remittances rose by 7 percent due to considerable pick-up since June 2016 after long period of decline.

Government plays decisive role within development of country economic. Government should have legislative base that will stimulate business development, simplify business making opportunities, offer benefits for local suppliers and insure production exports. According to this case, we've to mention that there were made major changes in legislation, according to what entrepreneurs are released from paying vat.

According to Georgian internal revenue codices, paragraph # 168, 4 about release from vat payment: A) product export or re-exportation is released from vat payment, just during the period when it's stated in declaration<sup>3</sup>.

To elucidate the main idea and tasks of Foreign Economic Activities and method of analysis, at the first step we've to clear up who is the subject and object in everything that . Foreign economic activity maybe legal or retail entities, also countries and regions, that have opportunity to cooperate without limitation, only limiting factors are legislative limitations.

In terms of rapid globalization, the economic zone became more widen and because of it corporations are oriented toward foreign economic relations, for improvement and strengthen their positioning and became competitive among high competitive environment. This activities have its pros and cons. For example to enter foreign market causes high expanses such as transportation cost, corporate cost, marketing activities cost and many other, this costs are unavoidable, when you want to maintain new product and assimilate foreign markets. But it also gives an opportunity for high revenue, up growths companyborders,access to high tech achievements, investigations, long term profitability and so on<sup>4</sup>.

Abandoning the importanceof marketanalysis andcompany audit,make decisions just according non reliable forecasts,may cause fatal results for companies and cooperation, during development and assimilation of new Markets and especially during entering foreign markets. The main idea and goal of conducting audit isn't just learn specific market and make conclusions, but to

analyze how rentable the market is for making new steps for growth and development, dipper understanding the internal situation of company, if it has an ability to overcome resistances, dose it has necessary resources, both material and human to overcome upcoming difficulties and problems that could be razed up. The knowledge of legislation of new country you are going to enter is majorly important, before making any decision and activities. Understanding main differences between local and foreign legislation, what kind of influence it may have for future development, variability of exchange rates, define risk estimate and only getting and analyzing all this data make activities and implement future plans<sup>5</sup>.

The custom is responsible for export operation analyzes and main indexes. Customs are using different types of accounting, Statistical method of analyzes, graphical method, indexing method, balance method, dynamical method of foreign trading and etc.

It's impossible to get clear picture of research just according to statistical analysis. For the first step systematization of data should be done, after collecting all necessary data the statistical data are collected and sorted. Whole statistical data are separated by groups and after this groups are sorted by types of operations. Customs, during grouping statistical information are using following subgroups: general information about export, export data by regions, export by nomenclature, value of export and volume<sup>6</sup>.

Statistical subgroups may be presented by custom mode. Statistical data is main instrument for analyzing appropriateness of indexes. Diagrams and graphics play also an important role during analyzing processes. During export operations we are using following indexes: average indicator of export growth and rate of growth.

The goal of research is moderation of dynamics and forecasting of future events, that gives an opportunity correctly organize and define economic processes. Moderation gives huge information and according to it you can forecast probable growth and future plans, internal and external markets play a major role and have strong influence on our economic. To overcome these issues,

audit ensure sits systematization and accuracy<sup>7</sup>.

Import is: bring or carry in from an outside source products and service and results and intellectual activities, especially tobting in (goods or materials) from a foreign country for trade or sale. Import is divided into following categories: Material and Nonmaterial. Nonmaterial includes: Tourism, insurance, transportation, money transfer and etc.

The volume of import is defined after the borders of import country are crossed.

Import operations should be analyzed: by structure, amount of import, volume of import and transfers, its share in total transfers, bank income, what's the share of import in total transactions according to custom declaration, countries and products. During foreign economic activities entities are cooperating with foreign and local organizations, with banks. They are forming agreements and budgetary payments. Controlling and monitoring is produced by financial accounting method, export and import operations are included. Submitted transactions have to be correspondent together with international accounting standards and local legislation<sup>8</sup>.

The main goals of Audit are:

1. Study of methods of internal control. Monitor if export/import operations are correctly and fully registered.
2. Correct accounting of foreign liabilities, rational usage of resources and accordance with import/export operations.
3. Insurance of getting planed missions and avoids unrealized liabilities.
4. Overlook total foreign economic activities.
5. Usage of internal reserves and forecast future aims.

It's important to analyze import and export indexes during valuation of company productivity.

During analyzing the data, it should be studied by countries and the revenues of previous years considered. According to quantitative

and income analyzes, the reasons of export/import raze and falls are defined. The reason of reducing export may be: problems with transportation, overloading of ports or risks according to exchange rates and reductions, changes in international market and so on.

Companies have to be quality oriented, as they are intended for export, and insure quality of products that are defined for import. Product quality has main influence on the amount of product imported and exported. Aim of audit is to study product quality and its accordance with presented certificates, also to display the cons and weaknesses. The total amount of fault in whole export/import, refund of faulty items and in a case of repairing how timely and utterly was the damage compensated<sup>9</sup>.

The audit of import operations and the auditor have to learn the amount of import, delivery terms and conditions and according to this prepare acts. These acts include all claims according to quality, quantity of faulty items and loss. The loss contains not just the cost of products but also any additional costs that's bundied with product delivery and any other expanses company have to spend. During compensation of the loss auditor have to define marketing activities and results of those activities, on which relies amount of import/export, if the activities were planned and implemented correctly.

Analyze if it's possible to raise amount of import/export according to elected strategy and in a case of inevitability make changes. Auditor has to mention in final conclusion/recommendations according the whole process.

Next step is analyzing the contracts, their accordance to legislation. How correctly are composed documents and monitoring of internal controlling departments within organization, dose the logistic department accounts correctly merchandise movement and is there any chance of production damages and loss while the final customer gets it<sup>10</sup>?

Following documentations have to be searched and cleared up:

- Documents of transportations, blading, invoice and so on.
- Act of receipt, confirmation of merchandise delivery in port or warehouse.
- Fitness of product and amount customer had paid.
- Confirmation of client (if the goods are received) and in a case of lack or additional product writes a claim.

Auditor controls how correctly are this operations accounted by accountant, is freight transfer and documents according to which are money transfers done and their confidence with products delivered controlled, is every transaction reflected, product on sub account, for example: merchandise on the way and are the additional cost totally and correctly reflected.

It's in touch not just with production, but also with costs, taxes, transportation cost, insurance and etc. the object of study also is understanding if the costs are unavoidable and find any ways for reduction and raze its profitability, delivered products payment conditions and dates. Also many other cases that are connected with economic activity of subject.

During conducting audit it have to be learned difference between the product cost sold in internal market and its cost during export, this underlines how effective export is.

Export is free from any taxation, this case is also under study, which taxes are not foresee during export and how correctly are calculated costs and expenses. Also during import it's necessary to measure difference of custom expanses that are and should be paid.

Audit has to check the following info:

- If the entity has permission for import and export operations.

- Are the export documents correctly submitted?
- Accordance of contract and export declaration.
- Accordance of money receipt and cost of good delivered.
- Correct calculation and payment of taxes.
- Correct calculation of product cost.
- Correct calculation of gain from exported products.
- Correct declaration of export transactions within delivery term- consignment.
- **Correct financial accountant of goods delivered from warehouse in other country.**
- Correct accountant of products that are exported outside country because of recovery.
- Correction of transactions according to products that are sold with mediator.
- Correction of transactions of imported goods.
- Calculation of taxes during custom.
- During import check if document are relevance with custom goods.
- Correction of transactions sold in foreign currency.
- In a case of re-export or Barter, correct financial accounting.
- Correction of currency exchange operations.
- In a case of leasing - control and monitor agreements.
- Find out and fix any errors according to foreign economic activities.

The correct accounting of credits that are taken or given by Foreign Economic Activities, in order to avoid unreasonable spending of funds.

We live in an age of cities, yet cities are the nation's most notable failure. The nation has weathered the shift from a rural to an industrial society but has not coped with the urban revolution that came in its wake. The book is therefore timely, and if it will irritate some of the experts it will also help bring some neglected issues and theories into public focus. This, after all, has always been Mrs. Jacobs's most notable talent and her

most constructive contribution [11].

Mrs. Jacobs disregards most of these and other scientific studies of cities and regions. She ignores or slights such important influences on the urban economy as location. Basic resources, climate, transportation. Availability of skills. Differential wage rates. The impact of government policy. Particularly taxation and subsidies, public development strategies and other factors that speed or retard urban growth. Her theory is put forth in a kind of vacuum in which cities grow or wane in accordance with her few simple rules.

Influences on the growth and decline of cities. However, are not only multiple but change with times and conditions. Among the factors conditioning urban growth today, for example, are the availability of the right executives and the living conditions in cities.

As the volume of its exports and imports grows, a multiplier effect is set in motion and more and newer kinds of goods and services are produced. As imports are replaced by local production, economic activity expands and by generating new and more exports, the city earns more imports. If it loses some of its export production to other cities, it may produce new exports to compensate for the losses. As the city continues to generate new exports and can afford more imports, the city's economy expands. If the process slows. Its economy declines.

Role Georgian Local Authorities to support foreign economic activities: Tbilisi and Tbilisi metropolitan area is the economic center of the country. This area generates 48% of national GDP and GDP per capita was 85% higher than in the rest of the country<sup>11</sup>. It is the metropolitan area with the highest number of enterprises - 45% of the country's business units are registered there<sup>12</sup>. It generates more than 50% of state tax revenues<sup>13</sup> and 70% of total business turnover<sup>14</sup>. Tbilisi metropolitan area the main driver of economic growth and the biggest consumer market in Georgia and its development has wide implications for growth and prosperity across the country. The metropolitan area's



locational advantage and connectivity offer opportunities for economic growth. The area is easily accessible via railway and the highway network in the Caucasus region. Within a one hour flight from Tbilisi, businesses can access a market of 100 million population and \$100 billion market; and a 1 billion population market within a 4 hour flight.

In recent years Tbilisi metropolitan area’s economy has been performing strongly, however a significant part of the growth took place in consumer services and construction, which are non-tradable sectors<sup>15</sup>. The dominance on non-tradable sectors reinforces Georgia’s trade balance issues and restricts growth. With Tbilisi accounting for such a large part of the economy it is no wonder that this reflects the national story. Sectors that have been developing most rapidly in recent years include Hotels & Restaurants, Wholesale and Retail, Construction and Real Estate and other Business activities. Thus, economic growth has been driven by the expansion of the tourism industry and real estate investment, a large portion of which has also gone into hotel development. This growth model is unsustainable. And for now there are no alternative growth drivers on the horizon: manufacturing sector is weak, business services and financial sectors are not developed enough to drive growth and innovative activity is limited.

Tbilisi’s economy is dominated by large firms although small and medium enterprises represent the fastest growing segment. The economy is mostly reliant on large firms that contribute to more than 60% of employment and 85% of turnover, both significantly above national average<sup>16</sup>. However, in recent years start-ups and small businesses are starting to play a more significant role in the economy. Total employment in small enterprises grew by 90% in few years and the share of total employment in small firms increased by 1.5 percentage points. These suggest that small businesses in Tbilisi possess significant growth potential that the city should build on.

Despite this, export promotion isn’t priority for Tbilisi Municipality and for other municipalities in the metropolitan area. By

Organic Law of Local Self-Governments, Georgian local self-government authority shall be entitled to take actions in accordance to the rules as defined by law, for the purpose of promotion of employment, attraction of investments to the municipality, support of innovative development. Based on this, Strategic Direction of Tbilisi City Development Strategy is productivity, but Initiatives for strategy implementation include:

- To make Tbilisi the gathering point for artists by facilitating and providing opportunities for promotion and marketing.
- To strengthen the City’s capacity to produce, attract and keep talents.
- To extend skills, employment and training opportunities to all citizens, including increased apprenticeships to create competitive workforce in the city.
- To convert Tbilisi into the innovation Hub of entrepreneurship and to attract, enhance and concentrate global minded early stage entrepreneurs to start their businesses in the city.

In Georgia only state authorities are care about export support. Entrepreneurship Development Agency<sup>17</sup> activities are very important for export support. Activities include:  
**International Trade Fairs** - The agency organizes the presence of Georgian stands at international trade fairs. Sectors and fairs are selected based on the requests from the companies.  
**Local and International Trade Missions** - Enterprise Georgia arranges meetings between Georgian exporters and potential international partners, both inside and outside of the country.

The number of participant companies and the frequency of their participation is usually not restricted. B2B meetings are arranged according to the specific needs of Georgian companies.

**Trade Portal and Online Export Database** - [www.tradewith-georgia.com](http://www.tradewith-georgia.com) is a trade portal and online export catalogue, with detailed information about Georgian products and services. Using

the “Business Inquiry” function companies will be able to publish their requests and offers directly on the website.

**Participation of Georgian Products at International Awards** - In order to promote Georgian export, the agency actively supports companies in submitting entries into various International Awards.

Conclusion

Foreign Economic Activities is changing every day, export/import operations share is rising , and also changes there types, its important entities to be involved and deliver correct and truth worthy information, that will have positive influence toward economic growth and future forecast and planning of operations. Any additional needless expanses will be avoided, Audit of this operations is important not just for country but alsofor the individuals who are involved in agricultural economic activities. Government involvement and support will definitely have a positive effect on long term perspective.

NOTES

<sup>1</sup> - International Auditing Standards, Tbilisi, 1998.

<sup>2</sup> - The Law on Entrepreneurs, Tbilisi, 1994.

<sup>3</sup> - Baratashvili Evgeni, Pailodze Nino, Bolkvadze Ana, Sulashvili Giorgi, Potential of Comperative Management and Aspects of its Application in Georgia, International Scientific Conference, International Science Index Vol: 9 No: 7 Part XII. 2015. Paris, France.

<sup>4</sup> - Baratashvili Evgeni, Pailodze Nino, Bagrationi Lasha, Svanishvili Nino, Takalandze Larisa, Natroshvili Nato, Entropy factors management. International Scientific Conference, International Science Index USA, Chicago Oct. 08-09, 2015. 17(10) part I.

<sup>5</sup> - Kokrashvili Ketevan, Abralava Anzor, Kutateladze Rusudan, Pailodze Nino, Kutateladze Ketevan, Sulashvili Giorgi. Global Processes and Georgian Economic Policy. International Science Index Vol: 18. Dubai UAE Jan 28-29, 2016, 18 (1) Part XXV.

<sup>6</sup> - <http://notes4.state.ak.us/wa/postapps.nsf/JobsByDept?OpenView>. Checked eventually 02.05.2016.

<sup>7</sup> - <http://MUNI-AUDITS@OSC.STATE.NY.US>. Checked eventually 02.05.2016.

<sup>8</sup> - <http://www.gov.mu>. Checked eventually 02.05.2016.

<sup>9</sup> - <http://www.dpi.state.wi.us/dpi/grants.html>. Checked eventually 02.05.2016.

<sup>10</sup> - [www.nbg.gov.ge](http://www.nbg.gov.ge). Checked eventually 02.05.2016.

<sup>11</sup> - National Statistics Office of Georgia.

<sup>12</sup> - National Statistics Office of Georgia.

<sup>13</sup> - Ministry of Finance of Georgia.

<sup>14</sup> - National Statistics Office of Georgia.

<sup>15</sup> - The World Bank, Ministry of Economy and Sustainable Development of Georgia. Georgia Urban Strategy. Part two. Economic Role of Major Cities.

<sup>16</sup> - National Statistics Office of Georgia.

<sup>17</sup> - Entrepreneurship Development Agency (Enterprise Georgia) was established in March 2014 under the Ministry of Economy and Sustainable Development of Georgia. <http://enterprisegeorgia.gov.ge/en/whatwedo/export-Promotion?v=20>.





# PART 4

## Socialist Districts Exposed Sociocultural Urban Issues

### The Iniciative Groups and Phased Activities As a Trigger of Transformation and Revival. A Case Study of Gldani (Tbilisi). The Formation of Timebank Community

Authors: N. Lekveishvili & A. Andghuladze

#### Introduction

After the collapse of Soviet Union all its ideas and projects started to diminish, people who were promised better life conditions appeared in a new reality where their living spaces became gray lifeless ruins, where melancholy is harsh and a daily routine is monotonous. The local government failed to progress those district and up today, the residents find themselves living in the sleeping districts. Some of them tried to adapt to those conditions some tried to change it in their way, what made it look even more chaotic, after the shift from state regulation to a market economy, people had to reestablish themselves by reshaping its public and private spaces in alignment with the new economic system.

A lot of time passed but the reality stayed the same, districts and its inhabitants where in a constant search of self-identity. Previous public services were privatized and sold. Citizens had to use extremely poor public space with no infrastructure for living.

One of those district located in Tbilisi, Gldani is often referred to as a separate city, a micro-town situated on the northern periphery of town. The majority of “Microrayons” were built without basic facilities and were often converted into simple dormitory settlements. Inhabitants with better economic situation left the district and it started to attract people who were in need of cheap housing. In the result quality of life in Gldani was decreased at minimum level.

This paper will develop a prototype approach in the urban transformation of the typical soviet districts, it aims to find ways that can help sleeping

soviet-districts in finding their identity with minimal interventions. After analyzing the sequence of events which hampered the advancement of the district, the paper will concentrate on discussing the case studies and represent time bank- a module of contemporary bottom up transformation as the most convenient prototype for Gldani’s development. Where citizens are the main actors of the transformation.

The ideological vision towards the urban change inspired by Plato’s philosophy regarding the form and Henry Moors sculpture series “Helmet” will assist in composing unique ideological layout fit to the district.

#### 1.1 Historical layout of housing in Georgia in the 20th century

Georgia is a country located at the crossroads of Eastern Europe and Western Asia, a place where different cultures, ideologies, and architecture overlap. The capital of Georgia is called Tbilisi, which is the largest city and has a linear urban structure. Tbilisi has an interesting history of a soviet mass housing having taken place in the 20th century. The biggest urbanization and ideological transformations took effect after Georgia’s forceful integration in the USSR and after its dissolution.

According to the Georgian research group - “Urban Reactor”, soviet construction methods are divided into three parts: Avant-Garde, Stalinism, and Late modernism.



After the Russian Revolution of 1917, Soviet construction methods were mostly focused on sharing the living spaces and experimenting on the communal way of living. Wealthy citizens of USSR taken away their private houses and these houses were divided among other citizens of the union. Specifically, Avant-Garde approach led the inhabitants to the communist way of life forcing them to share the living spaces between each other. Avant-Garde epoch buildings still represent a significant part of the historic districts of Tbilisi and other cities of the Soviet Union. The transformation of private homes into communally shared housing envisioned the creation of a particular living model for a new communist society. Examples of such buildings are “Narkomfin” constructed by Moisei Ginzburg and Ignaty Milinis, in Moscow in 1932.

In the early 1930ies when Stalin’s power strengthened the avant-garde ideas were changed with more traditional approaches to town planning and housing, mainly concentrating on standardization of construction and planning.

If the 20’s were considered as a time of experimentation, Stalinist period started with standardization and massive constructions. The buildings were put up along the main avenues and squares hiding poor neighborhoods behind. This practice is widely known as “facadism” that showed Soviet the glory by signifying ornamental and decorative approach towards architecture.

1.2 Urban Layering of Tbilisi, a capital of Georgia

While walking from historical city center towards the suburbs in Tbilisi, it is impossible not to mention changeability of layers from one place to another. Starting from the 5th century when the city was first created, it went through four radically different urban developments. As Tbilisi developed along the river, four different urban layering formed side by side. Currently, there are four layers in Tbilisi.

First layer: The medieval town, historical city center

Tbilisi was founded in the 5th century AD and had a military structure. Namely, was surrounded by a fortress protecting the city from the enemies. The strategic location of the city has always been the issue of rivalries and wars between the main powers in the region, including Persia, Byzantium, Arabia, Mongolia, and Ottoman Empire. As a result, different cultures, ideologies and functions were overlapping and forming an eclectic pattern of the town. Due to the constant wars, Tbilisi shrank in population and economics and was almost on the brink of loss of existence as a country. Because of this fact, then Georgia’s King Erekle II asked protection from the north neighbor - Russia, which saved Georgia from Persian invasion, but incorporated the country into the Russian Empire.

Nowadays, the old town is full of touristic infrastructures like museums, galleries, cafes, and restaurants. Public life is most dynamic in this part of the city.

Second layer: European town

In the 19th century, after Georgia became the part of the Russian empire, the military structure of the old town lost its function and the city started to develop outside the fortress, the ruler of Georgia Mikhail Varantsev, invited European architects to renovate Tbilisi. Italian chief Architect Giovanni Scudieri, with a team of German and Austrian architects, managed to rebuild the old town from the ruins.

The old town was reconstructed on the foundation of the old buildings, having kept their traditional U-shape inner courtyard system on the back side of the buildings, while contemporary facades represented neo-classical architecture.

Presently, important national buildings such as national galleries, national museums, Opera, theater, and parliament are located in this reconstructed area. Wide streets are equipped with pedestrian

walkways, green infrastructure, and touristic sightseeing create an ambiance of public space.

Third layer: Stalinist City

After the 1917 Russian Revolution, the Bolsheviks soon gained control over Georgia and forcefully integrated the country into the Soviet Union. The rise of Stalin’s power resulted in a large-scale urbanization of the cities including Tbilisi, which later became a regional capital city. Tbilisi developed according to the master plans (Gen-plans) of 1934, stimulating hyper-urbanization of the capital cities of the Soviet republics. Under the Soviets, Tbilisi was transformed from a medium-sized, compact settlement into a large industrial metropolis. Communist symbols, monumental infrastructure, and strict shaping widely spread the architecture of the Soviet buildings. With the shift from private to mass housing in the late 1950s, the soviet urbanization policy concentrated on building “mass-produced”, cost-efficient and uniform construction buildings.

“Rustaveli Avenue” - the central avenue is one of the Stalinist projects of Tbilisi, which is now filled with university campuses, libraries, cafeterias, research centers etc. The neighborhood is considered as the most prestigious and highly developed part of the city.

Fourth layer: Sleeping city

After the collapse of the Soviet Union in 1991, Tbilisi, like other ex-Soviet cities, stepped on the post-socialist transition treadmill. Late modernism housing had changed but soviet idea of maximum standardization has remained. All building of USSR countries were built by same, standardized logic. The approbated methodology kept the districts full of residential era districts like Tbilisi’s “Gldani”. The Fourth layer of the city is a vivid example of the failure of soviet urbanization methodology, as it is completely isolated and disintegrated from Tbilisi’s center and its social life.

It can be considered that first three layers of Tbilisi have a social and urban relationship with each other and strong cultural meaning, while the fourth layer is totally abandoned and stripped away its identity.

1.3 “Gldani” - An experimental district

In the soviet era districts of the cities were built with exactly same building methods and aesthetics despite their locations or social structures. The architects were using most optimal, most cost-effective, simplest and quickest methods to build the districts. By building districts like “Gldani” destined for thousands of inhabitants, the Soviet government was attempting to urbanize larger areas and solve the problem of housing shortages. In order to achieve this goal, the government introduced cost-effective construction method by which the houses were no longer built but mass-produced. The period that most affected the mass production of these prefabricated blocks in residential suburbs like Gldani was greatly influenced by Nikita Khrushchev, who rejected the Stalinist architecture and called on architects, planners and engineers to develop “cheaper, better, and quicker” constructions.

“Gldani” is often referred to as a separate city, a micro-town situated on the northern periphery of Tbilisi. Gldani was named after the village on which it was built. The construction started in the 1970s and was the result of a master plan, prepared by the Soviet government for Tbilisi. “Gldani” consists of nine “microrayons” that stand for residential blocks accommodating 5,000 to 10,000 inhabitants. The necessary amenities like kindergartens, schools, health care, grocery shops, cinemas, and libraries are included in the overall structure of the “microrayons”. The “Gldani” settlement was originally designed for 147,000 inhabitants but the number of the residents has grown rapidly and reached almost 170,000 persons. As a result, “Gldani” became a dense and overpopulated place.

According to the soviet project, the buildings were built with large-panel structures and had 9 to 14 stories. 2.5 km long and 100-meter width central axis used to be the core of the district,

with pedestrian roads and highways in every 500 meters. The highways were arranged on two levels and were surrounded by other “Microrayons” from both sides.

In distinction with other soviet residential districts of Tbilisi, where the main highway divided the district into two parts, in Gldani’s case, public services were located on the central axis and were connected to the “microrayons” with bridges and bridge-buildings. As a result, central axis represented a consolidated pedestrian road system.

Planning of the Gladni’s “Microrayon” dwelling buildings radically differed from other “Microrayons” of Tbilisi where buildings were mostly placed solely and did not have many intersections with public spaces while in Gldani the public spaces were surrounded by residential buildings and those spaces, had defined functions.

The parking spaces were located beside the roads that were leading to the residential buildings. On top of the parking spaces, there were disposed recreational areas and sports fields.

This kind of disposition created multi-functional two-leveled areas. “Gldani” district was an example of a planning system where different structures with different functions were located on different levels but in the end, created one entity.

When discussing Gldani district, it is important to highlight two peripheries of the district - “Gldanula” and “Gldani 3A Microrayon”. These two peripheries are notable as the arrangement of the residential buildings create enclosed square yards that are surrounded by 9 and 14-story prefabricated buildings. The enclosed yards are different in scale, the smaller courtyards are destined for leisure activities and children’s playgrounds while the bigger ones are used as sports fields. Enclosed square yards create tranquil ambiance as the vehicular roads are away from the residential blocks.

Gldani’s development Project included separated multi-level

pedestrian and vehicular roads. The roads divided district in 8 “Microrayons”. The transport had to use the lower part of the road that was situated 4 meters above the pedestrian road. The project also separated parking areas from pedestrian sidewalks and public service buildings. At the end of the district, it was planned to create large recreational space with lakes.

1.4 Problem Statement

After the break-up of the Soviet Union and the shift from state regulation to a market economy, the living conditions in Georgia changed drastically. The society, formed in Soviet times found itself in almost anarchic condition, having to reestablish itself by reshaping its public and private spaces in alignment with the new economic system.

In the initial stages of Gldani’s construction, the pilot urban idea was carried out successfully. However, the process of

- 1. The linear center main (III) complex was not performed, that broke the linearity;
- 2. The underground collective garages were not built in micro regions;
- 3. The public premises were sold separately as private ownership objects that doomed the basements storage - utility, economic, trade and other objects project system;
- 4. Facilities that were located in the linear center sectors were privatized and fenced, as a result, the pedestrian passage bridge lost its destination.

In 1989, the Soviet government of Georgia permitted the construction of vertical extensions - sometimes called “vertical slums” - on multi-story buildings, which are clearly visible on Gldani’s blocks today. Some refer to Gldani as a ghetto, others say that it is like the “Bronx.”

Many believe that because of the lack of funding, the original plan for Gldani was not completely realized, and many ideas

were left on paper as a majority of “microrayons” were built without basic facilities and were often converted into simple dormitory settlements.

Facilities and were often converted into simple dormitory settlements. The district has emerged as a dormant suburb and its inhabitants adapted their own lives to the existing soviet architecture. In an interview with one of the inhabitants of Gldani, by a journalist Tinatin Gurgenidze offers a unique insight into a standardized USSR home.

“I live here with my sister and my mother. We had to move in Gldani as we had no other financial choice. I don’t want to live in a block house like this one. The flat is not planned well. Nevertheless, there is enough light during the day. My favorite room is the one with the balcony that has a separate entrance. Originally there was one room in the center leading to three bedrooms. But the previous owners changed that. When I am at home I spend most of the time in the living room. Some time ago we have renovated the flat, and we made an addition to the kitchen. Now it has about 6 m² more space and a small balcony. In the loggia we installed smaller windows. Before there was a window wall but it was not isolated very well. If I had to change the space today, I would turn the living room and loggia into one big room and would pull down the addition. My flat is comfortable in some situations but you cannot change the planning. As I am an architect, I have to work a lot and move around in order to work in different rooms. I am occupying the whole space by working almost in every area.

The flat has changed my way of life. I don’t feel connected with my neighbors, I just meet them sometimes in the elevator. The architecture of his building is rough, brutal; a bit boring. The quality of the building is also very low; it was built too fast but compared to other blocks our building is still in a good condition. I think that the spaces just don’t work in this framework, as the connections between neighborhoods are inconvenient. I don’t think that the state and architects back then made a good job in planning these blocks. They just considered the

basic needs of people.

In 1989 there were legislative changes allowing the people to make additions. I think this was a big mistake. In general, Georgians don’t take responsibility for public spaces, they simply don’t care about it. They only take care of their own place. Here you can see that people are trying to adjust the space to their own needs but they don’t adapt to already existing spaces”.

The interview shows how incomplete the district is. The privatized service buildings that have no infrastructure for the public living, affect the life of the residents of “Gldani”.

An informative documentary about “Gldani”, shot by a Georgian Director -SergiGvarjaladze represents Gldani’s problems in depth. The documentary starts by a scene where Sergi asks population of the district just one question:

“We are shooting a documentary movie about Gldani what you think we have to film about?”

People answered that besides the social and economic factors there are additional problems like private garages occupying the sports fields and an extremely low quality of the public spaces in the district. One respondent said that Gldani is an image of the whole city and county as well.

The response is partially true that as the only city that manages to attract people nowadays is Tbilisi- the capital with 57,4 % of the whole population of Georgia living there. Because of this fact, the situation is chaotic in the city, people have no sense of community. Nevertheless, it is common to see car parking’s everywhere and generally, the quality of public spaces are very low in all the districts of Tbilisi. In order to restore and save the unique urban planning system, an involvement of state governmental bodies and local authorities is inevitable. Their financial efforts could stimulate necessary constructional works and restoration of “Gldani”.



1.5 Case Study

1.5.1. Creative Class - Gentrification

The analysis of the case studies of different countries and diverse approaches forms an idea and clears out the most relevant methodology for Gldani’s transformation.

A book by Richard Florida - “The rise of Creative class” analyses the unique phenomenon developed in 90’s, where Florida represents a theory that focuses on diversity and creativity as the basic drivers of the innovation and regional growth. He names scientists, engineers, professors, poets, novelists, artists, musicians, entertainers, actors, designers, architects and LGBT people as the representatives of the creative class. They foster the creation of open, dynamic, and professional urban environment. This environment, in turn, attracts more creative people, as well as businesses and capital. The theory recognizes creativity as a fundamental and intrinsic human characteristic. According to the author the key to understanding the new economic geography of creativity and its effects on economic outcomes lies in technology, talent, and tolerance.

In order to attract creative people, generate innovation, and stimulate economic development, a place must have all three. “Creative class” in general prefers places that are open and liberal to diverse social groups. Florida defines the three elements as follows:

- Tolerance is an openness, inclusiveness, and diversity to all ethnicity and races.
- Talent is defined as a bachelor’s degree and above.
- Technology is a function of both innovation and high-technology concentrations in a region.

According to Florida “Creative Class” could provoke the new economic structure, based on unique production and could push the district towards further development.

1.5.2. Development

Belayevo Forever

“Belayevo Forever” - is a research conducted by KubaSnopek which represents unique vision on the building block of the Soviet city - the microrayon (“micro-district”), a standardized housing unit of USSR. Belyayevo is a classic microrayon, the standardized neighborhood system that Soviet regime laid out across the USSR with its expansive program of industrialized construction. The landscape of Belayevo is repetitive and consistent, if anything changes, it’s the height of the buildings and the spaces between them. The simple silhouettes of concrete housing are scattered in an endless space. Essentially, Belyayevo, like any other dormitory suburb (or “sleeping district”, as it’s known in Russia) is a generic, slightly chaotic space. Unmemorable, bland and melancholic.

According to KubaSnopek, Belayevo is an intangible heritage because of its originality, uniqueness and quality as the amount of culture produced by this environment and the amount of artists who were describing this environment was so big and so dense that its uniqueness can be perceived as an intangible heritage and the district deserves to be preserved by UNESCO.

Pakhuis de Zwijger

“Pakhuis de Zwijger” is a unique cultural organization and an independent platform located near Amsterdam and designed for its inhabitants. A group of young people gathered to encourage urban innovations and initiatives. Pakhuis de Zwijger organizes events on the urgent and complex urban challenges of today. The goal of the organization is to always inform, inspire and create.

The events are categorized in ‘creative industry’, ‘the city’ and ‘global trends’. The subjects of the events vary from European politics to culture, design, and healthcare to photography. The old cooling warehouse acts as a hub for the creative industries.

For a long time the warehouse stood empty and having been stripped off its original function. In 2001, the building was restored by StadsherstelAmsterdam and further developed in 2006, when the building started to being used as an area for cultural institutions and activities.

The transition process of a warehouse into a creative and innovative hub, made the building one of the most interesting and popular locations in Holland, especially for artists and representatives of creative industry who make the hub what it is nowadays.

1.5.3. Time Banking community

The world’s first time bank was started in Japan by Teruko Mizushima in 1973 based on a simple concept where each hour of time given as a service to another person earned back hours of services that could have been used in the future, especially in old age when people would need it the most. In the 1990s the movement spread the US. Dr. Edgar Cahn was the first to introduce time bank in States. Following Edgar, in 1998 Martin Simon opened the first time bank in the UK in Stone house in Gloucestershire. There are now nearly 300 time banks in the UK involving over 20,000 participants who have given and received over one million hours of mutual support. Time banking came to Scotland in 2001 as the residents of Castelmilk asked for setting up a time bank that later achieved a great success.

The original model of time banking is a system where people can exchange ‘services’ with each other within a community. This exchange of ‘personal services’ where time is used as a currency for reciprocal service exchange.

As a philosophy, time banking is founded upon five principles as follows:

- Everyone is an asset - everyone can define what they consider to be an asset and enshrine its value through the

hour for an hour principle.

- Some work is beyond a monetary price - The market does not value certain activities like caring, learning, imparting values, sharing, socializing, raising children, being a good neighbor, adequately until it becomes scarce.
- Reciprocity in helping - a mutually beneficial process where “You need me” becomes “we need each other” in a time bank.
- Social networks are necessary - A time bank creates a system that builds social capital generated by trust, reciprocity, and civic engagement.
- A respect for all human beings- respecting and recognizing value of every contribution.

In a time bank everyone’s time is equal, so one hour of a person’s time is equal to one hour of another person’s time, irrespective of whatever they choose to exchange. Time and services can be exchanged between persons, it can also be exchanged between person and agency, where organizations use time banking as a tool for achieving their own goals and in the end agency to agency where time banking can serve as a system for trading assets and resources.

“In Italy time banks were born in 1988 Emilia Romagna and about 70% of its members were women. Exchanges of time and activities often coincide with an improvement in time management for individuals and families. The average age of members is falling gradually thanks to the spread os social networks”.

In a real time bank, all three models are brought together in order to exchange skills, support, and physical assets between the people. The principle value of investing in time banking is co-production where people are given the ability to solve their own problems by using assets that exist in other human beings. The benefits of time banking are broad. Firstly, people are valued for their ability for delivering services no matter their race, class, gender, national origin. Secondly, time banking has a multiplier effect and enlarges the pool of resources available throughout the community. Thirdly,

in time bank community members gain equal access to services that allows them to learn new things. Fourthly, time bank is a highly effective community development tool, empowering individuals and groups with different backgrounds to give and receive support from each other, come together and form connections and friendships. Lastly, time banks are successful in attracting people who would not normally get involved in traditional volunteering.

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#### 1.6 Interviews with the social movements of Georgia

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Tbilisi is a city with almost no public spaces, polluted air and fragile policy of the city planning. Citizens are very concerned about the poor ecology, a high number of old and faulty vehicles and scarce greenery. There is no place to relax in the natural environment, play sports or just walk around with the children. Although people raise their voice and protest with the social movements of Georgia, which are quite popular among the citizens, but only insignificant reaction is shown from the side of the Government and authorities. The social movement representatives are the part of the society who are trying to raise awareness among the inhabitants of Georgia and are striving to change the existing situation in Tbilisi.

The interviews conducted with the movements unveil alarming problems of the city and Government’s ignorant approach towards their protest. Still, thanks to hard work of the movements some positive results have been reached in favor of the city. Interviews with the social movements of Georgia

1. What is your manifesto?

*Guerilla Gardening:*

Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has.

Margaret Mead.

*Green Fist:*

The concept of our movement is to preserve existing social structures and public spaces. After gaining independence the public spaces have been privatized. Our manifesto includes social, environmental, educational, cultural and urban protection of everything that is open to the public.

*Critical Mass Tbilisi:*

“We do not block the traffic, we are the traffic.”

Our goal is to inform vehicle owners that we, cyclers, need the space on the road for the safe movement. Lately there is a huge rise in bicycle users in Georgia.

2. How does your movement impact the city?

*Guerilla Gardening:*

Our main goal is to rise an awareness by social involvement. We plant the trees and we take care of them, but at the same time we work with the society to speak out over their concerns and transmit the message to the governing structures. We want society to acknowledge that the common areas should be preserved and taken care of likewise their private space. We demand from the authorities to change the law that is harmful for the environment and health, we also ask for improvements in the jurisdiction. Often we have to take physical actions like planting the trees ourselves or blocking the streets and construction sites to show the society and the government that things have to improve for better. Sometimes we succeed and we’re proud.

*Green Fist:*

It’s been only 2 years, our movement exists. Mostly we organize alternative educational spaces in the city and the province. For example, we started collecting old books across the city, created a storage and later transformed several spaces in the villages of Georgia into green libraries. This helped to deepen contact between city and provinces. Each library is supported with permanent events organized by our movement. Another activity we did was called “the tape” - unofficial documentary movie screenings in public spaces that was followed by open public debate. Green Fist often uses alternative methods for protests as street

performances and symbolic protests. Even protest concerts. We try to occupy public spaces, create posters, banners, and use street art and stencils in order to inform the society about existing problems. Sometimes people let us use their balconies. In order to gain some economic assistance, several times we organized Sunday markets of “information souvenirs” -souvenirs giving information about existing problems.

*Critical Mass Tbilisi:* We try to raise awareness between vehicle drivers that part of the road belongs to us and we foster the cycling culture and healthy lifestyle. There is a general perception in the city that healthy transportation is good but cycling is impossible in Tbilisi because of tits sloped terrain. Though the existence of our movement destroys this stereotype. Another faulty perception is that bicycle is just for leisure activities, for the children, or just for the sports people. Now things have changed and bicycle is accepted as a public transportation, but there are still many problems, one of which are the pedestrians who believe that we have to go around them or pass between to persons to continue our way.

3. How big is a social support?

F he support is pretty huge about 25 000 followers on Social media and 15-20 active decision makers and organizers. The physical social support from the side of population reaches thousands.

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*Green Fist:*

Main organizers and active participants are about 50-60 persons, but each event changes from 30-500 participants. On Facebook we have 10 000 followers. Some of the members of our group aren't Facebook users at all and get information from personal contacts.

*Critical Mass Tbilisi:*

Today we have more than 5 000 followers on social media and about 250-300 active members who participate in events organized by us. Lately, we started to get support from other cities like Kutaisi, Batumi, Zugdidi etc. This makes us happy and we wish to partner up with them in future. Number of participants also depends on time, in the end of summer when in mid-winter we have less participants.

4. According to your vision: Who and what creates the city?

*Guerilla Gardening:*

I can say what destroys the city. In our reality it is unprofessional or ignorant approach to the subject. Too many key positions in governing structures are occupied by highly unprofessional employees of this particular field, mostly they are not able to make any relevant decisions. This creates an impression that only one person is authorized to make important decisions and others are just executing it. Unfortunately, the society is not reacting properly. I guess it is typical for post-Soviet state that nobody wants to take responsibility, nobody wants to take decisions, nobody wants to criticize the facts loudly. There is a "fear" of something that unclear. Contemporary reconstruction of Georgian parks totally destroyed usable recreation areas.

*Green Fist:*

The city is created by the citizens. The public spaces represent

the most important aspects for the city. They bring quality to the city and the society. For us the city is its society and public spaces together. If the changes in those spaces happened very carefully and with high involvement of the citizens it could have developed both the society and the city.

*Critical Mass Tbilisi:*

A City is created by the society living in it. Everyone should participate to create particular order. Functions of the city is often dependent on how we perceive the space. Despite the faulty urban planning, we can use the infrastructure the way we find it useful. Unfortunately. Big part of Tbilisi's population is not active enough to achieve fundamental changes though the trend is changing lately. We are an example of it, and we demand the use of infrastructure as it's needed in current reality. What creates the city is the organized public transportation. Metro or bus station should be max. in 10 minutes' walk, same amount of time should be needed to reach the first park or a green space. Universities and Hospitals do not have to be in city center. They can be situated away from the city but with mobile public transformation service for reaching it.

5. What are the main problems of the Parks in Tbilisi?

*Guerilla Gardening:*

Soviet "park-building" style with too much concrete, organized lines of trees and monumentality. There is no feeling that you are in nature. It is forbidden to walk on the grass and there is a lack of vibrant places at the parks. For example, in Vakepark you hardly find a place to play Frisbee. You should sit on a chair and put legs on the concrete. Contemporary European parks are interactive and natural. In Tbilisi there is much concrete, colourful fountains and loud music.

*Green Fist:*

In our vision the problem of the city is a wrong governing system. The present neo-liberal approach towards the city concentrates all the power to several elite-business groups and not the professionals who are interested in development of the city and

the society. Business interest is to own as much as possible, while city needs more thoughtful and careful development not just a lucrative gain from it. In public spaces, we don't mean only open areas but also buildings and functions that are public, like libraries, universities, research spaces, museums etc. all of them are taken away from the city and have become the property of business-groups, as a result the city became poorer. There are almost no recreation spaces left, we have less parks, squares and gardens. Science institutions are replaced with private constructions. Pedestrian walkways are left unnoticed.

Another huge problem is in urban planning, there is no sustainable masterplan where human scale would be noticed, there is no strategy of development of the historical zone and there is no implementation of contemporary methods for the city development.

*Critical Mass Tbilisi:*

Today I believe the main problem is disorganized urban policies. The city is full of new constructions that penetrate green areas and close the sidewalks. Wrong road planning created extremely high amount of vehicles heavily polluting the air and causing unregulated traffic. I want to have the parks in my city where I do not hear the sound of the cars or the construction. Even in ethnographical museum you can still hear the sound of the cars. 6. Which environment in the city do you associate with your movement's vision?

*Guerilla Gardening:*

Eventually not the parks. I would say that the most connected environment is the Gergety district, which is in need of conservation, but is still carries spirit of the city. Gudashvili square seems like a tortured patient in palliative care. For now the liveliest place is Hippodrome that is totally wild but most occupied area by the society.

*Green Fist:*

Universities, Libraries and all spaces where we can have the possibility to conduct research and plan meetings are the places

we associate ourselves to. Sometimes we also meet in suburbs or riverside areas.

*Critical Mass Tbilisi:*

Our most beloved environment are parks and recreations zones. We meet in Vake Park and go through main avenues like Chavchavadze, Rustaveli, we reach Freedom square and then we ride to the monument of the bicycle in the city Centre. This is the main core, so more people can see us. Sometimes we leave one line for the cars but if police is controlling the traffic we totally block the street. Sometimes we meet in old Hippodrome territory.

7. How do you organize and educate yourselves?

*Guerilla Gardening:*

Through discussions face to face or with the help of social media closed group conversations. We also have meetings in parks or sometimes at conference halls. We are self-educated. We gain information from the by internet, books, seminars, and from personal contacts in the field. We try to meet with interesting people and go to the public events that could be interesting for us. We discuss issues with foreign professionals, participate in meetings at the local municipality as listeners and sometimes we succeed to bring our voice to them.

*Green Fist:*

There is no hierarchy in our movement, every decision is made with common consent. Most of the time we meet in university area. Our community is quite colorful, we have socialists, anarchists, ecologists, etc. All of them are researchers in their own fields. Our group is deeply involved in research process of existing social and ecological realities. We act based on research results. University is our step-stone. We have blog were we post all the information, the documents, essay's, critics and articles.

*Critical Mass Tbilisi:*

We use closed groups on social media, where we define the main goals and challenges of the movements. Sometime we add several creative ideas and plan interesting events. We take an

inspiration from critical mass movements of other countries. We are mostly self-educated and inform each other based on different critical mass culture experiences.

8. Except yourself which of the urban movements do you find are important for the development of the city?

*Guerilla Gardening:*

We had attempts to create unions with other social movements, with whom we share the same goals but in the end it never worked out. At this time we just respect other movements but we do not team up with them. In our view social movement “Tiflis Hamkari”- plays an important role in the development of the city as it is focused on preservation of historical heritage.

*Green Fist:*

“Vegan Base”, “Solidarity cell”, “fabian society”, “guerilla gardening”.

*Critical Mass Tbilisi:*

There is no other movement like us in the city that would be directly oriented on transportation infrastructural changes. We often participate in different events defending ecology, women rights etc. Mostly we collaborate with “Guerilla Gardening”.

9. How is your movement related to the trinity - “create/ inform/inspire?”

*Guerilla Gardening:*

This trinity can be the core of everything. I would put the order in this way, inform, inspiration and then create. It is more relevant to the nowadays situation of Tbilisi.

*Green Fist:*

It is our trinity in fact. We produce new spaces in order to show an example of preservation of the existing monuments. We protest in order to raise awareness and to inform public about the existing problems. We inspire ourselves by reaching the set goals.

*Critical Mass Tbilisi:*

As for creation, we create cycling culture that provokes businesses like, cycle repairing shops, cycle accessories, stickers and all those little things and most importantly healthy lifestyle. We have lot to do with education and inspiration. We are in the streets most of the time and are having direct contact with the people. We try to raise awareness on different lifestyle, we organize workshops, participate in different public activities etc. There is an incredible growth in the number of cyclists between these people are the ones who use bicycle as an only mean for transportation. I believe that we highly encourage cycling culture in this city. There is even a monument of the bicycle in Tbilisi. As for inspiration, we get inspired by critical mass movements in different countries, and we’re trying to inspire local population the same way. People are free to join us because what we do is not just a healthy lifestyle, it is a philosophy.

1.7 Philosophy of Form. Plato’s interpretation of the one and the whole

*Critical Mass Tbilisi:*

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*Plato’s concept of form*

According to Plato’s philosophy, the whole is something that has no absence in any part while the form is archetypes or abstract representations of the many types of things. The whole consists of nothing, it has no boundary, it is without figure, is neither in another nor in itself, and has no parts, it is an ideal entity while the form is existent and has the beginning, middle and the end. According to Plato, “The beginning” (Arche) - is a principle that defines the inception and everything else that follows it. The beginning had already contained all necessary features to have been considered as such.

“The middle” - is the representation of the being as the being is formed and organized only by the middle which has inner and outer structure. The middle connects the beginning and the end to each other, and determines their interconnection, the middle itself consists of two layers - inside and outside where outside is a physical representation of an inside.

“The end” (Telos) - is the end as it had already contained all the necessary features to have been considered as such. In Plato’s view, the end cannot be defined as a termination of something but more as an aim as an ultimate cause. Therefore beginning, middle and the end is understood by Plato dialectically as each of them, represents an opposing unity, but on the other hand, Plato also interprets the beginning, middle and the end aesthetically as each of them represents the unity of the inner and outer, sense and circumstance.

In ancient times most of the architects were experimenting on the form by developing small scale sculptures. Furthermore, during renaissance period artist like Michelangelo, RaffaelloSanzio and majority of the architects were experimenting their artistic skills in sculpture, painting and finally in architecture. Between the contemporary sculptors who have been searching the relation between the forms, it is important to mention, 20th-century sculptor Henry Moore and his series of sculptures widely known as “Helmet” developed between 1930’s - 1950’s.

The sculptor represented the idea of an outer facade covering the inner form. The helmet is a long series of sculptures where one form is enclosed within another, where a complex internal structure is contained within a simpler outer form. This piece may have been inspired by an illustration of ancient Greek tools or from an idea of protection, where the internal element is protected with an outer element like a mother protects her child.

In between the forms, Moore created a third element - emptiness that changed the concept of the sculpture and represented a major message rather than sole, independent forms.

In the whole, beginning is not just a beginning, but also its continuity and ending is not just an ending but the cause, for which it is perceived as an ending. The middle is not just a middle, it is the active-semantic result and balance of the parts of a whole.

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Conclusions

As result of the research project of invervention has been developed.



The form of the project is represented, following the layout inspired by Plato’s and Moore’s overlapped ideologies. The realization of the project is based on Pakhuis de Zwijger system with particular additions, such as the first building of the “Mediatheque”, second of the time bank market with co-working spaces and the third a research centre. The intervention is carried out on existing three soviet buildings of Gldani by giving them new functions. The three buildings are detached from each other and are distributed along the main core of the district.

In order to aspire the project as a whole, it is important to understand all the three functions together, connected by cycling and pedestrian roads as working as one system. The first building - a “Mediatheque” functions as a gate to Gldani, where physical infrastructure gives unlimited information about the district, we call it information forest.

Three parts are spread along the core giving them opportunity to work independently, while connecting three buildings with well-organized cycling infrastructure in order to keep the functioning as one single building system as well.

In order to aspire the project as a whole, it is important to understand all the three functions together, connected by cycling and pedestrian roads as working as one system. All the interventions give in-between spaces the chance to develop and use the connection points between the buildings to reanimate the dying central axis with more public spaces in order to rise up standards for living. Cycling and pedestrian paths are created on the existing vehicular road shrinking its original size and giving more space to public interest. New ramps or roads connecting the lower level of the street to higher one will be developed along the core of the project the first building - a “Mediatheque” functions as a gate to Gldani, where physical infrastructure gives unlimited information about the district, we call it information forest.

Aforementioned interventions pushed us to clean the ground

floor from functions that would encourage real aspiration of the district. QR codes are placed everywhere giving people random information about the district and time bank structure.

“Mediatheque” is distributed on the first floor, where visitors cannot see the surrounding areas of the building, as the floor is cantilevered with the layer of trees and the wall behind it. The only relationship “Mediatheque” has with the outer world is through skylights. The Ceiling of the first floor is totally covered with skylight system, letting the indirect light that creates a pleasant ambiance in the interior space.

The Core of intervention is the physical implementation of the time bank market - a place for skills, knowledge, and experience exchange between the people. The building consists of a big time exchange market, co-working and administration spaces.

Time bank market should work like web platform, where experience is a very important element of the hierarchy. New members can register through the web at registration points located in the “Mediatheque” building. Once they start exchanging time they become beginners and are authorized to use time bank market for gaining credits in order to become an advanced user later.

Advanced users gain limited access to co-working spaces while professionals are getting unlimited access to co-working spaces and can also be engaged in coaching activities. The professionals can work for money as well and at the same time exchange skills with other members. All three users are administrated by the managers, who are experienced professionals working to assist the community members.

The three buildings connect two sides of the district with bridges and passages. In open spaces, there is designed a floor lowering in order to create a cave effect while co-working areas are located on mezzanine floor to limit access for unauthorized users. Those areas are connected with third building - the research centre, where coaching activities and workshops occur.

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The research centre is fully connected to the rest of the interventions because it serves as an area for recruiting users. Moreover, it includes research and presentation spaces and is a place where all the data on Gldani happenings are stored. The prototype was taken from “Strelka” institute of Moscow, where the centre is an open air amphitheatre and the classrooms are organized as independent clusters around it. Each cluster has its own entry from the outside.

As mentioned before, abandoned building has been reused by removing all the partition details and by keeping the structure. The midpoint of the research centre is used for analysing the problems and fostering innovation in the district. It is equipped with 3 research labs, cafeteria, one closed presentation space and an Amphitheatre in the centre. All three buildings are well connected with cycling roads and district’s urban infrastructure.

The main mission of the interventions is to assist young people, not having enough resources for creation and innovation, to change things for the better. The goal of the project is to turn the central axis of the district into a dynamic and a vibrant spot.

The following prototype serves as an example where small-scale interventions can change the life of people living in the post-soviet districts, it can also be applied in other districts of post-soviet countries. Bottom-up transformations of the local communities and the right infrastructure can foster positive change.

As in previous examples abandoned building has been reused by removing all the partition details and keeping the structure. Researchcentre is a space to collect all the possible data happening in Gldani, analyse the problems and present the innovation. Research centre is equipped with 3 research labs, cafeteria, one closed presentations space and one main amphitheatre in the centre.

All the three buildings are well connected with cycling roads and related urban infrastructure. The main mission of interventions is to provoke the formation of sequence of communities of young population willing to create a change but have no tools for it. Aim of the project is to turn the central axis of the district into dynamic mechanism which will stimulate the areas in-between.

The middle itself consists of two layers - inside and outside where outside is a physical representation of an inside.

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In the whole, beginning is not just a beginning, but also its continuity and ending is not just an ending but the cause, for which it is perceived as an ending. The middle is not just a middle, it is the active-semantic result and balance of the parts of a whole.

Therefore beginning, middle and the end is understood by Plato dialectically as each of them, represents an opposing unity, but on the other hand, Plato also interprets the beginning, middle and the end aesthetically as each of them represents the unity of the inner and outer, sense and circumstance.

As a value of this research is the definition andpresentation of the diversity, nature and behavior of invisible city layers structured by the following components: Creativity, Social Activity, Human Inspiration, Information and new virtual environment in a whole. Study of their intersection with other urban factors, new technologies and city physical development process.

Based on these issues original concept and methods of urban transformation was developed; ideology for father activities was suggested as the source for a new and fresh movement through the city lifelines toward the human wellbeing, harmony and sustainability.

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# PART 5

## Urban Design

### Urban Design

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#### 1.1 Social Mood Indicator - Modern Graffiti

In the complex hierarchical communication system of the urban environment, the “Street art” has already become a phenomenon of a modern urban culture. The most common and well-known form of this phenomenon is Graffiti (Italian. “graffito” Gr. “γραφειν”), with running constant experiments with the space and, conducts a flexible, comprehensive, free of censorship, anonymous, visual dialogue with the public. This one of the actual form of the artistic expression creates images on any surface, scratched, cut, painted or written with different materials by so called “Street writers”,

be it the “Tag” - a stylized signature of a writer, “Sketch”, or a wall fresco “Mural” - full-valued, large-scale prints.

Graffiti, with its technique, “slang” and style, is a lot of directions and flows, and each of them have their distinguished features and natures. Many countries and the city have their famous writers, who create true masterpieces in the city streets. Among them are well know Seen UA, Banksy, Above, Blu, Mad C, Pixnit, Peeta (Manuel di Rita), Daim (Mirko Reisser), Delta (Boris Tellegen) and



Banksy. The little girl and the soldier. Bethlehem. 2008



Blu. Never follow. Cracow. 2011



Above. Shoreditch London. 2013





Herzog & de Meuron. Residential house "40 Bond Street". New York. 2007



Metaform Architects. "Small residential complex". Luxembourg. 2011



ITN Architecture's. "Residential House". Melbourne. 2012

others, which are usually "masked" under aliases, nicknames, codes, and symbols. Their prints, as an independent genre of modern art, form an integral part of the culture and the urban lifestyle.

If look through the history of graffiti, and the movement of 1960-70-ies American amateur writers it becomes clear that it was not aimed at improvement of the urban environment by visual point of view, but expression of a protest was a priority. That's why, in some ways, graffiti was understood in the public life as an illegal extreme hooliganism, insipid, aggressive and vandal act, while the modern graffiti, as an art, is gradually taking position above the negative manifestations of this movement and, from a pure marginal direction, which was linked to just a protest against the established urban environment, is transforming into the form of a legal art, with representing its creativity differently in the heterogeneous informational layer of the urban environment.

Just this factor has preconditioned both qualitative and quantitative transformation of the given type of the Street Art ,which is reflected in other spheres of the arts synthesized with it, which,

being enriched by new artistic techniques, develop new interesting potential of the graffiti. This creative activity is in some way involved in resolving the tasks of design, architecture, etc.

For a number of well-known artists and designers, e.g. Mike Giant, Pursue, Rime, Noah and the others, graffiti became a so called launching pad. They made their careers in the fields of industry and clothing s design/ A clear example of penetration of the graffiti in the field of design is the Studio "123Klan", which successfully uses it and develops logotypes, illustrations, shoes and clothing design for such well-known companies as Nike, Adidas, Lamborghini, Coca Cola, Sony, etc.

At present, graffiti may be noticed in everything - clothes, accessories, vessels, lighting fixtures, jewelry articles, etc. Its impact is observed in many areas of graphic design, namely: TV-style visual solution, food products packs, typography, books design, web design, etc.

In the context of the urban space, relationships between the graffiti and the architecture, is a separate subject of discussions,

which, as a rule, may have either negative or positive direction. The first one can be often observed in a form of scratches, less attractive handwritings on the buildings facades, while the second one is the art-phenomenon with its strong conceptual influence of the contemporary architecture, where the multi-faceted combination of architecture and graffiti demonstrates a striving to their synthesis.

An idea of connecting architecture and graffiti to each other, is reflected in the concepts and projects of a number of well-known contemporary architectural offices, where the aesthetics of the artistic-and-cultural phenomenon of graffiti is introduced on the building surfaces through printings, perforation, graphite-stylized sculptural modeling and other methods. In this regard, It should be noted: Herzog & de Meuron-'s "Brandenburg Technical University Library" in Cottbus; Residential house "40 Bond Street" in New York; The concept "Small residential complex" in Luxembourg, developed by Metaform Architects on the grounds of the symbiosis of the modern architecture and graffiti; ITN Architecture's "Residential House" in Melbourne, which has already become a recognizable and known art-object of the residential area, etc.

In these works, by architectural context, the tag-like motives are stylized, the graffiti paintings are reprocessed and, the simplified system of signs are introduced in a form of a rhythmic, organized ornament, which, on one hand, creates a decorative element of the building, and on the other hand is an indication on origination. A rebellious spirit of graffiti is seen in the design's solution by means of a rich polychrome and a figurative plastic of the font. Architecture, with using the graffiti boldly but by a very moderate dose, is striving to introduce and underline those Artistic dignities of this phenomenon, which promote harmonization and individualization of the environment.

Phenomenon of the modern graffiti is as interesting and actual as many years ago. Improvement of its artistic techniques and patterns makes a certain influence on the contemporary arts, architecture, and transformation of the visual appearance of

cities, as a whole. By content and nature, these indicators of a social mood, offer some new paths of self-identification and communication, to the society.

Summary

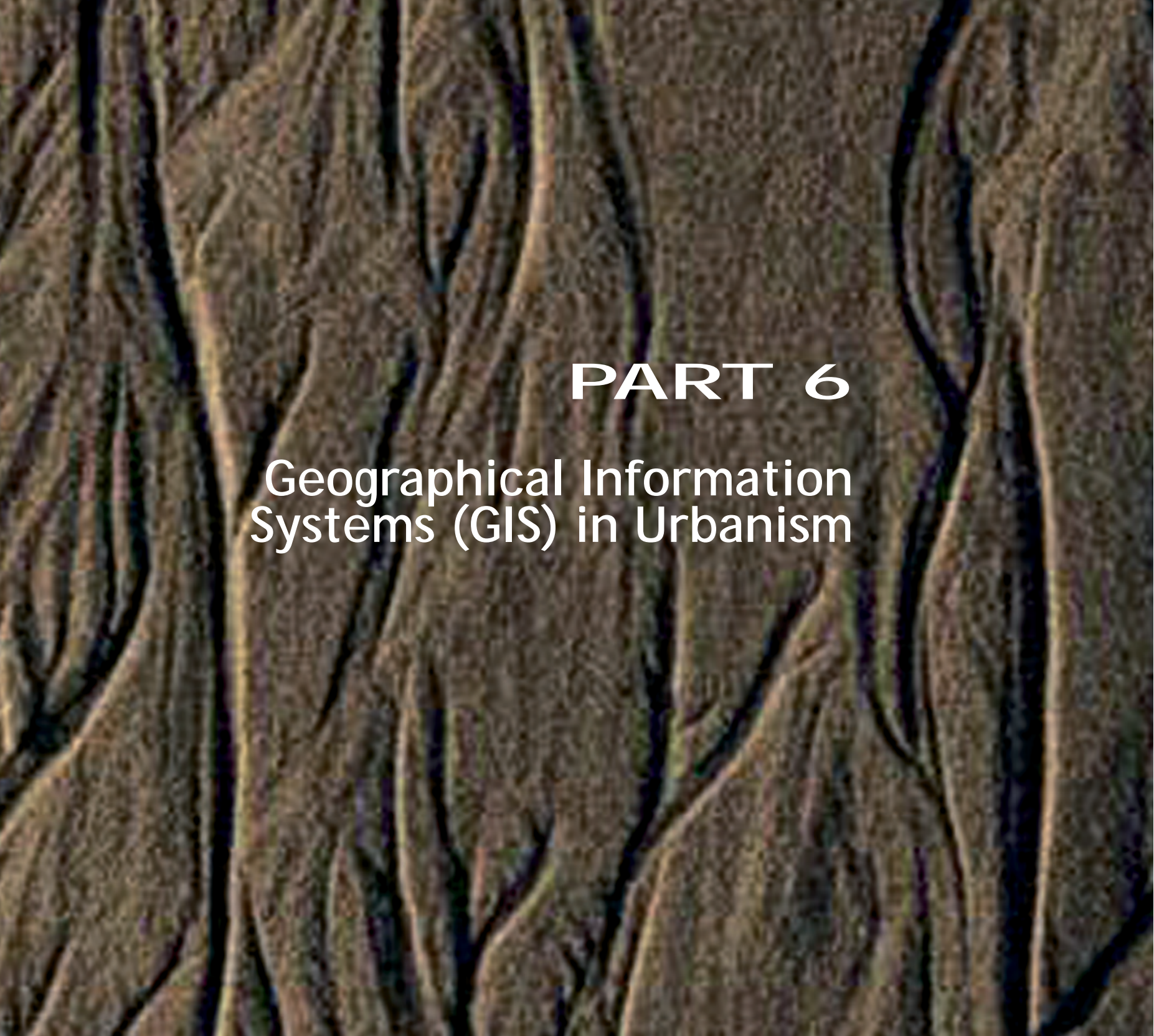
Contemporary graffiti is gradually transforming from a pure marginal direction into the form of a legal art and, with representing its creativity differently in the heterogeneous informational layer of the urban environment. This qualitative and quantitative transformation is reflected also in other spheres of the arts synthesized with it. in terms of the architecture, with serving for harmonization and individualization of the environment, Graffiti offers new paths of self-identification and communication, to the society.

Key Words: Street Art; Graffiti; Architecture; Design; Synthesis; Urban Environment.

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# PART 6

## Geographical Information Systems (GIS) in Urbanism

### Concept of GIS (Geographic Information System)

Authors: Zurab Laoshvili

#### Introduction

Cartography is an ancient science and is developing and improving constantly. Modern Cartography is basically defined by integration with latest technology. Data spatial analysis is used successfully worldwide-Geoinformational Systems (GIS). Its covering all areas of human’s activity.

The exact date isn’t known, but the history preserved a very successful attempt of spatial data layered over each other (it’s a main principle of GIS)dating from XVIII century. French cartographer Louis AlexsanderBerti, used transparent layer to put it on a map, to define troop movement during battle.

GIS has been developed very fast during last 2 decades in Georgia, it’s the most important format for keeping spatial data in Agency of National Public Registry. GIS projects are becoming more and more popular all over the country.

Geographical data market is growing about 10-30 % annually. Therefore data search facility, identification of location and navigation services improves too fast. Demand on Geographic services is too high on real estate market, touristic and insurance industries, transportation sector and so on. It’s quite difficult to have an access on today’s market spatial data, it requires a lot of time and money. Because of it, it’s not used affectively.

Geoinformational systems are based on ideological bases of Geodesy, topography, cartography. Qualified and powered GIS requires in

depth knowledge of this components.

XXI century is known as a century of information. One who ones information can get a success. It’s important to realize that information has not any borders and we’ve to mention that that enormous amount of information is accumulated all over the world and at list it doubles in every decade, it causes lot of problems and obstacles. Among the problems it may cause are: loss of information, disappearance of data from scientific and practical turnover, double extraction of information and a high costs according to it, it’s a small list of problems. There is formed kind a maze and a man is in cankered within it. It became more difficult to keep and process information. To avoid informational crisis, its rational usage is imminent and spatial technologies have become needed.

Technology of spatial analysis - Geographic Technological Systems became a salvation for humanity and it’s used successfully within in every working field.

GIS - abbreviation is used as a definition of Geoinformational Systems, and we’ll use this abbreviation in this book.

In general, Geo Informational system is processing tool of spatial information. This definition is not exact. The term covers several subject areas. There isn’t one exact definition for GIS. It’s changed according to intellectual, political, economic and cultural



Table 1.1  
Synonyms of GIS (M.Demers)

Term in English	Source
Geographical Information System	American Terminology
Geographic Information System	European Terminology
Geomatique	Canadian Terminology
Georelational Information System	Technical Terminology
Natural Resources Information System	Disciplined Terminology
Geoscience or geological Information System	Disciplined Terminology
Spatial Information System	Non Geographic Terminology
Spatial Data Analysis System	Terminology according to the field of work

aim. As the term became very changeable it has a lot of synonyms (Demers 1999).

The book that have been published in 2012y: “The reference of Geographical cartography” (authors G.Liparteliani, D Liparteliani) you can read following definition: “geographical Informational system (GIS) -is GeoInformational system, automated, software system, which provides gathering, saving, keeping and spreading of spatial coordinated information.

In Wikipedia you can find the following definition: “Geo Informational System gives opportunity of gathering, storing, analyzing and graphical visualization of statistical information according to the geographical location”.

Frequently the following terms are merged: digital cartography, computer graphics and Geo Informational Systems, however

they are strongly differ according the map analysis.

Sometimes GeoInformational systems and Geo Informational technologies are mixed. The last is kind of informational technology and is used for processing spatial data. GIS means much more.

Reconciling opinions of different author and also depending on my own approach, I’m providing simplified explanation of GIS.

Geographic informational system is informational system that’s based on computer maps and databases, it’s used for managing spatial data (gathering, data storage, searching, annualize).

Simply GIS is:

- Complete, multi-functional, reliable data storage for Database
- Instrument for data modeling and analyzing of spatial analysis.
- Merging, integration and comparison and transformation of different kind of information.
- Getting ,sharing and transforming necessary and timely information from information bank.
- Finding out and analyses, cause and effect within data,
- Tool for managing spatial data.
- Visualization of data within the spreadsheet, creation of a map.(Pic 1)

GIS systems are the best program software for systematization, organized storage and spatial-thematic analysis.

GIS Geo-data is becoming a common standard format and is effective tool for decision makers. Using GIS gives perfect opportunity to rule business, economic, politics, social processes and environment. In early 90th leading countries, admitted GIS as a strategic reserve of economy.

GIS is a result of integration of cartography and geoinformatics. It’s asphere of science, technic and manufacturing, which combines theory and practice, of usage personal computers for processing geographic

information. To say it in more common Geo informatics shows us, how to use computer technology within geographic field and cartography.

GIS is closely connected with cartographic science and practice. Often it’s considered as digital cartography, but it’s much more than just computer map. Map drawing automatisation is possible just because of GIS. Integration of cartography and geo informatics cause a formation of new directions: geoinformational and operational cartography, geoiconic, telecommunication cartography and so on. Geoinformational cartography includes analytical, synthetic and complex sides of cartography.

GIS is an informational base, it supplies cartography with necessary information. GIS is basically designed for gathering, storing, transforming and present geographic information. At the same time it’s also kind an informational technology for merging theories, directions, methods, technical tools, systems and so on. The main prescription for above mentioned tools are gathering, storing and usage of information.

GIS can be introduces as: Geoinformational base, digital map, data management system and spatial analysis.

Geo Informational system-Data Base

When we are talking about GIS, it’s more appropriate to link it with data base. GIS -is an electronic storage for spatial data, any changes within the data base influences it. Bases are renewable constantly, it makes map more alive and fills with information and besides possible to keep already available old information. It gives opportunity for visualization, of how facts are changing in time. Databases and information banks insure opportunity to generate different complexity maps, three dimensional models, graphics and typical operational reports. This is a reason why demand for GIS is huge and it’s used so wide scale.

We’ve to mention that during working process GIS is using databases that are geoinformational bases. We’ll discuss it lately in following chapter.

Geo Informational system-MAP

GIS is often associated with digital map, but it’s not right opinion. GIS isn’t just a map. The map is visualization of GIS data. GIS-MAP first of all means electronic mapping process. We know that it’s impossible to conduct any geographical survey without a map. The field of study for Geography are spatial aspects, as for map it’s a model of objects and spatial-in time events on a plane. Map presents not just location of objects and processes on earth, but the spatial connection between them, behavior and changeability in time, of course all this specifications are also maintained within GIS, and its technical possibilities gave an opportunity for cartographic depiction and in depth analysis. Programs of GIS are equipped with universal cartographic elements, so it gives opportunity to generate map of any complexity.

Maps are used by GIS, as a source of data base. Digital map is more flexible for use. It’s possible to merge different sheets of topographic nomenclature as a map, it makes easier to manage data.

Geo Informational system- Data management system

The basic function of GIS system is to manage Database. It means entering, editing and gathering information. Of course it includes filing and sorting GIS data, that essential and differs from any other computing files. Some programs, for example (ArcGIS) has a special application.

To find objects on a map is one of the main cartographic problems, There are made, kind of searching instrument on atlas and maps to make it easier to find objects. For example map is divided into a small cells that is assigned for column (Latin) and row (Arabic) crossing sign (ex B4). Cell number is defined for specific object, in which it’s possible to find it. This classic search method is often used in even nowadays in traditional cartography. But on a loaded maps (ex. reference map) it needs some time to find an object and not every map has this kind of search engine.



All this procedures are easier on a digital maps, with the help of GIS it's convenient to find spatial data. With the help of search engines you can find needed objects according of thematic mark or spatial specifications. Also it's possible to create special search engine that suits for conceit user and is more flexible.

The formation of organized GIS system is important for effective Data management.

Geoinformational system-spatial analyses. While GIS is used widely within last decades, the main usage of it is to create a map, however it has a huge possibilities, more than just visualization of data. The main benefit of GIS is analyzing and modeling of spatial data and it's called GIS ANALYZIS. Because of its Geoinformational system is mostly discussed as a system of spatial information than technology. It's hardware-software algorithmic system of procedures. It's in charge for managing and manipulation of geo information and modeling of spatial analyses and mathematical cartographic simulation.

With the help of analytical opportunities, GIS is able to define, how it measures the location of special objects and what the connection between them is. It's possible by GIS not just to analyze different type of information but the formation of qualitatively new information. Its best opportunity for decision making process. GIS is becoming more and more popular in our country.

In comparison of 4 method, it's clear that GIS is union of maps, databases and analyzes.

**GIS components:**

The system of GIS includes few shares within it (pic2). The 1st one is **Spatial Data** -the initial for any GIS. It may be different information about objective valid things and facts, in a different format (text, timetable, static, graphic, cartographic and so on). From different fields: geographic, social-economic and political.

Special technical support is necessary for GIS production, computers (personal, portable, tablet and so on), data storage products (server, hard drive, discs and so on), data inputting devices (scanner, digitizer, digital camera and so on), printing devices, (printers, plotters, projector and so on), global positioning system and many others.

"What should be the capacity of a computer for successful run of GIS in it?" It's quit logical question and you will hear it frequently, from people who'd decided to work within this field.

From the beginning it was needed really expensive computers for GIS usage, but it was till 90th, but for today it's possible to install GIS in any kind of personal computer. But anyway you've to think in advance.

Computer devices have to be elected according to GIS demands and level of production. For a local GIS even a computer with not strong capacity is enough but for big organizations and governmental structures its needed computers with strong PC features, with modern technical specifications, (newest digitizer, printer, plotter and so on). Also we've to know the specifications and attitude of GIS with computer specification. To blowjob any digital redactor (ex: Photoshop) in a case of auto dimensioning and dislodge, to redraw the image on a screen, (depiction of image in a different position and size). During this process hard drive disk and RAM are involved. In GIS program in a case of the same procedure, processor is included during workprocess, every pixel data is controlled (coordinates, colors), and in a case of vector every vertex coordinate and every figure of attributive schedules and only after it redraws an image.

For a long time GIS was formatted for 2 hardware bases, personal computers and workstations.

When we're discussing GIS that's formatted for PC, as usually it was considered PC, board systems that were intended to work with

small data. In PC processor of Intel- 8086 or Cyrix's Microprocessors were used, they were modified according to GIS Architecture. Computers work only on a specific operational systems MS-DOS, MS Windows, and the magnitude of the RAM was just 32mb. Geoinformational systems were built in a workstations, they were using RISC- high capacity microprocessors and monitors with high resolution and large scale. With RAM of 512mb. Operational systems UNIX, Solaris, VMS, and O/S2da were used.

Within the field of technology technical blowout substantially changed situation. GIS production became more consumable, because of affordable prices of computers and improvement of computer characteristics.

The development of new operational system as Microsoft Windows and Linux also promoted on GIS demand, for example from ESRI to Windows NT's characteristics totally had fitted NIX operation system, because of it exploitation of Geo Informative systems became more easier. A huge importance have peripheral devices of computer that were used for data entry and out. Digitizers - a tablet were used for vector data entry, and with the help of the graphical data are kept within a computer memory. It was rarely used in Georgia.

In Georgia mostly are using scanners. With the help of scanner paper maps, plans and schemes are storage in computer memory card as a raster format (tiff or jpg). After georeferencing (linking on a coordinate system) they are swirling as a vector layers.

Mainly is used 2 types of scanner, tablet and one with wide formatting. Tablet type scanners enables to format 4 and 3 format scanning, the second one enables to scan even 0 format data.

The printouts devices are also important, during selection process of colored printer, you must take into consideration specifications of the working process and the results. If you need to print few copies of a map you can use laser printer, but if you need to print high resolution map you should use inkjet printer.

**GPS receiver**

It is one of the most reliable solution for data gathering. It's for a while GPS Global Positioning System is used within GIS system. Its global satellite navigation systems, it makes possible to define occupation of any object on the earth, regardless the weather and time (24 hour) and of course it's free.

We'll discuss satellite navigation systems in 4th chapter, for now we are considering receivers.

**GPS receivers** - radio receiver device, its used to define location of antenna, define coordinates, for what is used the radio signals, what are received from the satellite of global navigation system.

There are many sorts of GPS receivers, professional, high precision and common receivers. The first is used in military systems and cartography, the second one for everyday use in working field.

**Geodesic receiver** - is used for exact-topo geodesic works. It consists of receivers block (antenna that's merged with receiver-issuing devise) the name of this devise is shrove.

**GIS class receiver** - is kind a pocket tablet, in which its installed receiver-issuer and antenna. Geodesic receivers are used successfully and give exact coordinates but some of GIS models are replacing them.

**GPS receivers also differ by purpose and constructive peculiarities.** Most of modern GPS receivers have 8-12 channels. Maximum quantity of channels are 24.

There are two types of receivers with 1 or 2 frequencies and insure cover fast initialization.

According to accuracy and prescription there are few receivers: geodesic class (accuracy 1m), cartographic receivers and IS class (1-5m) and navigation class (100-200 m)

First one is used for exact topo-geodesic and engineering works. They’re expensive. But during working process in automatic mode generates defining of coordinates 13sm, and during kinematical mode 1.5-5sm.

Also there are portable devices and receivers that are built in other devices.

**Portative receivers are:** auto receivers (as a separate device or onboard devise in a car) touristic, and sporty. Devices built in pocket tablets and notebooks and smartphones are **built in receivers**. Receivers are often equipped with electronic maps and specialized services. **The next main component is Software.** The program should be chosen correctly according the working field and GIS productivity. We’ll discuss it in separate chapter. Software packages mainly have same characteristics but there is a huge gap in prices. In market GIs Systems differ by their functional characteristics, interface, and dependence of the demand of a system.

There are 5 classes n GIS program software.

**First class** - functionally is mostly perfect, they are defined for most complex tasks, to enter data (both cartographical and attributive) and to storage it, processing of complex informations, solve spatial analytical tasks (network tasks), generation of thematic maps and schemes. Typically GIS instrumental programs have both raster and vector support. They have data base for digital ground and attributive data or they have distributed data base support (Paradox, Access, Oracle and so on). Developed software has system runtime that can optimize functionalities of a specific task.

**Second class - GIS visitors.** Enable to have an access to generated maps within instrumental GIS. User can request for information, rule cartographic image (positioning and sum). Some of them give a limited opportunity to fill up data base.

**Third class** - reference cartographic systems, they are defined for huge

spatial data visualization, uses graphical and attributive search engine. Making any changes in da data base is strongly limited.

**Fourth class** - is defined for spatial moderation. Among them have to be mentioned relief, environment pollution, flooding area and so on. They are founded on a matrix data and have strong visualization effects, the typical tool is designed for calculation of spatial data (add, minus, multiplication, divide and other operations).

**Fifth class** - is special software package for earth sensing data encrypt. Among their functional possibilities are lots of operations (rectification of raster images and many other corrections, synthesis, analysis and so on). Alongside of above mentioned classes there are also program packages .that are defined for manipulation of spatial information, for example: geodesic data processing, navigation, ecological, geological, and hydrological and other tasks.

Below you can see main GIS program packages. Some of them are used in Georgia (Table 1.2).

**Data storage** is one of the GIS main function. It includes gathered information, systematization and classification. Ranking ding and placement of data in geodatabase.

**Query**, operational data search is one of the main functions of GIS, its digital map differs from traditional map. We are losing a lot of time to find some kind of information on a map. The more complicated the map is, more time and energy is needed to get required information. Some maps and atlases has special search indexes that helps a lot to find objects. But anyway, even so its limited opportunity to find data. GIS enables not just to decrease time and efforts to find information, but also widens area of required information.

In GIS we’ve 2 variety of searching data: thematic (select by attributes) and spatial (selected location). We’ll discuss this cases in other chapter.

Some of GIS programs (ex: ArcGIS) enables to create search engine.

Table 1.2  
GIS Software

Program	Manufacturer
ArcGIS	ESRI
MapInfo Professional	MapInfo Corp
AutoCAD MAP	Autodesk GmbH
AutoCAD Land Development	Autodesk GmbH
GeoMedia	Intergraph
Mapitude	Caliper
Tactician	Tactician
ГеоГрафГИС 2.0	Geography
КБПанорама (ГИСКарт)	
CREDO	КРЕДИО-Диалог

**Display**, visualization of data is one of the benefits of GIS. With the help of this function, its possible attribute spreadsheets to be transformed in different cartographical images. The figures could be transferred in map. Visualization of GIS means map generation, construction of three dimensional models, formation of diagrams graphics and so on. GIS programs has unlimited ability of creating data visualization.

**Analysis** geographical data processing and usage is basic part for data analysis. It’s versatile and shows exactly cornerstone of GIS. It enables to define appropriateness between data. To get the result GIS uses different kind of programs. One of the most important program is ARCG, it enables manufacturing of analysis with the help of additional modules. 3D analyst,spatialanalyst, Geo-statistical analyst, schematic analyst. ArcGIS network analyst.

**Output** - It’s really expensive to use GIS and when we are paying for

it, need to get valuable results. There may be lots of outcomes. First of all it’s easier to gain and work on a data, storage. It’s possible to get spatial data from data base and also qualitatively new data are formed during this processes. It improves working process and helps to plan and forecast results and working schedule. The result is: better managed system, optimization of decision making process and cost reduction.

1.1 Classification of GIS

GIS is quiet multifaceted and hard, multifunctional system. The complexity of its tasks create multi GIS that could be defined as follows:

GIS is defined by its functionality:

- General-purpose, multi-functional
- Specialized GIS, that’s oriented on an exact task within a thematic field
- Informational reference GIS for private users
- Inventory GIS
- Monitoring
- Research
- Training
- Publishing

GIS based on Architectural principles and their construction

Closed systems, that don’t have any opportunity for improvement. The can work according the system that was programmed during creation. Open systems, with development features, in this case GIS programming enables for creation of new programs.

According to territory coverage:

- Global-planetary(5-10km)
- National-governmental(104-10km7)
- Regional (103-10km5);
- Local- (102-10km3).



According to problem - thematic orientation:

- General geographic area.
- Ecological and nature benefited.
- Sector (water resources, earth cadaster, tourism, transportation and so on).

According to the organization’s geographic data:

- Vector
- Raster
- Vector -raster
- 3D dimension.
- Sub systems of GIS

1.2 GIS Subsystems

GIS is a kit of subsystems, there are 4 main subsystems within it:

- Data processing subsystem - it includes next elements: information gathering, already available maps, roistered images or field survey;
- Data input - input data in digital data base;
- Data storage - define format, mechanism and intensity, frequency of usage and others.

Data analysis subsystem

It consists of following elements: data research and analysis, -beginning from data easy search to statistical analysis, and also work with huge amount of data.

Data usage subsystem

Scientists can use data, so can decision makers, training organizations and so on. GIS programcanorganize data optimally.

Data management subsystem

It includes: Organizational structure- defines departmental a corporate geoinformational systems structure, define directions, spectra of analysis and so on. In this group system developers should be considered, together with database administrator, system operator, system analyst, GIS operator and others.

Interactions procedures - its vitally important, cooperation and intense ties between structural units and GIS departments for effective functioning. So to insure it there are established special procedures and regalements.

How to use GeoInformational Systems

GIS is used worldwide and demand is rising daily. It’s covered mainly all working fields, it’s used for: managing data, analysis, develop recommendations, monitored ongoing processes, and decision making process and so on.

GIS has huge impact on natural science area, together with social economic areas. They have some advantages within this field. It determinedbecauseGIS improvesconstructive, applied side of geographic. It’s because of GIS possible Complete and comprehensive study of defined territories, geographical analysis, and creation of operational maps, manage automated systems, inventarisation, geographical simulation, forecast, planning and management.

Because of its practical usage, GIS spread worldwide and is successfully used in scientific- research and studying organizations. There are a lot of huge number of multi informational systems all over the world.

GIS can solve multitask and complex tasks, the map gives opportunity to see things clearly that could not be seen from spreadsheets, GIS is unchangeable in this field. Because it has receive and work with data that’s not even shown on maps.

We can manage Geo Informational systems usage aspects within 3

group: studying, scientific and practical. You can use GIS in different terms during managing learning objectives. For example in Geography, its used not just by a teacher as an interactive and universal visualization, but also students can modify own, updated thematic GIS. He’ll update it periodically and use it in different activities.

GIS’s are actively used within Scientific Viewpoint. Some sciences are using huge amount of spatial data, and GIs is irreplaceable for systematization and analysis.

It’s a long time GIS is used in many working field successfully. It’s in field of security, emergency situations and conflicts management, cadastral production, agriculture, environment protection, urban development and city constrictions, transportation planning, communication and network management, regulation of business environment, create navigation systems and many others. Each of them is using common GIS programs together with specially moderated modules for sectors. It’s a solution for saving time and money, create optimal and recommendable packages for business environment, and it’s the best instrument for decision makers.

So the spectra of GIS is unlimited. The main reason why it’s so popular and usable, is the fact that better opportunity for time management and its operational spatial analysis.

There are 4 levels defined for GIS usage: residential, office, industrial, science.

On residential level, basically are used informational systems, with ability of modification of attributive data.

Office level, issimilar toresidential level, but additionallyit’sfulfilled with many functions. For example: optimization of cargo distribution, regulation of routes and so on).

On Industrial level special systems are formatted, each of them is in response for salvation of a specific task.(cadaster of land and real estate, forecast of natural disaster, forest care and so on) it

already has functions for spatial analysis. It’s strictly defined technical requirements of a system and access to information.

On the level of science is used open systems, user can modify and custom system by himself. It’s fulfilled with lots of functions of spatial analysis.

The tasks of GIs could be managed as follows:

- Land cadastre
- Land development
- Zoning
- Plot rate of land
- Land usage
- Urban development and city construction
- Acologicalmonitorin
- Commissioning of engineering infrastructure
- Demography
- Population description
- Management of demographic processes
- Agriculture
- Informational support for decision making
- Regulation of subsidiaries and investigations
- Manage agricultural land area
- Forecast of harvest and cost calculation
- Increase harvest
- Planning OD agrotechnicalactivities, monitoring and analysis
- Tourism
- Strategic planning of tourism development
- Insure customer awareness
- Insure tourism security informational support.

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By Zurab Laoshvili.

Table 1.2 -GIS Software  
By Zurab Laoshvili.

# Geographic Information Systems in Georgia

Authors: ZurabLaoshvili

## 2.1 GIS development

It’s for a long time GIS is used on a market. In literature is defined 4 levels of lifecycle. **Beginning** (novatori), state initiatives in commercial development and consumer, during this period GIS technologies has been formatted as independent scientific - technical area.

**Beginning** (novatori) level covers 50 years of the XXth century and yearly 70’s. For that time, the idea was to evaluate new opportunities that will enable to integrate with electronic devices. This period is characterized by rapid development in cartography, that is linked with the development of computer technologies.

That period was mainly important geographic and cartographic scientific theoretical works, in which were discussed interconnection between geo objects. Also foundation of quantitative methods in Geography. This field was mostly popular in the USA, Great Brittan and Switzerland. Works of William Garrison, Torsten Hagerstrand, Harold McCarty, Ian McHarg should be noted.

At the beginning period of GIS development digital data was insignificant, and needed hard work to create the data. The main device for creating data in digital format was the digitalizer. Also automotive designing systems were used (mostly autocad). Information wasinputted form paper maps, rarely from original maps and aerial photos. Cartographic images on display cause admiration. For that period of time it was the main goal and expectation, so that period is called” Time of funny images”. The interface of available systems were clumsy and it needed long time to master in it.

Homeland of geoinformational system is defined Canada, in early 60th governemant storaged huge amount of cartography and texts information an in digital archive, it’s how the Canadian geoinformative archive was created (The Canada Geographic Information System – CGIS). It should be noted that large scale system (1:50000) is functioning from 1962 year, is improving and has a great support from government.

For the beginnings was intended for searching, analyzing and systematization of huge data in the department of land record (Canada Land Inventory). It was used in agriculture and forestry, for planning land usage and gather statistical data according for land.

English Geographer Roger F. Tomlinson is known as an inspirer of GIS in Canada, at first he was specialized in the glacial geomorphology of Labrador. The topic of his PHD thesis was “The application of electronic computing methods and techniques to the storage, compilation, and assessment of mapped data.” his pioneering work led him to initiate, plan and direct the development of the Canada Geographic Information System, the first computerized GIS in the world. From the 1970s until his death, Dr. Tomlinson worked in geographic consulting and research for a variety of private sector, government, and non-profit organizations, largely through his Ottawa-based company, Tomlinson Associates Ltd. Which has branches of consulting geographers in Canada, the United States, and Australia.

In 1996 he was awarded the GIS World Lifetime Achievement Award for a lifetime of work with GIS, and he was the first recipient of the ESRI Lifetime Achievement Award in 1997.In 2011, he was presented with an Honorary Membership in the Association of Ontario Land Surveyors. All his works are gathered in wonderful book - “Think for GIS- planning of GeoInformational System: book for managers”.

Harvard Laboratory for Computer Graphics & Spatial Analysis in USA had also a deep interest for producing GIS. They had some success within the conceptual and practical direction. Among works that were created in this laboratory should me mentioned: SYMAP- multi target cartographic system or mapping system program to print cartographic images on a plotter, SYMVU is a computer graphics program written for the purpose of generating three dimensional line-drawing displays of data and also ODYSSEY – ArcInfoPredecessor.lately SYMAP had been transformed in CALFORM- because of usage of large displays .SYMVU was created to 3D dimensions, GRID for raster cells. In 70th years it had been transformed in POLYVRT and after it transferred to ODYSSEY- complex program package that was based on vector graphics.

In 1967, in the USA census bureau James Corbett headed group of programers Donald Cooke and Maxfield created special format GBF DIME (Geographic Base File, Dual Independent Map Encoding. For the first time in history was developed scheme of spatial relationships between objects on a map. After this invention was easier to find out topological errors and mistakes. They’ve borrowed algorithm from Canadians GIS and POLYVERT from Harvard laboratory.

Evaluation of GBF DIME format played a major role in development of Geo information systems. In the 70’sGIS was used in every country. In the 80’s, it was transformed in format TIGER(Topologically Integrated Geographic Encoding and Referencing), and was used for count of population in USA in 1990 year, for now it has intensive meaning within different GIS Systems.

Jack Derjemon played an important role for GIS development, Jack Dangermond was born in 1946 and grew up in Redlands, California as the son of Dutch immigrants. His parents owned a plant nursery in Redlands. Dangermond attended Redlands High School. Dangermond completed his undergraduate work at California State Polytechnic University, Pomona (Cal Poly Pomona), studying landscape architecture and environmental science. He then earned a Master of Architecture degree in Urban Planning from the University of Minnesota, and a Master of Landscape Architecture degree from the Harvard University Graduate School of Design GSD in 1969. In 1969, he co-founded with his wife Laura the Environmental Systems Research Institute (ESRI).

From the beginning ESRI was private consulting company, that used GRID format for cartographic works, and from 70 Th year they begun use of vectors. In 1973y it has transformed on MAGI (Maryland Automatic Geographic Information system) system from a small software products.

For nowadays ESRI has 2.5 thousand employees worldwide, and serve more than million customers. Its official representative in Georgia is geoinformationlal systems and distance sensing consulting group “GEOGRAPHIC”.

ESRI- founded special award to appreciate contribution in GIS development, first laureate that was nominated for this award was R. Tomlinson.

The second part of GIS development begun in 70-80 years of last century, a lot of GIS projects were performed during this years. Governmental institutesand working fields became more interested in GIS. But simultaneously belittled role of separate groups and researches. GIS took the form of local experiment.

During this period in USA were discussions to use GIS during description of population. The main conceptual problem was conversion of population addresses to Geographic coordinates.



it should become one map with address bar.

Lately it became mandatory to use new technologies for population census. After this in 1970 year population census was held with the help of Geo informational Systems. Files were updated for the first time.

Simultaneously with land usage and poluationcesus, GIS was used on a state level, to manage navigation systems and city transport.

Below geoinformational thematic systems of national interest were modified.

- Land cadastre
- Calculation of forestry
- Description of geological environment
- Managing of communication engineering
- Ecological monitoring
- Emergency management agency
- Military GIS

This systems were modified according to strict and regulated data storage formation, classificators, cartographic expression of data. Data legitimacy, relevance, accuracy and access to information were noteworthy for them.

New modules have been formatted for every concrete product and they insure data processing and task salvation. For example for land cadastre it was like this: geodetic data analysis, cartometrical operations, evaluation of land cadaster rate, and preparation of land usage and land cultivation documents. The module have been created for communication engineering enabled to inventarization, hydraulic computations, prepare documentation for emergency brigade and so on.

At the end of 70’s, in the USA have fully examined usage of GIS within different fields. Under the aegisof International Geographic

union, inventarisation of applied GIS utilities were performed.in 1981 year according to this works professor F. Marble published book “software systems for processing spatial data”<sup>1</sup>. The result of analysis showed up that GIS software products didn’t satisfy demands. It cause creation of new hybrid informational system, it enabled to work both with raster and vector data.

We’ve to mention that the cost of system is too high, as the demand is high forhardware products with strong characteristics. System mostly works on a base of expensive stations. Most part of data is created and used within the ministry. Further, information is sustainable, it’s updated periodically by Field Topo geodetic works and processing of aerospace images. It’s true that list of tasks to be solved is limited. Main accents arefocus on visualization and documenting.

**Commercial level** - from 1980 until 1990. For that period of time computer devices and software’s became cheaper and available, it was caused by high level of production and rapid development of computer technologies. Its notable high sales of GIS system and products. New spheres have been developed and network systems of GIS have been widened, new network systems have been formulated. Within the GIS development processes were involved not only cybernetics. Everything this influenced widening of the software market, this period is also known as the mass period.

On 3rd level of GIS development, a lot of software products were developed from informational and referral nature to board requesting, they were created for everyone. GIS systems work in internet, smartphones, GPS systems, watches, car navigation devices and so on.

International cartographic association (ICA)<sup>2</sup> promoted Geographic informational systems. In 1982 year in Warsaw was held 11th international conference, after what this thematic have been emissionedIndependently and after it cases according to GIS are discussed separately.

In 80<sup>th</sup> years network spatial geographic informational systems are widened together with natural resources informational technologies, it was the result of geological (GEOLIS), soil (BIS), landscape (LANIS), natural resource planning (CUM LIS), ecological (oelis) and other informational systems.

Microsoft- gigant of computing industry became interested in the GIS market and created program EXCEL for working with spatial data, lately created separate programs. In 1981 y Denjermon released first commercial software program of ESRI- Arc/Info.Afte software systems UNIX and Windows have been launched, ESRI modified programs according to them.

First time in Arc/Info were presented separately geometric (cartographic) and attributive information. Attributive data were stored and processed within spreadsheets (info) and for graphical data were used arc (arc).

In 1986 new players appeared in GIs industry, 4 students graduated from RENSSELAER Polytechnic Institute Laslo Brando, Endrew-Dressel, John Haller and Shono.Hallivan decided tocreat cheap and easy instrument of digital cartography. They’ve founded company MapInfoCorp, and first order they’d received was from local school district, Bus routing order. The gain they’d received spent on software development and improvement.

The first GIS program MapInfoProfessional have been lounched in 1987. It became popular very soon and keeps popularity in nowadays. In Georgia it’s used as first GIS program from 1994 till now. But it didn’t became mass usage product like ESRI.MapInfo Professional 15 version is out in market.

In the same Year University of Clarck professor R.Eastmen leaded development of raster GIS software “IDRIS”, it became popular all over the world. In 2015 new version have been lounched-TerrSet. Its geoinformative systems and distance sensing integrated software. Its GISs instruments are fundamental and during 30 years of development its quantity reached to 300.

Together with GIS development data market is also widening. System loses independent meaning and is linked together with the overall system of duments formation,it widens borders and combines spatial data. Satellite images became an essential part of the spatial data. Even the low cost systems features are improving. “Funny images” are created , new production systems are created and improving. Gis manufacturers became focused on mass consumption and comercial GIS products.

Consumer level (from 1990 year till now) is characterized with increased consumer market, standardization. Geoinfomational system is formatted as an “open system” that’s connected with other softwares. GIS entered in every field of public life. Global geographical infrastructure have been created.

In 90th new digital devices have been used more and more often. And also Global Positioning System GPS was launched - a revolutionary system to get exact geodetic data within the shortest time.

From 1990 begun the era of changes for ESRI. In 1991 the first board GIS - ArcView GIS was launched and was intended for wide community.

In 2000y ESRI issued revolutionary product ArcGIS’s board in a form of GIS’S family. It includes ARC GIS additional applications (Arc Catalog, Arc Map, Arc Toolbox, Arc Reader) and modules ArcGIS 3D Analyst, ArcGIS Geostatistical Analyst, ArcGIS Schematics, ArcGIS Survey Analyst – Geodesic processing of data, ArcGIS Tracking Analyst - spatial control of moving objects, ArcGIS Network Analyst - manage transport network, ArcGIS Military Analyst - manage military data, ARC GIS has board, server and web versions.

The first version of ArcGIS was 8:0, now it’s ArcGIS10.4. In 2015 new version of ArcGISPro-ArcGIS Desktop new application have been issued. It’s a fundamentally new solution for data correction, visualization and spatial analysis. With its help is possible the simultaniousvisualization of two and three dimensional

data. It can be defined as the main feature of this application. Beside, data publication is possibleinwith options: thematic layers, web-services, in the form of 3D web services and webmaps. Application uses also ArcGIS Online and ArcGIS portal.

Simultaneously program “City engine” have been released by ESRI, it was defined for modeling, planning, analysis and prediction of 3D dimension. 3D objects are easily corrected by its help. It’s the best instrument for architects, city contractors and entertainment field.

In 2009 year J. Danjermon noted in his interview with “Government Technology” that development of ESRI is linked with web technologies. Today devices produced by this company are significantly using internet opportunities. GIS program products are created by different companies. ESRI owns 47% of total market share, another 53% is shared between similar 11 companies.

As an example of success of Geoinformation technologies should be mentioned Intergraph Corp it was founded by J.Medolck, his success was determined by USA's interests in defense. Spatial managing system of controllingrahkets in real time have been created for armed forces.

The product of Intergraph Geomedia is being used especially within cadastral production.

Development of GIS is continuing actively .The amount of sales of this technologies all over the world is about 9 Billion USD. GIs systems even are used for study of cosmic space.

USA and Canada are leaders in introduction, usage, and production of GIS. From the 80th years of last century they’ve created more than 1000 Geo informational systems for various purposes.

In Soviet Union, Georgia had been a part of it also, started using of GIS lately. It was first attempt for adaptation with foreign experience. Officially it was suggested during the conference

that was held in early 80th by Estonian Geographical Society and University of Tartu according to problems of Geoinformatics. The first researches were conducted by Academy of sciences, Institute of Geography, Eastern research center, Kazan’s, Tobolski’s, Tartu’s and Kharkov Universities. First automotive cartographic systems have been created during this period. Spatial analysis, cartographic -mathematical modeling, automatization of thematic cartographic were implemented there.

The conference “Automatizasion in thematic cartographic” that had been held in Moscow in 1985 year , played a huge role for development of Geoinformatical theory and development of technology.

Within the territory of Soviet Union, first products of GIS had been created after its disintegration. In 1992 Russian academy of sciences geoinfomational research center created GeoDraw. In Russia a lot of GIS product shave been created lately: “ПANO-РАМА” (Тopographic Service of the Russian Armed Forces) “Парк” (“Ланек”, Moscow), CSI-МАР (“КСИ-технология“) Sinteks ABRIS (“Три - софт” Moscow), ObjectLand (“Радом-Т”, Taganrog)da Ингео (“Интерпо” UFA). But anyway, in this market foreign manu-factured GIS products were more demandable (ESRI, Intergraph, Map-Info, Autodesk and others).

Development of GIS systems in Georgia had been laid the foundation about 3 decades ago, when in 1987 year in Tbilisi State University in a cartographic-Geodesy faculty with the initiative of Professor NikolozBeruchashviliwas formed new direction – Geo iformatics.The faculty had been called “Faculty of cartographic-Geodesy and Geoiformatics”. Simultaneously there were created raster maps with different thematic, and different sort of programs had been used (DEGAS, NEOCHRON, GRAFIC, ARTIST).

In 1990 N. Beruchashvili introduced and implemented Graphical GIS program -Dr Halofor the very first time.

From this point of view its quetprimitive, but in time when even Windows didn’t exist and everyone worked in Disk operating

system, it was kind a magic to get colored images. The first presentation of program was followed by wild applauses. As we’ve already mentioned Georgia’s first digital basics took place within this program.

In 1993 year N. Beruchashvili published first book in this field” personal Computers in Geography”.

But in reality GIS have been developed in Georgia from 1991 year, when N Beruchashviliintroduced APPINFO in Georgian market. In the faculty that have been also founded by him “TSUstudding aerospace methods for the environmental conditions in Research Laboratory” were created different digital scale basics, thematic maps and first GIS analysis.

“Black See “-Geoinformational system was created according to ecological problems. It was created on the bases of special programming that was developed by preserving the environment of the National Fund -Global Environmental Facilities. The system contained 7 blocks: Geography, Geology, Meteorology, Physical Oceanography, Biology, Chemical Oceanography / Pollution, Fish Resources, included 2000 thematic map. About 11 research Universities and more than 50 experts took participation.

A lot of specialists were born/created within the Research Laboratory of Aerospace methods for the Environmental Conditions. The very first experts of GIS are: AsmatAkhmeteli, Tamar Bakuradze, MalkhazKhurtsidze, Dali Nikolaishvili, Manan Qurtubadze, ZurabJincharadze, and many others.They were studying form N. Beruchashvili GIS theories and practice. They’ve created first Georgian territorial administrative geoinformational system -GIS.

NikolozBeruchashvili was one of the greatest persons, lecturer and professor within this field, not only in Georgia but worldwide. His strong interest and efforts laid the foundation for GIS development in Georgia. He was inspirer for all this events and activities. It have to be mentioned that for the end of 80th Simultaneously

there had been existed colored images- prototype of GIS.That was created by employees of polytechnic University especially for Tbilisi . The founder of this idea was professor of State University IosebSaluqvadze.

In 1992 year within a faculty of geomorphology-geoecology was created “Earth’s Remote Sensing Research Center study” . The author of the idea was Giorgi Abuladze, Academician Zurab Tatashidze played also a huge role forits development and improvement.

On the roof of the administrative building, from mounted Earth’s artificial satellites (Meteosat - European stationary stelliteadn NOAA - Orbit satellite from USA) center was receiving satellite pictures of our planet. Interactive software processing results also became the basic for many theses. The center was equipped with stereophotogrametic and analytical equipment produced in Germany (Karl caisi). Soon they were changed with the computer technologies.

Remote sensing centrewas involved in studying process of the University. There were founded dozens of the academic discipline in the field of earth research with remote methods G. ABULADZE had a huge experience in encryption of aerospace photos. Had universal knowledge and shared it with young students and scientists with huge enthusiasm.Zurablaoshvili and George Gotsiridzeweredeeply involved within the process of mastering newest technologies and its distribution. Knowledge, experience and information gathered during this years were used as main basics for the number of new GIS projects. It had a huge impact on development GIS systems in Georgia in terms of remote sensing development.

By that time first GIS nongovernmental organization showed up. In 1994 was made new nongovernmental organization by M. XURCIDZE AND Z.JINCHARADZE – “Georgian Geo-informational center”.

Organizations active works gave important push up to the development of GIS technologies outside of university. In 1988



have been founded new organization “United Nations Environment Program”-UNEP. On its basics was founded new Thematic non-governmental organization UNEP/GRID and GRID/TBILISI (Z Jin-charadze, T Bakuradze, M. Qurtubadzeand others) it’s functioning successfully and is solving problems according with environment and natural recourses protection.

Earlier in 1991 G.ABULADZE founded teaching center of the geo-information systems “DEDAMIWA”which in beginning was working in the field of distant sensing but for now its main directions are:

- Learning and consulting of the program products of GIs
- Gathering and working on spatial information
- Providing project work
- Analysis of the environment
- Providing of the cartography products
- Branch geo-informational systems
- Create specialized software system.

Exactly in this center was held first GIS studying courses. Collaboration of the centre became more alive after cooperation with M. XURCIDZE. In 1997 with the order of Government, was made first huge geo-information system of the Kolkheti national park (sacle1:10000). Cosmic and aero shooting photos have been used for updating exciting information.

To help commercial activities M.Xurcidze and G.Gociridze decided to found commercial centre “Geographic”. We can say that it is the unification of “Dedamiwa”and “GINFO”. It was first projects that was funded by UNDP. It was successfully lounched and was created to create Georgia’s natural disaster process controlling GIS, of scale 1:200 000.

GIs software program MapInfo is becoming more popular! But one incident totally changed the way of development of the GIS. One day in the street professor with the professor of physic-methematic university IURI KOLESNIKOV, during conversation

with him, he’d found out that there showed up new product had been developed in GIS systems -ARC WIEV it was much better than MAPINFO and was successfully used by universities, and in Moscow there was official representatives of this American company ERSI- that’s manufacturing this product.

In the organization had strong interest according to this case. With the help of G.Abuladze, Khurtsidze AND Gotsiridze traveled to Moscow on the international conference. This conference was held annually by the official distributor of ERSI - “DATA+” (www. dataplus.ru).

The founders of “Geographics”returned from Moscow, with the documents of Data+, ERSI and ERDAS program products and with huge learningmaterials. After this developing of the GIS became rapid. Program products of ERSI-professional-ARC/INFO- and ARC VIEW become loved very soon. The difference was really huge. In addition to this remote sensing technologies have been produced. It was universal program- ERDAS Imagine, which was produced by the American company ERDAS (Earth Resources Data Analysis System). Using this program it became possible to take aero cosmic photos, decoding of data, spatial analysis, 3D dimensional modeling and so on. It basically works with raster data, but in a case of need uses GIS format. Its toolbox gives opportunity for versatile transformation of raster images.

The first one was ERSAD 4, its first version was launched 1978y for Cromemco computer (8 GB processor) and was improving gradually. In 1980 ERDASIncworked on ERDAS 400, it was kind of monitoring and managing system for NY green plantations. In 1980-82 some of its modification have been presented in USA’s cosmic agency (NASA), US forest cervices and Agency of Environmental Protection of Illinois.

In 1982 ERDAS 7.0 was lounched, which was based on IBM PC personal computer (op.system MS DOC).It worked on consul regime and had small menu that helped users to prepare photos when working in GIS.

In 1983 the department of geography of South Carolina State university bought first license of the ERDAS7.2 and were soon this technologies of remote sensing were widely used in practice all over the country. In universities they were used for teaching and for scientific terms.

In 1983 to the ERDAS 72 was improved -ESRI ARC/INFO with the help of it was possible to work in to the real time. This function was called “ERDAS-ARC/INFO LIVE LINK” it worked at the same time with the raster and vectoraldata. From that moment relationship of this two companies on technological and management level became stronger. It was defined by the fact that JACK DANJERMOND, LORI JORDAN AND BRUCE RADO (the cofounders of ERDAS) were studying in HARWARD University together.

“Erdas Imagine” firstly introduced to wide society in 1991 and in February of 1992 was launched its new version8.0.It was made for sun workstation (operational system SUNOS) Graphical User Interface have been used that gave opportunity to users for data visualization, represent vector layers and mapping. ERDAS 7.5 version was totally integrated within it.

In 1992 ERDAS developed new radar model of the Radar Interpreter. After integration of ERDAS and Arc/Inf in 1993y, for the first time ERDAS presented vector modul “IMAGINE Vector Module” it was fully programmed by the ERDAS programmists but it was licensed with ERSI format-Arc coverage .ERDAS IMAGINES was one of the most popular product until the new version of ERDAS 9.3.

The last model of the ERDAS7 was ERDAS 7.5 which represented finalized model of the ERDAS7. In 1991 was produced its new fotogrametrical model-ERDAS DIGITAL ORTHO. In ERDAS Imagine 8.2 it was named IMAGINE OrthoMAX but in ERDAS Imagine 8.3.1(since 1998y) - OrthoBASE.

In 1990, in ERDAS 7.5 was laumchedlanguage and new model with it -GIS modeling (GISMO) based on Ben Tomlin’s cartographic algebra for creation complex spatial models. In 1992 with the

release of new erdas imagine 8.0 GISMOmodul had been transformed in Spatial Modeler scripting language. One years later ERDAS introduced MODEL MAKERs language script, it was graphical extansion of SpatialModuling.In 2004 ESRI represented new model of ERDAS -MODEL BUILDER .ERDAS new model was kind anafford for adaptation.

In 1991 company produced imagine7.5 new model ERDAS Digital Ortho. It was first commercial fotogrametrial package. Later with changed name it became the member of imagine digital ortho 8.0.1.and version 8.0.2 was called as IMAGINE ORTHO MAX. This model widened the borders of the market. In 1998 ERDAS imagine 8.3.1. Orthomax was improved and was called OrthoBASE.

Nowadays erdasimagane is produced bycorporation”Intergraph”. In May, 2014 was produced last version - “ERDAS IMAGINE 2015”.

In 2000y with the help of DATA+ “Geographic “held an international conference in parliament building where were presented executive manager of ESRI KEVIN DOGERT and ERDAS President LORIE JORDAN. The first conference was successfully conducted and it was huge victory and contributed a lot for GIS development.

GIS Boom era had begun! The company “Geographic” made the ice start moving. Before this event everyone looked with doubt for this case, but after the conference everything went in different way. Begun the era of the big projects of GIS. All the good things happened at the same time. Despite ofmany positive or negative attitudes this models showed result in short time.

In 2000, in Georgia with the help of Germany’s financial and technical support, also with the help of UNDEP and USAID together with the World Bank Lands cadaster had begun. The head of this project was I. SALUQVADZE together with M.XURCIDZE.D LIPARTE-LIANI and others. In 1996<sup>3</sup> State Department of Land Management Policy was founded, that was deeply involved within this project development.

The idea of the project was the development of the land market in Georgia. To make cadastre maps with the scale of 1:1000. The whole territory of Georgia had been covered by cadastere.

In the field of landcadastre was created strong material - technical base and were prepared employees. From 2000 'DEDAMIWA' " prepared dozens of persons and who now are working in private and public offices.

KFW project gave very good push to the development of GIS and land remote sensing development. Within the framework of the project it became possible to make colored images of country with aerial shooting and photogrammetric processing of data. Corporation "Geographic" invited expert VIACHESLAV ZAITSEV for holding special lectures for Georgian specialists in a field of digital photogrammetry. Within a short period of time they became specialist of this field and founded organization "Fiorto" that was functioning for years within this field.

From 2004 the continuation of the project is Georgian national agency. It provides in our country real estate and business, political units, registration of municipalities, public - legal restrictions, lien mortgage, addressing Gedasy and functions of cartography. For now GIS and software are created.

Until 1998 GIS projects were developing in Georgia spontaneously and they weren't used practically by governments. Now it is established in every field working area. Strong departmental geo-informational systems are successfully functioning in national public registry, also in Government of Tbilisi, in Ministry of self-defense, National statistics office, Ministry of Agriculture. Corpore GIS are modified ubGeorgian water and power, silknet, new lines, Telas, Nongovernmental and commercial sectors. Gistechnologys are also used in Scientific Research Institutes. The flagman of GIS foundation were members of academy of science geo-physics institute group of seismologists. Nowadays it is included within earth learning institute (Ilia State University). GIS technologies have been used for making Georgian seismic maps.

This works have been held since 1996 year, Seismic places of Georgia and of digital geographic layers catalogues of earthquake, have been prepared, were made parameterization of the hotbeds, and integration of the result of the seismic danger analysis and mapping within GIS format. The results became the basic of the new standards of the construction system in Georgia since 2009.

Simultaneously of calculation of Seismic dangers estimation, GIS technology was used in many ways. Georgian digital geological map was prepared in 2003-2006(with the scale 1: 500 000) digital maps of the different geophysical field (magnetic and gravity anomalies, helium anomaly and etc.), digital maps. GIS was used for modeling disaster scenario enguri weir. Beside desktop application and their products were also developed GIS web applications, as an example we can provide: web page of Seismic monitoring center ([www.seismo.ge](http://www.seismo.ge)). It provides online catalogue of the earthquakes and operative massage system.

In the same time in geographic university and GIS laboratory had begun GIS works, with supervising of Aleqsandre Javaxishvili. The main product they've created is GeorgianAtlas. In 2015 it was published, they also made thematic and territory geo-information system.

We've to mention 1:200 000 scale military engineering geo-information system. It was made by the Geoskope in 2006 (founders Mamuka Saluqvadze and Zurab Laoshvili). The author is the founder and president of academy, scientist and Professor Elguja Medzmariashvili. Digital map with the scale photographic maps which is a result of the aero cosmic instrumental and visual result. Digital map (2006y) is the result of, visualization and decrypt of aerospace images, of separate planshets of topographic map with appropriate scale. (pic35)

In bases of the system information with the basic photographic information huge military engineering thematic special detail information. They can be expreced with the special button on the areal objects of the thematic areas.

To make it easier it was created search engine with Georgian script, for thematic and spatial data searching.

Parallel to the 1:200 000 scale geo-information system was made the same system for APXAZIA and SOUTH OSETIA with special geological mission.

Must be mentioned that military-engineering academy and its president-E MEDZMARIASHVILI made huge impact on the developing of the geo-information system. This systems was used in different pay-rolls.

In 2006 as a result of the Georgian Cosmo-building and Georgian military military-engineering academy reorganization. By Medzmariashvili was created institute of the institute buildings special systems and engineering university. Where he takes place of the general constructor and head of the scientists council. Institute is still interested in areal analysis of the information and have some project in it. On the intellectual basis of university was made geo-informational systems developing fond.

At the same time is developing GIS productivity market. On its basis were developed number of new GIS independent companies such as "Geoland" and "Geolabi" "Tbilisi group" "Geoskop" "Sanson" "idea design. Group" "skafisi" and so on. From the thematic "seismic monitoring center" and "tourism geoinformation center"

Geoland created interactive web map "MyGeorgia" ([www.mygeorgia.ge](http://www.mygeorgia.ge)) basically for tourists and contents detail information. Company was established by Irakli Ugulava in 2003. It's one of the most known organization with the specialists in Geography and Cartography. Geoland is also one of the leading companies in producing navigational instruments GERMINS official reprezentator and with a help of its instruments provides navigational charts.

Learning GIS is one of the most important thing. "Geographic" is a certificated teaching center of ERSI where it's possible to study GIS systems. First international certificate was

awarded by "DEDAMIWA". On commercial market there also are number of GIS companies (Geoland, skafissand other) and teaching Centre for Eginteleqtcenter, vipminteleqt group).

Geo-information systems are also studied in Georgian technical and state Universities. In the first one there are many traditions. In "Distsensesensing GIS teaching center" founded by G. Abuladze, Z. Laoshvili and G. Gociridze and they've teaching additionally about 15 more discipline.

In 2004 was published auxiliary manual by D. Nikolaishvili for high education universities for geographic specialists. "Geoinformation and expert systems" in this book is discussed geoinformatic, digitalkartography, basic issues of geoinformation and expert systems. Work played huge role in developing of the of GIS systems and is table-top book for persons interested in geoinformatic and information areal Annalise.

In 2016 in Tbilisi state university was founded auxiliary educational unit. Geo-information systems laboratory. Which includes teaching of the creating geo-information infrastructure with different technologies and also modern standards. The idea of creating of it is connected with the name of GIS group. And took huge part in it members of this project: NIKOLOZ KVIJINADZE, LADOGRIGOLIA, LASHA SAMNIAHVILI, NATIA KARIWASHVILI, and TAMAR CIBARASHVILI AND OTHERS.

GIS GROUP was founded in 2012 by the members of natural sciences. Faculty geographic and modern technologies students. Laoshvili who was a teacher of the geoinformatic from 2012 the idea of creating it is connected with the name of Mariam Narsia who wanted to know about it more than was mentioned. At first at about 20 students were gathering in the 2<sup>nd</sup> building in "NATO AUDITORY" year later they continued studding in the first building of university. Subjects were various: geo-information system, using aspects of the geographic directions, computer technologies and etc. For 4 years of existing students who were educated here began their work in difference state and private services. Dozens of students



were emplode in company. Must be marked some of them such as: “Georgian water and power” (Tbilisi water-supply company) group from GIS consisting of ten man according to the job done by them the quality of the water-supply of the town was improved. During one year GIS group continued working in the national agency of the areal “neasfero” in which took part the leader of the agency Tamar Bagratia.

Nowadays in GIS group are involved many students from different Universities. It take a role in developing of the GIS in many ways. In Technical University with a help of geographic in 2010 was created cathedra of the modern standards, where is studied complex GIS, distant sound and geodetic-photography.

The studding of above mentioned technologies in modern ways is payed special attention at agricultural faculty and engineering of bio systems. Which is equipped with modern technical tools.

In ilia state university geo-information system is compulsory for all the students.

From 2012 in university named by GuramTavartqiladze, GIS is studded in the accordance with tourism.

From all over the country in developing of areal analyze of the information took huge part N.Beruchashvili, G.Abuladze, V.Chxaidze, D.Nikolaishvili.

In Georgia can be parted general trends of the development of geo-information. In the beginning stage different scale digital foundations of GIS formats were made. Day by day there was created thematicallyGIS products. Later was added elements of annalitycgis and programming elements. Which became basic for the number of the products. In 2002 to improve town building management in “geographic” was made program city analyst .Nowadays it is used to to keep documents and to estimate the situation of the building. For the planning of the reconstruction

activities, for the control and monitoring, project was used in Kutaisi, Tbilisi and Poti.

GIS is an effective instrument during decision making process. It gives possibility to spend money carefully.

Annually in every November GIS international conference is being held. In 2014 was held 15th conference as a mandatory there are presented world technological achievements new projects and etc.

The levels of developing of GIS can be divided in 3 levels: Descriptonal, Manage and Analytical

From this 3 in Georgia were finished 2 of them.: Descriptonal and Analytical. What about manage we can say that in some organization is already began and is developing with success (forgex.tbilisi government, telavi and etc).

Finally we can say that in Georgia the part of society that understands the efficiency of GIS technology grows day by day and today there are more than 200 users of the GIS.

Among the GIS projects developed in Georgia in last 20 year we can name some of them:

In 2001-2002 by the order Development Alternative Inc was created by “Geographic” geo-information system of the pond of Mtkvari and Araqsi geographic systems that gives opportunity to be planed the using of the water resources and to be improved using of them on the regional level.

In 2002 he made geo-information system of the historic parts of Tbilisi. Which nowadays is used by architects, art critics, engineers and other specialist of the Tbilisi municipality. During this project were created about 100 analytic and synthetical maps.

In the same year was created first Georgian digital atlas and so on. At the state level the clear example of the developing of GIS

is the foundation of the infrastructure of the national spatial data infrastructure (NSDI).Which is held by the national agency according to the request of the united nations of Europe. It is based on the directives of the euro parliament - INSPIRE. According to which the members of unit agree on the free exchange and harmonization of the basis geographical information in within the range of Europe.

NSD is a coordinate system of the institutionalactings, technologies, rules, standards, coordinated system of the information and human resources. Which give opportunity for the municipal self-government, academic circle, business sectors and general for the citizens. To search. Realize, use effectively.

Geographic information market grows annually 10-30 percent. Accordingly developing fast search of objects. Defining there locations and navigation services. The request of the geographic information grows on the realtor market. Tourist and insurance industry, transport sectors and atc .Nowadays for markets it’s hard to get necessary digital information it needs much time for funds. That’s why they are not used effectively.

To change existed situation is the main reason of the creation and developing of the national areal information infrastruccion. It will uptrend in Georgia existed profit from the geographical information. Creating of new and improved services of the geographical information and using them as a basis of the making decision will create better prerequisite for the development of society.

According to the project thatworked out in direction of the developing of GSI strategy for 2016-2018. Georgian government on 9 October in 2013 made decision #262 about creating government commission of the infrastructure of the spatial information and its developing. After that was done some activities grew consciousness and its meaning became clearer. This is notas-taught as a separate subject in universities but is planned for the future. Process must guarantee to improve knowledge in

several directions:

1. Production and keeping of spatial information
2. Management of the quality of the spatial information
3. Creation and use of the web maps
4. Titling of the facts
5. Using of program languages in the geo-information systems
6. Opportunity of receiving and using of the modern satellite information
7. Classification and standardization of the satellite information

NSDI national agency of public registry is a member of the geo-information system of the open consortium of the geo-information for years. Consultations are held on subjects such as: location on internet of the spatial information, safety, saving astorage of information, geosemantics, and compliance with internet directives. Harmonization of the standards of the consealting. Town planning, mobile services for the definition of the location and so on. The purpose of the consortium of geo-semantic is to draw out international standards that unites more than 400 companies, organization, public agency and university. Each of them works for the processing of the geographic information standards and their requests. Those standards and requests helps in using of thedifferent geographic systems. Interchangeability of the mobile connections and local services. Also popularization of the information technology helps to the creators of the systems and programs, for the accessibility of the complex geo-semantic information for users.

The government of Tbilisi from the end of the 20th century starts GIS technologies, but also must be mentioned that often there did not existed coordination and information exchanging mechanism between different organizations of one service. Integrated service of the satellite information moreover in some cases interior competition impeded development of this systems and efficiency of using. With the purpose in 2015 was created agency of the developing of the municipal services (MSDA) purpose of which is location of the municipal services at one place. (With the service of the web page my.tbilisi.gov.ge) creation of the united municipal interactive map (maps.tbilisi.gov.ge).all this serves to the introduction of

the electronic systems of the united geo spatial information systems and their development. ForMSDA was formed base of the united geo-information -ArcASD.

In autumn of 2015 was started processing of the general plan of the land-tenure. Those works are held by City Institute “SAQARTVELO” (with the instruction of MAMUKA SALUQVADZE) with foreign partners Albert Speer and Partner Gmb.in 18 months must be renewed the plan of the territorial-spatial development. Work is held by “Tbilisi group” (NikolozCheishvili). This will be one of the most important public geo-information system.

Despite of reached success in development of the geo-information systems in Georgia there are still different type of problems such as:

- There does not exist general and thematic digital bases (basis information)
- Most of Existent digital bases does not satisfies standards.

Current Status:  
Within the development of GIS Systems, we’ve to look through the trend that covered whole world.

They are Open systems, it gives an opportunity to create independently GIS for exact task. We can mention 2 lines within it: Systems that were worked out in Universities and valuable products, that became unnecessary after some time. Open software’s are spreaded by licensed systems: GPL, LGPL and so.on.

Development of GIS within the background of rapid development of computer technologies, can be shown in Table 2.1.

Conclusion

Cartography is an ancient science and is still developing. It plays a major role in the daily activities of the human being. In the century of information, it acquired new opportunities though the integrating computer technologies. Consequently, the current situation of cartography is significantly defined by integrating with the latest technologies.

Table 2.1  
Development of GIS

Time	Graphics	Geometry	GIS
1950-1960	Linear and Vector graphics	Easy Geometric Algorithms, mesh model	Pilote use of Cartography, creation of Space Digital Model in university of technology in Massachusetts
1960-1970	Interactive computer graphics	Curves and geometric computer languages in the development of methods for approximation	Usage of space digital model. Digital image processing, Creation of GIS in Canada
1970-1980	Restriv graphics, standarts, animation, computer games	Unambiguous depiction of spatial objects, Complex geometric algorithms performance	Development of large Geoinformational project, with the support of government. Formation of GIS universities, development of computer cartography and photogrammetrical
1980-1990	Cognitive graphics, Computer vision	geometriulimonace-mebis da meTodebi-sbanki, logikurisiste-mebi, standartizacia da pirdapiriwvdomis-sivrciTimeTodebi	Huge spectr of GIS programs and board GIS development, with integra-tion of non-spatial data, widening of its usage area, development of network applications
1990-2000	High-resolution computer graphics, development of pictograms from consumer interfaces	Proceed standardization, create MBs that are oriented objects	Hybrid GIS, Consumer oriented GIS, wide use of GPS, formation of geoinformational structure formation

In this regard, spatial data management and analysis technologies - Geoinformation systems (GIS) are at its core. These technologies are based on digital maps and databases, and are an irreplaceable tool in the hands of the decision-maker.

With the help of digital cartography, it was not only on the new heights of the mapping and its use industry (The process of mapping has been accelerated; map decoration, design and composite processing quality got improved. More varied became conditional signs and generalized methods of cartographic visualization and so on.), but also significantly simplifies the use and analysis of spatial data. GIS-products help us to make daily life easier. Indeed, it has been of great use in urban planning and design. In fact. there are a number of GIS software products designed to help with sustainable development, planning and management of cities.

That is why, the implementation of GIS-technologies is being funded by the Georgian Government. A clear example of this is the establishment of the National Spatial Data Infrastructure (NSDI - National Spatial Data Infrastructure) which is implemented by the National Agency according to the EU request.

It is based on the instructions of the European Parliament - INSPIRE, according to this, EU Member Countries agree to the basic geographical data exchange for free, and the harmonization in the authority of Europe.

Since 2018, all state branches or private ventures, that use spatial data in their activities, with the legislation will have to place this data in GIS format. In regards to this, with the intent of training cor-responding personal Public Registry created state strategy for studying of Geoinformation systems. The situation on the county was studied in terms of GIS teaching. Examined schools, where these technologies are taught. Material-technical base, training-methodological and theatrical material and qualifications of teachers was studied for this work. As a result of research analysis, GIS training strategy has been developed, which implies long-term cooperation with state universities in the first place in the field of specialists training).

The objective of this is the training of GIS specialists, which will

be accomplished in partnership with universities. In addition, it must be mentioned, that in Georgian language, there is a severe shortage of educational/methodological and of technical/terminological literature of this kind, which is a serious hindering factor in GIS learning.

Therefore, it is expected that the present work will provide important help to train highly qualified specialists; because in our opinion, the majority of GIS specialists in Georgia lack academic knowledge in this area, their terminological apparatus are weak; they do not have access to the unified standards of GIS and so on. All of this is often reflected in the quality of digital products produced by them.

This work, intended to present an introduction to geoinformation sys-tems. These are the following: what is GIS, Components, structural branches and aspects of using. History of developing GIS takes important part as well not just in Georgia but in the world as well. It also shows the problems that exist in this field for different reasons.

LIST OF TABLES CHAPTER 2

Table 2.1 - Development of GIS By Zurab Laoshvili.

NOTES

<sup>1</sup> - University Consortium for Geographic Information Science - UCGIS awarded F. Marble for his contribution for GIS development.

<sup>2</sup> - International cartographic association- was founded in 1959 y in Switzerland Bern. The first asambly had been conducted in Paris in 1961y. It counts down 67 countries, Georgia became part of it since 2016y. The fields of interest are: education in Cartography, its terminology and automatisation. The goal of ICA is to coordinate cartography research all over the world, conduct international conferences and symposiums, and organize cartographic workshops. Conferences are held once in a 2 y. Data are published in „International Yearbook of Cartography“(from 1961year), Assambly is highest governing part of ICA. It’s reunioned once in a 4 year, assembly is leaded by executive committee.

<sup>3</sup> - State Department of Land Management Policy in 1996 had developed unit concept for cadaster and registration.





# CONCLUSIONS

## Epilogue: A more sustainable relationship between the Human species and the Biosphere

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This publication is intended as a contribution in our quest for a more sustainable relationship between our amazing Human species and our unique and fragile Biosphere. Indeed, our planet is just another one among billions of other planets in our galaxy, or one in the eight planets that make up our Solar System, a system that has been around for billions of years, and will likely remain for billions of years after our species has disappeared. As such, the expression “Saving our planet” is really a misnomer as our species cannot save any planet. We can however strive to fit, and to integrate in a healthy and sustainable symbiosis with Earth’s Biosphere.

In part 1 of this publication, we aimed at contributing to the building of an intellectual framework based on holistic principles. Specifically, it is believed that this framework will provide the basis for the development of a methodology that promotes sustainability - in terms of territorial and urban planning as well as in architecture. To this purpose, the areas of the counties of Abrantes and Sardoal under study were divided into Drainage Basins, and the Drainage Basin North of Abrantes was selected as a case study for the application of some of the concepts that were considered to be most relevant.

Assuming then that there is the need to develop a new intellectual framework, it is then necessary to adopt an indicator that will serve as a tool for analysis, accounting and commerce.

This tool/indicator is - as we attempted to demonstrate throughout this publication - Carbon Dioxide (CO<sub>2</sub>). The effects and consequences of

the emissions of greenhouse gases (GHG) and CO<sub>2</sub> in particular, have become in a short time, universally accepted and understood to convey the meaning and severity of anthropogenic pressures on the Biosphere. It is thus proposed that this indicator could provide a basis for developing a paradigm of sustainable development applicable to the territorial planning and architecture.

In addition, it is also proposed that architects and planners have a duty, and a responsibility to expand their competence and their ability in understanding what sustainability really means, and to collaborate in contributing to a new holistic intellectual framework of sustainable design, both for individual buildings, and for urban planning - in symbiotic relationship with their drainage basins. Nevertheless, for this effort to be successful, a knowledge of international agreements and protocols (which are the basis of national legislation to reduce GHG emissions) and a notion of the methods of accounting for CO<sub>2</sub> is needed.

In Part 2 we convey the importance of understanding how natural disasters and seismic issues impact the urban areas of our Biosphere. Indeed, one of the goals of society is to create infrastructures that are protected from destructive earthquakes and minimize the expected loss. The task is complicated as there is always a deficiency of knowledge about real seismic hazard and infrastructure’s vulnerability. The proper assessment of seismic risk is of crucial importance for sustainable economic development of cities and protection of society. Seismic risk mitigation of cities, in conditions of its multifactor content, can be reached only by complex town-planning, engineering and volumetric reconstruction. The





model of definition of seismic risk can be considered as a part of a technique of a complex town-planning assessment of the territory of the historical city.

In Part 3, the Analysis of Urban Import-Export Operations is important not just for the country, but also for the individuals who are involved in economic activities. Government involvement and support will definitely have a positive effect on long term perspective. As it will have positive influence toward economic

growth and future forecast and planning of operations. As such, any additional needless expenses can be avoided. The auditing of these operations is important not just at the national level, but also at the individual level for those who are involved in all economic activities.

In Part 4, as a result of the collapse of Soviet Union all its ideas and projects started to diminish, people who were promised better life conditions appeared in a new reality where their living

spaces became gray lifeless ruins, where melancholy is harsh and a daily routine is monotonous. As a response, the Initiative Groups and Phased Activities was created and is presented as a trigger of transformation and of revival. Indeed, the definition and presentation of the diversity, nature and behavior of invisible city layers structured by the following components: Creativity, Social Activity, Human Inspiration, Information and new virtual environment in a whole. Study of their intersection with other urban factors, new technologies and city physical development process.

Based on these issues original concept and methods of urban transformation was developed; ideology for father activities was suggested as the source for a new and fresh movement through the city lifelines toward the human wellbeing, harmony and sustainability.

In Part 5, modern graffiti is presented as an Indicator of Social Mood. Indeed, Contemporary graffiti is gradually transforming from a pure marginal direction into the form of a legal art and, with representing its creativity differently in the heterogeneous informational layer of the urban environment. This qualitative and quantitative transformation is reflected also in other spheres of the arts synthesized with it. In terms of the architecture, with serving for harmonization and individualization of the environment, Graffiti offers new paths of self-identification and communication, to the society.

In Part 6, the concept of GIS (Geographic Information System), the technology of spatial analysis - Geographic Technological Systems as a very useful tool for humanity as it is used successfully in every working field. In general, Geo Informational system is a processing tool of spatial information. It is hoped that the present work will provide some directions as the majority of GIS specialists in Georgia lack academic knowledge in this area, their terminological apparatus are weak; they do not have access to the unified standards of GIS and so on. All of this is often reflected in the quality of digital products produced by them.

As such, the objective of Part 6 is a proposal for the training of GIS specialists, which need to be accomplished in partnership with universities. In addition, it must be mentioned, that in Georgian language, there's a severe shortage of educational/ methodological and of technical/terminological literature of this kind, which is a serious hindering factor in GIS learning.

This publication is a product of the European Union's strategy to reach out, to rise above ignorance, and to smooth out the differences. Indeed, it is one of the results of the RETHINKe Project, set within the European Union's TEMPUS program, a program which is about overcoming differences, and about the significance of bridge building. In fact, the TEMPUS Program has been a tool for bridge building; accordingly, the RETHINKe Project has intended to contribute to the process of bridging the differences between East and West, and to establish a common language on the sphere of Higher Education and Society through voluntary convergence in the name of our common interests; particularly, that of sustainability.







# Technical

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The idea of saving mankind is a recurring theme in the history of civilization, the prophets of doom invariably based their theories on this assumption. However, the work presented here is not so much about the idea of the salvation of the humanity as such, but in the reinterpretation of our relationship with the environment that sustains us. At the beginning of this new millennium, humanity is, in environmental terms, facing unprecedented challenges. The pressures on the biosphere and on its ecosystems are at the root of the environmental crisis which is becoming undeniably evident with time (...)

António CastelBranco & Oksana Turchanina

*"When I was born, the expressions and phrases which are to save humanity had already been written, one thing was missing: - to save humanity"*

Almada Negreiros

*"The causes of the collapse of Rome, were studied thoroughly, and one of the lessons that can be assimilated is that everything is connected to everything else, not only in its consequences, but also in its causes"*

Jane Jacobs

*"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete"*

Buckminster Fuller

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