NATIONAL TECHNICAL UNIVERSITY OF ATHENS
RURAL AND SURVEYING ENGINEERING
GEOGRAPHY AND REGIONAL PLANNING
Physical Geography & Environmental Impact Assessment Laboratory

FIG Commission 3 Workshop
on
"The Empowerment of Local Authorities: Spatial Information and Spatial Planning Tools**"**

France, October 2011

Title Project:

«***Sustainability indicators using for*** *measuring monitoring and reporting on progress towards* ***sustainability*****»**

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Keywords: Natural capital Indicators, sustainable cities, sustainability, environmental impacts

SUMMARY

The concept of sustainability typically encompasses social, economic, political and environmental components. This paper focuses on the measurement of factors that help predict whether a region is moving toward or away from environmentally sustainable paths.

‘‘Natural Environment’’ is defined as natural capital, where natural capital includes all our natural resources – the physical amounts of renewable and non-renewable resources, our ecosystems that sustain life and provide a wide range of goods , services. Measurement of natural capital is a challenge, especially for an urban area and involves collection of natural capital data from which later we can derive a list of indicators. As noted by Segnestam (2002, p. 3), indicators can be a more useful analytical tool than the data from which they are derived. They assist in the assessment of conditions and trends, facilitate informed discussion among diverse groups within the community because indicators are often easier to understand than the statistics that underlie them, and provide input into the policy making process. Examples drawn from different jurisdictions help illustrate issues that an urban area will face and in deciding how to adopt, implement, and interpret its environmental sustainability indicators and use these indicators to assist in decision-making about alternative development options for the community. Indicators help communities identify important trade offs they may face in all sorts of decisions that affect sustainability, including land use, transportation infrastructure and fiscal policies, to name a few.

The aim of this project is to measure the sustainability of an urban area using the environmental indicators according to the quality of the existing natural environment

Based on:

- Urban Environment Thematic Strategy of European Union (the priority themes and the Sustainability Tools And Targets for the Urban Thematic Strategy - STATUS tool)

- National Policy for the Protection of the Physical Environment (Directives in Water, Waste, Air pollution – Noise, Biodiversity, Energy and Land Resources)
- Environmental Impact Assesment on the Physical Environment from the current development of an urban area, study area Municipality of Glyfada – Athens (highlights in a descriptive way the variables of the Natural Environment that are important)
- Scientific Accuracy (map data update measurements, data availability)

1.0 INTRODUCTION

The concept of sustainability typically encompasses social, economic, political and environmental components. This paper focuses on the measurement of factors that help predict whether a region is moving toward or away from environmentally sustainable paths.

‘‘Natural Environment’’ is defined as natural capital, where natural capital includes all our natural resources – the physical amounts of renewable and non-renewable resources, our ecosystems that sustain life and provide a wide range of goods and services. Measurement of natural capital is the challenge, especially for an urban area and involves collection of natural capital data from which later we can derive a list of indicators. In that project as a **Physical Environment in an urban area is defined the one that encompasses the following variables (**C.Cassios 2002**) :**

1. Biodiversity
2. Land - Relief
3. Open Spaces: open land that isn’t covered by green or constractions
4. Water resources (rivers, lakes, sea)
5. Air- Atmosphere

As it concerns the **Sustainable Urban Environment (**by Olewiler N., May 2006) **includes the following**

1. Land Uses (Density of building, well designed construction)
2. Transportation System (air pollution, noise)
3. Water Resource Management (water pollution, water use)

4. Energy Management
5. Urban Green Areas Management (protection and preservation)
6. Waste Management (Liquid & Solid Waste)

The aim of this project is to measure the sustainability of an urban area using the environmental indicators according to the quality of the existing natural environment. Towards that direction, this project takes as a case study a Greek municipality that's is situated in the south part of Athens, is called municipality of Glyfada.
First is given an analytical presentation of the study area, and then we examine the impacts in the urban environment from the human activities that take place. A number of variables and subvariables are given as a result of the impact analysis. Those variables are taken into account to finalize the complete set of indicators that show the level of sustainability of the study area.
The interpretation of the results of the report is facilitated by

There are **guiding principles** that provide the basis from which effective and sustainable decisions can be made. According to those principles there are specific **goals** that should be achieved. For each goal specific **Indicators** have been developed to measure progress toward meeting the specific goals. The goals that have been set are based on the existing environmental problems in the study area.
The principles, the goals and the indicators that are presented here are continually being processed because more data should be taken into consideration in an on going process with the local authority. This new data should describe the integrated profile of the natural environment and the impacts due to human activities.

2.0 DERIVATION OF INDICATORS FOR NATURAL CAPITAL: A CONCEPTUAL FRAMEWORK

Natural capital is becoming the conceptual foundation for measuring of the role that the natural environment plays in sustaining communities.

Internationally the United Nations Environmental Program, Organization for Economic Cooperation and Development, European Environmental Agency, Environmental Ministries in the Netherlands, UK, Sweden and other countries frame environmental programs and indicator measurement in a natural capital context.

There are a number of conceptual frameworks proposed to help structure natural capital indicators in a way that facilitates interpretation and helps make them relevant for community based decision-making.

The most important is the 'driving force, pressure, state, impact, response' or DPSIR framework. Figure 1 lists the components and provides examples of each.

Driving forces are the human activities (social, economic, political) that contribute to the increase or decrease in natural capital. These could include how much of our renewable and non-renewable natural resources we consume (water, energy), how many kilometers are driven per year, or output from pollution-intensive industries. **Pressures** translate the driving forces into specific impacts on natural capital. Households and industries that discharge toxic materials into the air, water, land (e.g. pour waste oil into the sewers, flush antibiotics down the toilet, discharge raw sewage into the ocean) are examples of pressures or environmental stressors. The pressures can then be quantified into an increase or decrease **the state** of natural capital: the quantity and quality of the region's natural capital. Impacts translate the change in natural capital back into effects on nature, humans and other species, and the ability of the community to continue to produce goods and services.

Impacts measure how resource use and/or pollution affect health, plant and animal species abundance, agricultural output, materials, and the economy's ability to produce goods and services. Responses indicate how society reacts to environmental pressures, impacts on natural capital, and resulting impacts on society and the economy. Examples are the policies, public and private investment in infrastructure, and personal decisions (e.g. defensive measures such as increased noise barriers taken to offset environmental degradation) taken by individuals or, in concerted action, by communities. Decision-making by the community, of course, involves political processes as stakeholders discuss and debate potential tradeoffs (e.g. costs, effects on outputs, impact on different groups in society, and so on) created by the environmental impacts. The **response** component thus links environmental indicators

with social, economic, and political impacts. The arrows from responses to drivers,pressures and natural capital are to signify the extent to which the responses modify the behavior of drivers, reduce pressures and improve the state of natural capital.

Indicators for many of the drivers, pressures, and state of natural capital can be collected by various agencies at the local, regional, provincial, and national level.

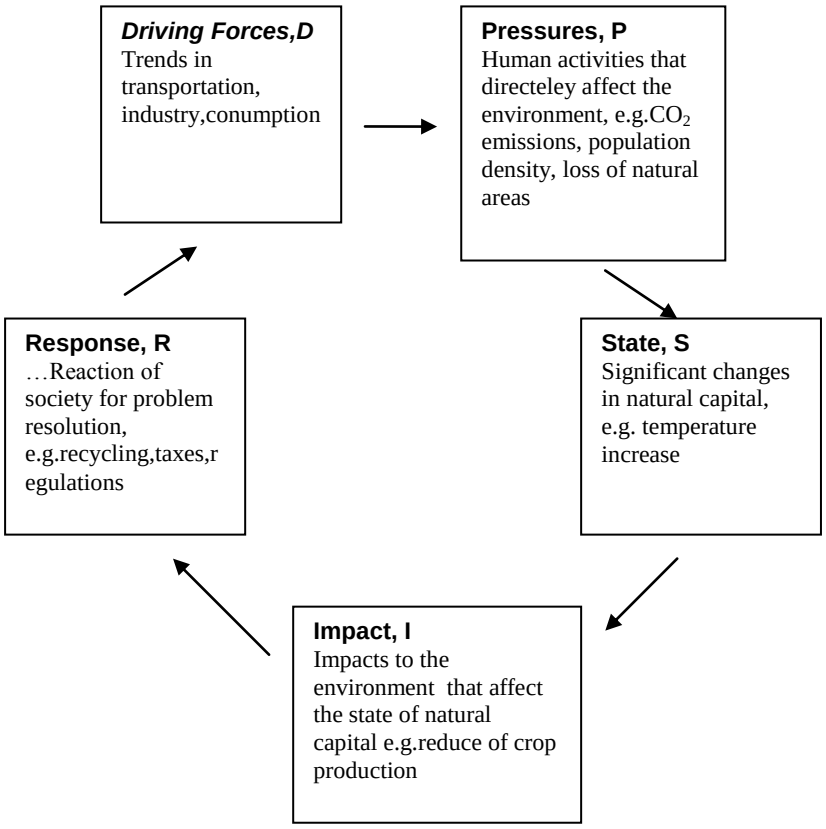


Figure 1 : "The DPSIR framework"

A chosen indicator can belong to multiple categories than one, can be pressure and state together.

This project uses Pressure, State and Impact Indicators to measure sustainability. Then local authorities can raise awareness of the key issues among them and policy-makers to adopt a specific environmental management plan. They can measure the progress toward sustainability that the adopted plan can have with the use of Response and Driving Forces Indicators.

2.1 SELECTION CRITERIA FOR NATURAL CAPITAL INDICATORS

At a minimum, indicators should have a meaningful and consistently measured link to natural capital, they should be able to tell us where we have been, how we are doing now (are things better, worse or unchanged?), and where we might be heading (e.g. levels are still less than a set target, but improving)

The indicators must tell us whether we are moving toward a more or less environmentally sustainable community. This requires a clear statement and understanding of the relationships between drivers, pressures, natural capital and impacts.

A pragmatic approach is to develop indicators iteratively, by selecting those that at the time seem to be most directly linked to the components of DPSIR and to discard, adjust, and add new ones over time, as information becomes available and greater understanding of the links between environmental components emerge.

2.2 DEVELOPING AND SELECTING NATURAL CAPITAL INDICATORS

Criteria help identify candidate DPSIR indicators for natural capital for a metropolitan area. But there are still likely to be dozens, if not hundreds of indicators that would satisfy all the criteria.

In general indicators should be:

1. Representative for the objectives of the program
2. Easy in the control, their measurement and their interpretation,
3. Economically effective,
4. Comprehensible by everybody (someone without a scientific background),
5. Independent from the presence, absence or situation of a unique type,
6. Sensitive in the environmental conditions,
7. Foreseeable, precise in limits of a small variability,
8. Comprehensive, relative and suitable for use in the ecosystems
9. To be considered as a sequence, indicative of the general environmental condition

2.3 EXAMPLES OF DEVELOPING SUSTAINABILITY INDICATORS FOR MONITORING SUSTAINABILITY

Sustainability can be measured in national regional and local level. A large number of examples are referred in the literature. Here are presented 2 cases of measuring local sustainability in Europe and in USA:

2.3.1 Local Quality of Life Counts

In December 1999 the Government published "Quality of Life Counts". This provides a baseline assessment of the 150 sustainable development indicators, which were proposed by the Government when the UK strategy for sustainable development "A Better Quality of Life" was produced in May 1999. These indicators are seen as a benchmark against which, future progress can be measured.

There are 15 headline indicators (see appendix A) which will be reported on annually by Government. Targets have been set for some of these e.g. reductions in greenhouse gas emissions, proportion of new houses built on brown-field sites; where targets are not being achieved the Government intends to adjust policies accordingly.

In order to protect and enhance the environment the following indicators have been used:

- Prudent use of resources
- Energy use (gas and electricity)
- Domestic water use
- Household waste arising
- Recycling of household waste

And specifically for the Protection of the environment the following ones:

- Number of days of air pollution
- Rivers of good or fair quality
- Net change in natural/semi-natural habitats
- Changes in population of selected characteristic species

2.3.2 CTSIP Indicators

The Central Sustainability Indicators Project (CTSIP) is intended to increase regional awareness and commitment to sustainability. This goal will be accomplished through an ongoing public discussion that defines Central Texas residents' vision of sustainability, creates quality of life indicators that allow us to track our progress and acts as a catalyst for increasing the effectiveness of community engagement.
As it concerns the protection of the environment the following indicators have been the followed:

- Water - Consumption
- Water - Quality
- Energy Use
- Air Quality
- Vehicle Miles Traveled
- Time Spent Commuting
- Solid Waste
- Hazardous Materials
- Rural Land
- Publicly-Owned Open Space
- Attractiveness of Landscape
- Density of New Development

3.0 MUNICIPALITY OF GLYFADA – BASIC FEATURES

Municipality of Glyfada extends from the Saronic Gulf to the foothills of Hymettus and covers 25.000 hectares.

There is a satellite overview of the study area:

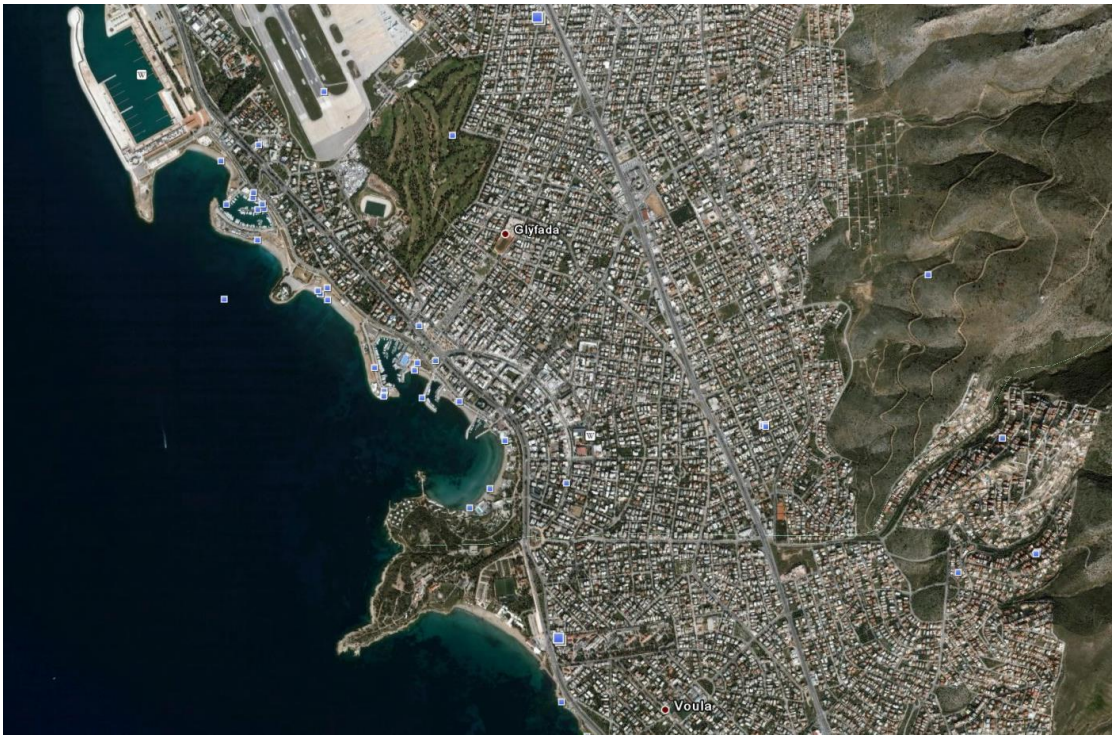
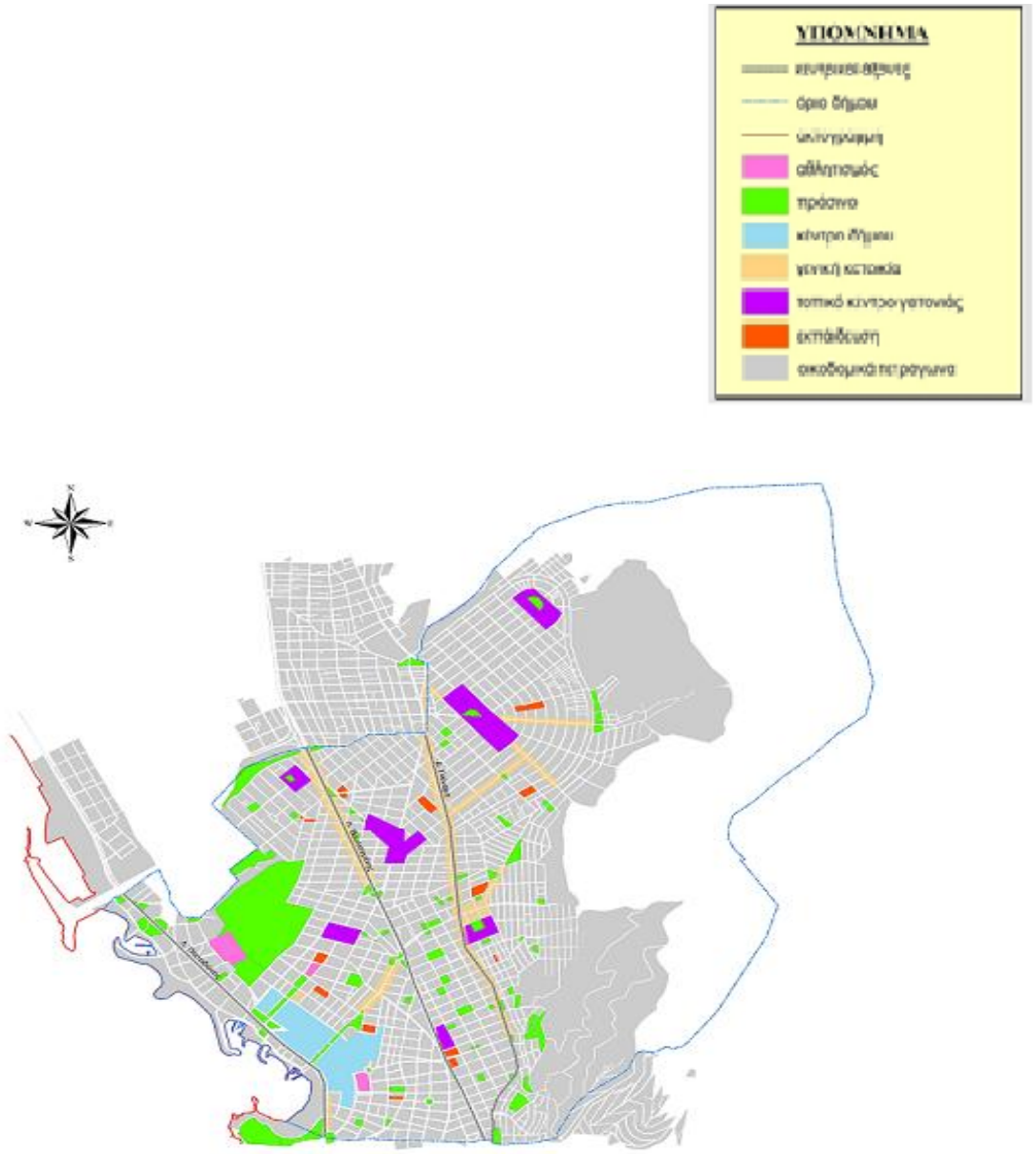


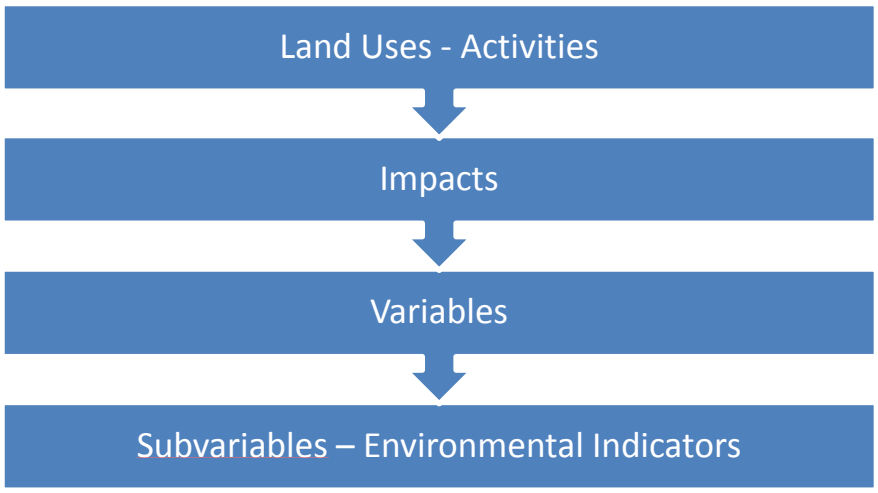
Figure 2 **Municipality of Glyfada**

Today the Municipality of Glyfada has a population of 100,000 residents. The distance in kilometres from the centre of Athens by car is 15 km and 12 km from the port of Piraeus. The ancient temple of Poseidon at Sounion is 45 kilometers away. According to the master plan of Glyfada (map2) land uses are mainly residential with some commercial parts (centre of Glyfada, along the Vouliagmenis highway and Posidonos highway, the 2 main high ways that cross over the municipality of Glyfada). Basic activities are Urbanization, Recreational Activities, Tourism Activities, Commercial Activities (transportation) and Coastal Shipping .



Map 1: "Master Plan of Glyfada"

The Environmental Impact Assessment –EIA analysis according to the basic activities follows the path :



The EIA of every basic activity that occurs to the study area to the environmental variables are presented below:

Urban Activities/Variables	**Atmosphere**
Transportation (Emissions by vehicles)	➢ Air Pollution ➢ Greenhouse Gas Emissions ➢ Ecosystem degradation ➢ Health of the Inhabitants ➢ Air Quality degradation

Table 1a: "EIA on Natural Variables"

Urban Activities/Variables	**Water Resources**

• Water Supply • Irrigation • Recreational Activities • Shipping Activities • Sewage resulting from sea side tourism activities	**Fresh Water:** ➢ Groundwater' reduction ➢ Groundwater's pollution ➢ Reduction of the quantity of Drinkable water ➢ Drought **Sea Water** ➢ Pollution ➢ Coastline Degradation by intense tourism development on shore line zone

Table 1b: "EIA on Natural Variables"

Urban Activities/Variables	**Land Resources**
• Expansion of Urbanization • Waste Dumping	➢ Natural & Agricultural Areas Loss ➢ Relief Degradation ➢ Land Degradation ➢ Stability of natural slopes ➢ Deterioration of geological profile ➢ Soil Erosion ➢ Soil Contamination

Table 1c: "EIA on Natural Variables"

Urban Activities/Variables	**Energy**

• Daily Operations of all Urban Infrastructure • Transport operations	➢ Air pollution ➢ Energy Reserves Reduction ➢ Greenhouse Emissions

Table 1d: "EIA on Natural Variables"

3.1 MEASURING SUSTAINABILITY IN GLYFADA MUNICIPALITY

As mentioned before the measurement of sustainability in the study area was

Based on:

- Urban Environment Thematic Strategy of European Union (the priority themes and the Sustainability Tools And Targets for the Urban Thematic Strategy - STATUS tool)
- National Policy for the Protection of the Physical Environment (Directives in Water, Waste, Air pollution – Noise, Biodiversity, Energy and Land Resources)
- Environmental Impact Assessment on the Physical Environment from the current development of an urban area, study area Municipality of Glyfada – Athens (highlights in a descriptive way the variables of the Natural Environment that are important)
- Scientific Accuracy (map data update measurements, data availability)

The Urban Environment Thematic Strategy of European Union sets 4 priority themes such as :

1. **Sustainable Urban Management**
2. **Sustainable Urban Transport**
3. **Sustainable Construction**
4. **Sustainable Urban Design**

The choice of environmental indicators (subvariables) is based on the thematic strategy on environmental sustainability and on EIA of the Natural Environment caused by Urban development.

The selected criteria :

1. Sustainable Urban Management
2. Natural Resources Preservation
3. Sustainable Urban Design

The Data sheet is presented below:

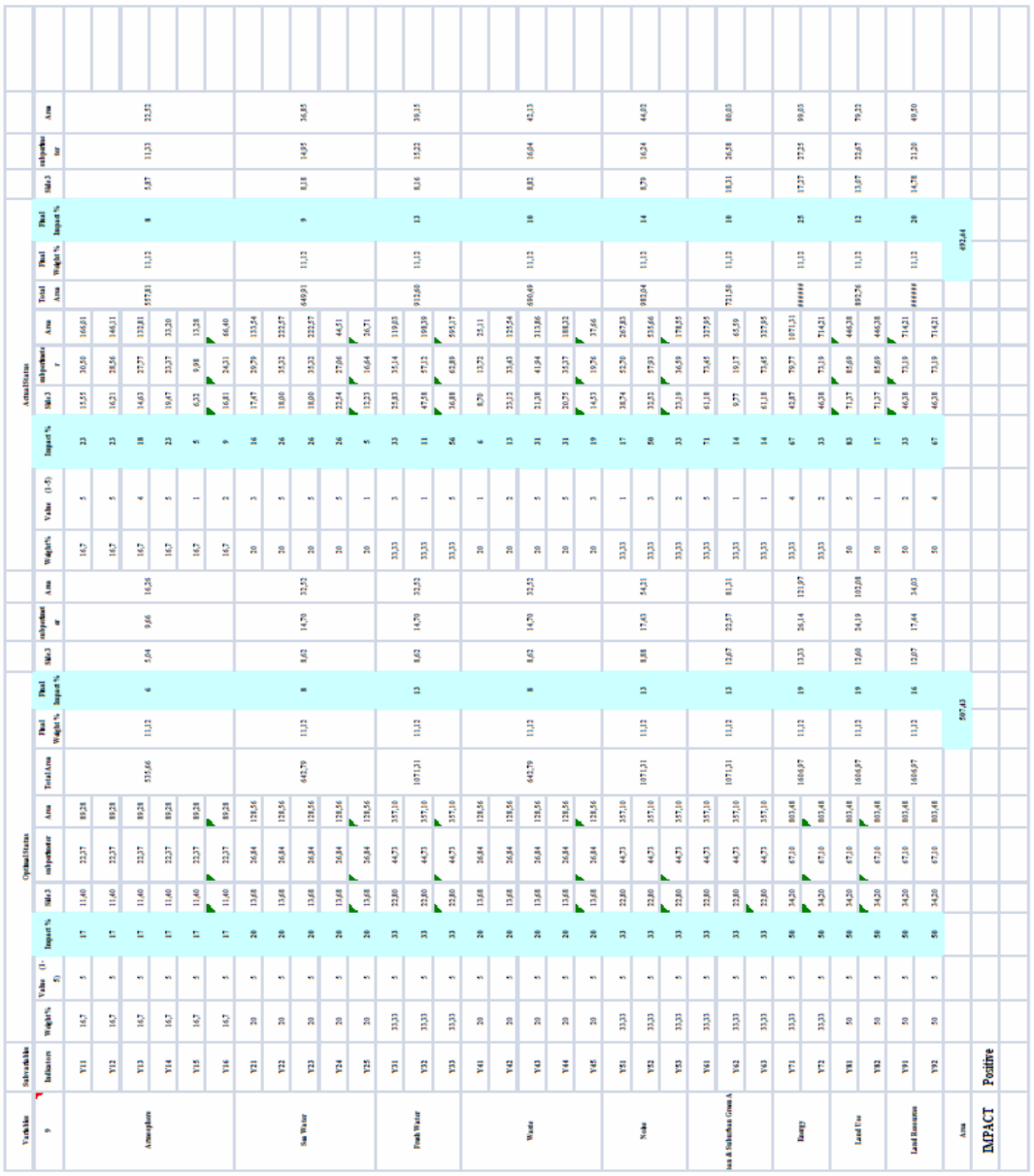


Figure 3 : "Data sheet for the Arachni diagram"

3.3 PITFALLS IN INDICATOR DEVELOPMENT AND USE

For the integrated approach of this paper, some common pitfalls that can be done in order to develop a set of indicators should be mentioned.

Common pitfalls in developing and using indicators may include:

- Relying on aggregates (indices) without understanding the component parts. Some aggregation is desirable, but to focus attention on only a few aggregates may distort relationships or fail to show when some component of the index is telling us something different that the aggregate value.
- Using what is measurable rather than what is important to measure. It is easier to use existing data than to collect new data, easier to do what others have done even if it is not necessarily relevant to one's jurisdiction. For example, energy efficiency measured as decreases in energy use per unit output produced may show improvement over time while total energy consumption (and hence, environmental pressures from that consumption) continue to rise. It is fine to show energy efficiency, but total energy use should be an accompanying indicator.
- Basing conclusions on indicators generalized to measurement units other than the one being studied. For example, Ambient air quality data do not tell us where the particular pollutants come from and in what quantities. The indicator should fit the issue at hand.
- Putting too much faith in the indicator. Indicators cannot describe all the complexities of ecosystems and economic systems. We do not understand all the relationships between drivers, pressures, natural capital states, impacts, and what our responses will do to enhance the quality and quantity of natural capital. Indicators can be a helpful tool; they are only as good as the data from which they are derived and our state of knowledge about what this data means.

3.4 PRESENTING THE RESULTS

1. A number of variables like land resources, water resources, landscape, atmosphere, climate, waste production & energy consumption, are chosen as a result of the impact analysis on the urban environment from human activities .

These variables are taken into account for finalizing the complete set of indicators [1]that show the level of sustainability of the study area. Sustainable Urban Management, Natural Resources Preservation, Sustainable Urban Design were the three selected criteria (the value in the parenthesis shows the measurement of the actual status). The selected criteria combined with variables and subvariables are listed below:

- **Sustainable Urban Management :**
    1. Urban Waste Management
        - Per capita amount of waste: 40.526 tones (300kg/capita/year)
        - Nr of recycling buckets per capita : 1 bucket / 33 inhabitants
        - Existence of Sewage Treatment: yes
        - Existence of trans shipment station :yes
        - Percenrage of recycable amount of waste/Total amount of waste : 25,5%<33%
    2. Energy Management
        - Energy Consumption per capita : 3,4 Kwhr
        - Energy consumption by other activities[2]
        - Percentage of buildings that have solar water heater : 30%
    3. Noise
        - Nr of Noise Monitoring Stations:1
        - Lden (day) 65-69dB
        - Lnight 65-69 dB

- **Natural Resources Preservation**
    1. Water Resources

        Fresh Water

[1] Indicators are selecred from STATUS database : http://status-tool.iclei.org/content.php/demo
[2]Some values aren't shown for technical reasons

- Water consumption/sector: Domestic-5.229.150 m3, Commercial Activities 704.381 m3 (per capita 36m3/year -100 l/day)
- Quality of fresh water : excellent
- Percentage of Water Loss in pipelines : 10%
- Illegaly covered rivers : 100%

Sea Water

- Percentage of sea water in good environmental status by EU: 80%
- Coliform Bacteria Concentration 3,8/100 ml<10.000/100ml
- Days of closed beaches caused by pollution : 0 ;
- Density of Sea Water Monitoring Stations : 1 Station every 500 meters (1 station every 25 meter)

2. Atmosphere
   - Annual mean concentration of PM10, NO_x, CO_2, O_3, SO_x [3]
   - Percentage of inhabitants that live <0,7 km from important source of pollutants
3. Land Resources
   - Land Degradation: 28%
   - Percentage of green areas loss within open spaces : 6%

4. Urban & Suburban Green Areas
   - Percentage of Green Areas in Open Public Areas within the study area: 5%
   - M2 of Green Area/capita : 9 m2
   - Access to Green Areas : max 300 m from the center of the neighbourhood

- **Sustainable Urban Design**
  1. Land Uses

[3]Some values aren't shown for technical reasons

- Land Uses
- Ratio of land uses % e.g. Residence 3%
- Construction density: 48%
- Reuse of Land : 5%
- Ratio of new buildings versus rennovative one : no available data

The interpretation of the results of the report is facilitated by graphically illustrating a change in selected indicators over time (with "spider diagram")

The "spider diagram" is made up of a polygon whose axis from the centre are the basic variables. Each variable and its value is shown on an axis of the polygon. Every axis is numbered from 0 to 100 and each value represents the impacts of this variable in the whole project. The value of each variable is a result of a variety of calculations between the subvariables – indicators and their weights. Those calculations are presented in an excel sheet called Data Sheet (Figure…).

The final result is a number that comes up as the ratio that results from the impacts pre and post project application. The blue line represents the acceptable limits between sustainability or not. The red line shows the today's results.

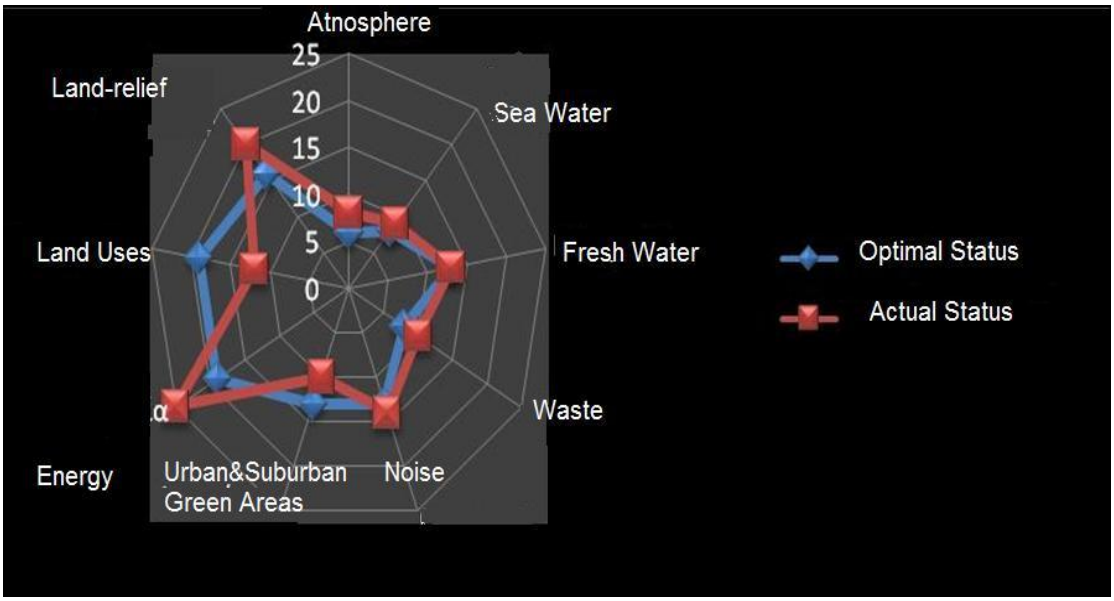


Diagram 1: "Graphical Representation of the Final Result"

4.0 CONCLUSIONS

Natural capital indicators are a mean by which communities can help understand the state of their environment, how it got to be where it is, and what might be done to make it better. They can show directions of change (are things getting better or worse), raise awareness and stimulate responses to improve the environment. They need to be well crafted, to show the state of the environment, and they must also capture the relationships among all the components of framework linking drivers, pressures and impacts.

As noted by Redefining Progress and Earth Day Network (2002, p. 6) ‘‘It is important to take as much or more time to develop and plan indicator series than to measure the indicators themselves.’’ Indicators should inspire the community to take into account the quality and quantity of their natural capital in decision-making about sustainability. It must be remembered that environmental indicators are one input into community decision-making along with social, economic, and institutional indicators. They help assist in setting goals and policies to help sustain the quality of life in the community.

The basic aim of this project is to measure the sustainability of an urban area in Greece using the environmental indicators according to the quality of the existing natural environment. One of the basic problems that we face in this project is the lack of available data. In order to overcome this difficulty, we try to choose environmental indicators that are easily measured or estimated by a small group of people.

After the application of the method on the study area the following results came up:

- Glyfada has a good level of sustainability.
- Sustainability in Glyfada is fragile.
- Variables in critical situation are:
    1. Energy
    2. Land – Relief
- By changing the weights of the subvariables more objective results can be derived

- Environmental Indicators can be a useful and reliable tool for monitoring progress or egress towards sustainability, because can simplify and communicate important issues and trends.
- The trends can be obtained by using regularly updated map measurements
- This method is a valuable tool for local authorities because it can raise awareness of the key issues among the policy-makers to adopt a specific environmental management plan. Then they can measure the progress toward sustainability that the adopted plan can have
- This method that based on STATUS tool can give comparable results to every capital city or urban agglomeration of 100.000 inhabitants with the same profile (basic activities) that adopt an urban environmental management plan with specific objectives to achieve

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