Theoretical and Methodological Contribution to the Sustainability of the Architecture and Planning

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1 ABSTRACT

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 endeavor has exploded in all fields, and this has put excessive anthropogenic pressures on the Biosphere, as seen at all levels of all ecosystems.

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 in commerce, and for sustainable planning of territories and their functions. We present a case study to illustrate a methodology developed for a Drainage Basin, near Abrantes, Portugal, with the tool/indicator being the area's capacity to absorb/emit Carbon Dioxide (CO2). The dangers of emissions of greenhouse gases (GHG) and CO2 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, and must create a holistic, transdisciplinary framework for both building design, and for assuring positive, symbiotic relationships between urban places and their corresponding drainage basins.

2 INTRODUCTION

In general, Portuguese urban planners have been out of touch 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 do with true sustainable planning.

In fact, these professionals have not yet understood that this is a task for which they ought to be responsible. Because in his job description the urban planner is still considered to be a professional who works in the field of land planning for 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 an intellectual framework and the tools to enable them to overcome the present day fragmented, incomplete and diffuse intellectual framework.

Therefore, it is important for the urban planner to claim his role and responsibility to master, but for this to happen he will have to resort to his inherent qualifications, those that differentiate him from other professions. This includes his ability to visualize complex problems and the interpretation of an extensive of interconnected issues.

Indeed, to be an urban planner it is essential to somehow foresee and to plan for the "future," but in order to plan for a sustainable future it is also important to be imaginative, and it is precisely the ability to imagine the future - the trait that characterizes the urban planner – the trait which will enable the planner to understand the new framework that is required, as to leave behind a better Earth (or at least equal) from that which was inherited.

3 A BRIEF OVERVIEW ON THE THEME OF URBAN AND TERRITORIAL SUSTAINABILITY

"In a holistic, regenerative, complex ecological system, its autopoesis or self-organizing characteristics serve to trim off the superfluous from that system" [1]**.**

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 is a guide in the disclosure of Earth's complex life support systems.

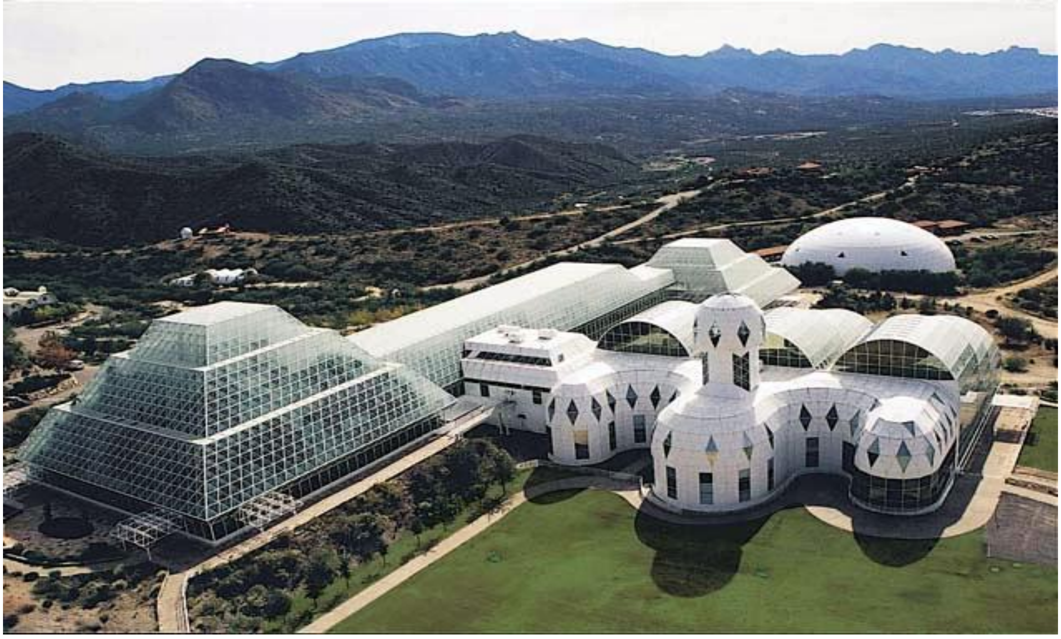

Figure 1 - The Biosphere 2 Project - Arizona, USA (Archtect - Phil Hawes).

On the other hand, its architecture, organization and interdependence of systems makes it into a 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 intended to provide a specific example of both the practical point of view (the importance of accounting and the mixture of atmospheric gases) and from the theoretical point of view (in building of 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 log book "In Biosphere 2 we have created an economy of carefully measured atoms: carbon, nitrogen, oxygen are the exchange. Instead of beginning the day by rushing to a computer to view the Dow Jones or to my doorstep to retrieve the Wall Street Journal, I rush to the computer screen to view updated graphs of carbon dioxide in the atmosphere and nitrates in the ocean" 2. Indeed, carbon was the major currency inside Biosphere 2, in this small replica of the planet, the carbon dioxide in the atmosphere indicated if the system was operating was in the red or in the black on a daily basis. Deficits and profits compound daily. This small world depended on careful daily measurement and management of all elements affecting the atmosphere.

One of the lessons learnt from the Biosphere 2 project - that has a correlation with planning and design - is precisely the concept that CO2 can been taken 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, as the Biosphere 2 features paradigmatic solutions that are synonymous with a

[1] Stitt F. A. (1999) *Ecological Design Handbook.*
[2] Leigh L. *(1992) Biosphere 2: Research Past and Present*.

transdisciplinary project. In short, this project can also be seen as a contribution to the development of a much needed holistic intellectual framework.

This paper also aims to be contributing to the searching of "specific solutions" in order to develop an intellectual framework and corresponding guidelines that will allow planners and designers a better visualization of our Biosphere. In this sense, the idea of CO_2 as an indicator and design tool is introduced in order to assess the sustainability of a given territory.

For example, the relevance of 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. As such, the division of the land ought to be based on such a holistic 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.

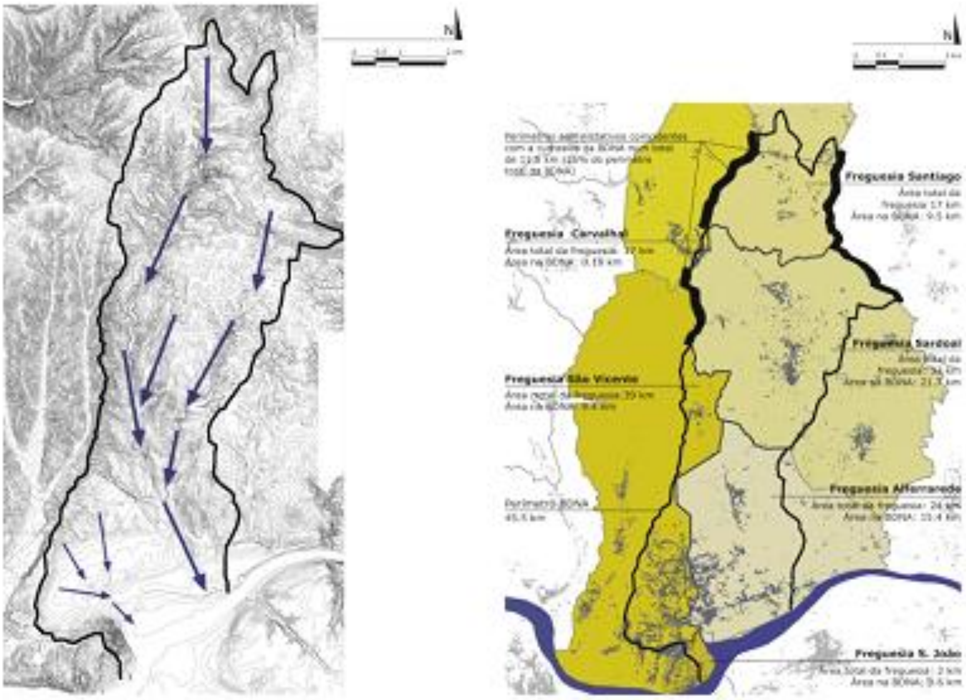

Figure 2 – The Drainage Basin North of the city of Abrantes, Portugal (the black line represents the ridge, the blue arrows the water flow lines). The map of the administrative limits of the parishes that make up the BDNA.

Thus, an area of 5662 hectares corresponding to the Drainage Basin North of the city of Abrantes which empties into the river Tagus was selected as the study area for the implementation of the some of the concepts already described[1].

In the process of research for this paper, it became apparent that current legislation - in terms of territorial and urban planning - does not take into account fundamental aspects of what actually is necessary to ensure the sustainability of a given territory. For example, it does not take into account the balance of CO_2 emissions in a given territory. As a result, 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_2 emissions.

We believe that taking into consideration the emissions and absorption of CO_2 in a given territory will add a holistic and transdisciplinary approach to the planning process, and will enable municipalities to plan and manage their territory in a more sustainable way.

[1] Castelbranco A. (2009) *A contribution towards the theory of sustainable of architecture, and territorial planning.*

4 METHODOLOGY

In order to achieve the previously mentioned objectives, we established a methodology which was useful for this research. Its synthesis is listed below:

1 - Select the area of study (one or more counties):

- Spatial Analysis of the selected territory.
- Divide the existing areas as emitters or CO_2 sinks.

2 - Perform the analysis of the selected territory:

- Perform cartographic analysis of perimeters and accounting of percentage areas in terms of emitters or CO_2 sinks
- Establish the specific capacity of each area to emit or absorb CO_2;
- Perform analysis of the population with verification of current demographic situation in the chosen field and to establish the trends of change in time.
- Check the features of the area chosen to point out the negative factors that contribute to increased emissions of CO_2;
- Establish links between the natural and anthropogenic factors in this territory and its contribution to the balance of CO_2 emissions.

3 - Develop the methodology for calculating CO_2 emissions applied to the territory:

- Apply a transdisciplinary approach for a holistic appraisal of the territory.
- Account for the annual volume of emissions and absorption of CO_2 for all areas previously established.
- Calculate the CO_2 emissions of anthropogenic origin of the chosen area (energy consumption, use of internal combustion vehicles, use of liquid gases);
- Calculate the environmental impact of this population and its Ecological Footprint.
- Introduction of CO_2 as an indicator for verifying and assessing the sustainability of that territory in terms of carbon dioxide emissions.

4 -Suggest changes to the form of municipal management:

- Introduction of the CO_2 as an indicator and as a tool in the design process;
- Analysis of the Municipal Plan, Plan Planning and Urban Development Plans in order to find and suggest ways to increase the efficiency of a given territory in terms of its CO_2 balance.

5 - Establish a theoretical and methodological basis for the eventual development of an Emissions Trading System on a national scale

- Methodology for calculating CO2 emissions apply to the territory that can be used to calculate emissions in all regions of Portugal and intended for being able to stimulate the reduction of CO_2 emissions, and that would encourage the planning and design process territory to be understood and implemented based on a broader vision of sustainability.

5 RESULTS

One of the challenges in the process of outlining a theory of land use - from which will stem sustainability - is to establish an equitable and efficient method to account for and measure the CO2 balance in a given territory, which means that the delimitation of the given area is elementary as well as the characterization of its population.

As mentioned, the concept of the oneness of ecosystems (such as in the biomes in the Biosphere 2 project) is translated to territorial planning as a drainage basin.

As for the accounting of CO2, it is stressed that the issue of climate change should be understood as a transdisciplinary concern whose origins lie in the consumption / use of resources, and its consequences in terms of pollution. In any case, the accounting and evaluation that follows refers to the drainage basin North of Abrantes and its inhabitants.

The most significant CO2 emissions in this area have their origin in:

1 - Natural causes:

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

2 - Causes by human activity:

• In the production of energy;
• The use of internal combustion vehicles.

15 555	tons of CO2/year caused by forest fires (considering an average of 170 ha. burned per year)
8 672	tons of CO2/year due to human breath (1441 ha Urban area and 14,000 habitants)
32 859	tons of CO2/year due to the generation of electricity (KWt 29 602 300 per year)
42 417	tons of CO2/year for car use (4 667 cars and 1 333 lorries)
4 117	tons CO2/year by using liquid gas (96.4 kg of gas-liquid per capita)
103 620	tons of total CO2 emissions on BDNA

Table 1 – Table 1 - Total balance of CO2 emissions on BDNA.

Thus, the amount of CO2 emissions per capita on BDNA is 7.40 tons (Table 2).

Number of inhabitants on the BDNA	Total emissions of CO2, tons	Tons of CO2 emissions per capita/year on BDNA
14 000	**103 620**	**7,4**

Table 2 – Tons of CO2 emissions per capita/year on BDNA.

The relevance of these numbers is confirmed by the previously quoted words of Linda Leigh, ("In the Biosphere 2, we create an economy based on the currency of atoms: carbon, nitrogen and oxygen.")
In any case, the Drainage Basin North of the city of Abrantes (DBNA) absorption of CO_2 and its sequestration is made primarily by the forests, the agricultural areas and the corresponding sheet of water of the river Tagus. In the DBNA, in Figure 2 the areas assigned to urban, agricultural and forest areas are shown, and in the table below the total of emissions of CO2 that are absorbed in these areas are calclated. (Table 3).

59 240	tons of CO2 emissions/year absorbed by areas of forest (2962 ha of forest)
1 940	tons of CO2 emissions/year absorbed by the agricultural areas (882 Ha of agricultural area)
5 841	tons of CO2 emissions/year absorbed by areas of fresh water (130 Ha area of fresh water)
67 021	Total tons of CO2 emissions/year absorbed by the BDNA

Table 3 – The total Balance of CO2 absorption in the DBNA.

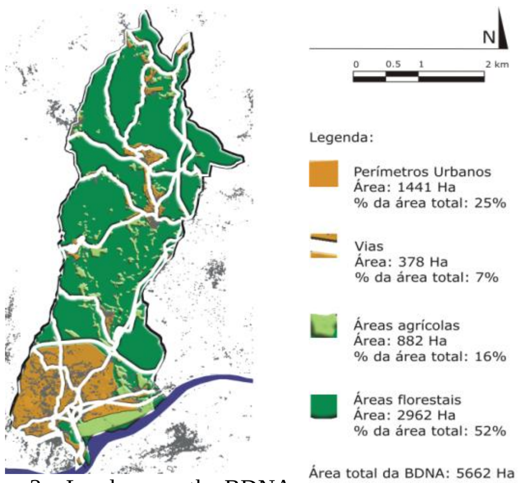

Figure 3 – Land use on the BDNA.

However, if we were to look at the absorption issue from the perspective that "one hectare of forest has the capacity to sequester 20 tons of CO2/year"[1] thus in order to absorb the 103,620 tons of total emissions of CO2/year in the DBNA (see table 1) would require 5181 hectares of forest (corresponding to an area of forest of 0.37 hectares or 3,700 m2 per capita).

Thus the forest area to sequester the total CO_2 emissions on the BDNA:
103 620 tons of CO_2 / 20 CO_2 tons / hectare = 5 181 hectares of forest.

[1] Turchanina O. N. (1999) *Peculiarity of the thermal destruction of coals of the different genetic types*.

On the other hand, this means that to offset the emissions of CO_2
5181 hectares of forest / 14,000 inhabitants = 0.37 hectares or
3700 m^2 of forest per capita in DBNA.

In any case, we come to the conclusion that there is a deficit of forest area, and that in order to absorb the total of CO2 emissions in the DBNA which is 103 620 tones to the total of CO2 that is absorbed 67 021 tones (from table 3). Therefore with a total deficit of 36 599 tons, it would take additional 1830 hectares of forest in order to attain an equilibrium between emissions and absorption.

36 599 tones of CO2 / 20 CO2 tons / hectare =
= 1 830 hectares of forest needed to reach a desired equilibrium in CO_2.

From the figures it appears - that despite the fact that the DBNA is essentially an agricultural and forested area with a population of only 14 000 inhabitants in 5662 hectares (equivalent to 2.5 inhabitants per hectare) – we find that there is a deficit in terms of CO2 absorption. This also reveals the importance of rethinking a more efficient and sustainable the form of land use. In short, this paper intended to contribute to the construction of a new intellectual framework, which is based on division of territory into drainage basins (as suggested by the experience made in the DBNA), and in accounting for CO2 as a useful indicator in order to assess the sustainability of a particular area. Considering that in the near future the Emissions Trading Scheme (ETS) will no doubt also be applied to the territory in its entirety (urban areas, agricultural areas, forest areas); however, the final format for this scheme should inevitably be invented and defined by planners and architects.

6 CONCLUSION

Environmental problems have a cause and effect directly related to the consumption of resources, whether in terms of energy consumption, or of land. In any case, the architect and urban planner have a vital role in reversing the trends and negative consequences that are destroying the biosphere, particularly with respect to climate change and biodiversity. The perception that there is a serious environmental problem and that this problem stems from human activity, has promoted a series of conferences and agreements, including the Kyoto Protocol, which seek to halt environmental degradation.

However, many of the methodologies and tools necessary to address these issues are not yet available, and there is compartmentalization/fragmentation of the different areas of knowledge. In any case, the size of the problem is so huge that it requires the development of a new intellectual framework based on a transdisciplinary and a holistic platform.

In the process of developing this platform, it is up to architects and planners to assume a role in "the processes of land planning and natural resource planning that must be integrated with an evaluation of quantifiable resources, and a consideration of environmental values, such as aesthetic values, historical-cultural values, and ecological values of the landscape. These are usually intangible in nature (...). It is therefore relevant to the investigation of principles and methods for developing the applicability of this concept, to consider the inclusion of these values in those processes"1

It is also important to strive to develop a standard measurement methodology that is intelligible and that can be useful to architects and planners. Therefore, it is appropriate to select which parameters should be addressed for the development of a transdisciplinary platform.

As Phil Hawes suggested, “in a holistic, regenerative, complex ecological system, its autopoesis or self-organizing characteristics serve to trim off the superfluous from that system”2. In other words, as stewards, urban planners or architects we will have to find and remove the superfluous, unnecessary, and inconvenient truths from this equation that is harming the Biosphere.

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