

Impact of the Qualitative and Quantitative Aspects of Human Activity on the Ecosystem: Demonstration through the Use of Ecological Footprint Approach

Makram GAALICHE

Department of Economics, Higher Institute of Management of Sousse, Tunisia
makram_gaaliche@yahoo.fr

Abstract

This article aims to show that the impact of human activities on the ecosystem, measured by the Ecological Footprint, depends on the qualitative and quantitative aspects of the population. Indeed, we confirmed our hypothesis by an empirical analysis on Tunisia, where it was revealed that the increase in its Ecological Footprint, is attributed mainly to massive consumption of goods, bad land management by building horizontal, and to a lesser extent, to the presence of polluting employments. The results suggest the adoption of targeted policies, according to the specific characteristics of population.

Keywords: ecological footprint, biocapacity, qualitative effect, quantitative effect, environment, Tunisia

JEL Classification: C13, Q26, Q51

1. Introduction

The interest granted to the impact of human activities on ecosystems and the planet, has led to the creation of the Ecological Footprint Indicator (EFI). Several definitions of this concept exist, all based on the needs required for an individual, converted in equivalent area in hectares (Kitzes *et al*, 2008). Indeed, this indicator provides an assessment of the environmental pressures associated with human activities at all scales (Van, 2005). It is usually measured in surface: hectares per person or hectares consumed by a city or a country). This indicator quantifies, through a system conversion, an amount of resources of bioproductive area, needed to produce the resources consumed by the population and to absorb its wastes (WWF, 2006). This metaphorical surface is virtual, but it reflects a very concrete reality. Indeed, in a world where the population grows, the more the ecological footprint is important, the more we move away from the environmental sustainability.

Theoretically, the ecological footprint includes the quantitative aspect of resource consumption by the population of a region or a country, thus emphasizing its link with the living standards of the population (WWF, 2006). We further assume that the ecological footprint is conditioned by both the level of consumption and by certain qualities relating to the population considered. In other words, each person traces his / her footprint, influenced by the extent of his use of resources but also by certain characteristics reflecting his awareness of the environment, the quality of the management of existing resources, and other qualities which are specific for him. Therefore, the temptation is great, where we try, from the Tunisian case, to detect the different elements that can explain the behaviour of the ecological footprint. In other words, we try whether the

ecological footprint in Tunisia depends both on the standard of living of the population considered, and on other qualitative elements.

In this case, we identify in a first step the concept of ecological footprint, while analyzing that of Tunisia. Then, on the basis of a battery of indicator, we try to identify the various determinants of ecological footprint of Tunisia. The analysis will be applied to the different Tunisian regions namely: the Greater-Tunis, North-East, North-West, West-Center, East-Center, South-East and South-West.

2. Ecological Footprint and Biocapacity: Definition and Analysis

At the Rio Conference (Earth Summit) in 1992, Professor William Rees suggests for the first time, in his article "Ecological footprints and Appropriated carrying capacity: what urban economics leaves out" the term of ecological footprint. Then, the term has been developed in a doctoral dissertation of Mathis Wackernagel, in collaboration with his teacher William Rees, who subsequently published in 1996 a book entitled "Our Ecological Footprint: Reducing Human Impact on the Earth" in which they refined the concept and calculation method. This book is translated into French in 1999 under the title "Our Ecological Footprint". Several definitions referring to this concept have been proposed. Rees (1992) defines the ecological footprint as, the surface of productive land and aquatic ecosystems, required to produce the resources used and waste assimilation released, by a defined population. For Fudge and Rowe (1996), it is the necessary geographical surface to meet the needs of a city and absorb its waste.

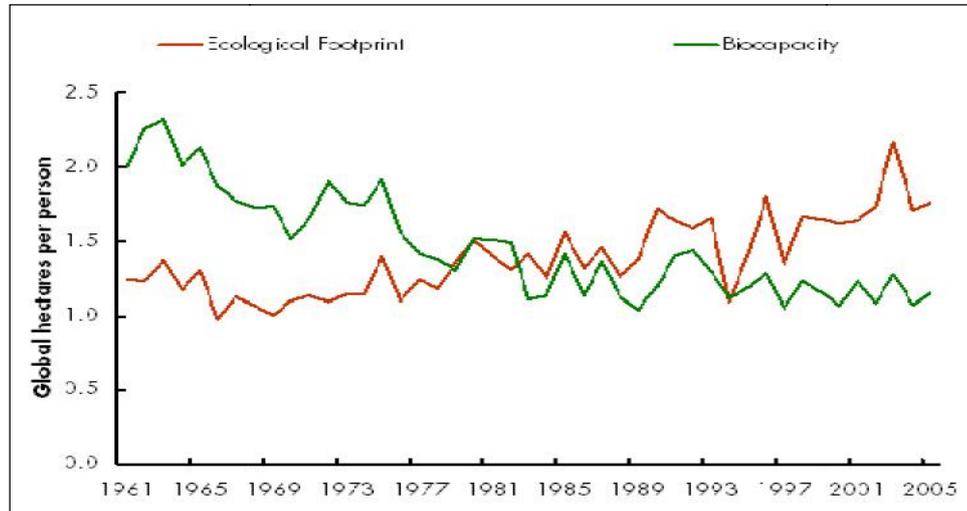
In all cases, the ecological footprint is used to measure the pressure exerted by the human on the planet, and to make an ecological bilan by comparing the demand and supply of renewable natural resources. Generally, it is a comparison between the ecological footprint and the supply of natural resources, i.e., the biocapacity, which corresponds to the capacity of ecosystems to provide resources to the limit of their capacity of regeneration (WWE, 2006). Indeed, an ecological footprint of a population that exceeds the biocapacity of their surface indicates an ecological deficit, i.e., an unsustainable consumption.

In Tunisia it was found that the ecological footprint per person is characterized by a growing trend throughout the period (1961-2005), and this against a downward trend concerning biocapacity of space available (see **Figure 1**). It is mainly from the 1980s, which its ecological footprint begins to exceed the biologically productive area, and whose gap does not cease to widen. In other words, the Tunisian person overexploits the available resources of its environment.

Admittedly, the ecological footprint is built by focusing only on biologically productive areas. Indeed, six soil types are considered, namely (Ewing *et al*, 2008): arable land, pastures, forests, built land, fishing ground, and carbon. From **Table 1**, we found that in 2005, the ecological deficit realized in Tunisia is 0.7 ha / cap (e.g., 1.8 - 1.1). This deficit can be explained more precisely by overuse of arable land and forests. Indeed, the consumed surface of the arable lands is of 0.78ha/cap, whereas their biological capacity is 0,71ha/cap. Idem for the Tunisian forests, where an exhaustion of their biological capacity is noted, which is in the limit of 0.02ha/cap, whereas its exploitation reached 0.18ha/cap. On the other hand, the consumption of Built Land and pastures is equivalent

to the capacity of their available space, i.e., the use of these surfaces does not exceed their offerings.

Figure 1: Ecological Footprint and biocapacity of Tunisia in global hectares per capita (1961-2005)



Source: Global Footprint Network (2007)

So, we can conclude that Tunisia is in the process of depleting its natural resources, without giving them the time necessary for their regeneration. Such an overuse proves that the Tunisian population puts pressure on its environment, which moves it away, from the sustainability. Thus, analyzing the effect of behaviours and attitudes attributed to the Tunisian people, on the conduct of ecological footprint, is an important task to detect the main sources of ecological deficit.

Table 1: Evolution of the Ecological Footprint and biocapacity components of Tunisia in global hectares per capita for the year 2005

	Total	Arable Land	Pastures	Forests	Fishing Ground	Carbon	Built Land
Ecological Footprint	1.8	0.78	0.10	0.18	0.09	0.57	0.05
Biocapacity	1.1	0.71	0.10	0.02	0.28	*	0.05

Source: Global Footprint Network (2007)

3. The Ecological Footprint between Level and Quality Effects

On the basis of a battery of indicators, we try to explain the causes of the increase of ecological footprint in Tunisia, that is to say, he is the result of a level and /or quality effects. The analysis will be applied on the various regions of Tunisia namely: Greater-Tunis, North-east, North-West, Central-West, Central-East, South-East and South-West. Firstly, basing on the assumption of proportionality of the surface of each region bioproductive to its geographic area, we constructed a proxy of EE in each region.

Indeed, we will weigh the bioproductive surface of Tunisia by the surface proportion of each Tunisian region of the overall surface, for having a proxy of the bioproductive surface of different regions. Then we divided the bioproductive surface of each region by the number of its population for obtaining a proxy of ecological footprint per capita of each region. Subsequently, we regress the footprint of each region of Tunisia by all of the following variables:

Variable of Level:

- Level of Consumption (LC): Apprehended by the share of monetary expenditures for consumption of goods of the total consumption by region and person. This indicator allows us to detect the level effect on ecological footprint . In fact, more the population of the region is a consuming population, and thus very exploiter of its agricultural surface, more its ecological footprint will be important.

Variable of quality:

- Quality of Population (QP): Apprehended by the academic scholarisation rate. Indeed, when the person is educated, and therefore generally conscious of the environmental problem, he will has a rational behaviour on his ecological footprint.
- Quality of employments (QE): Percentage of the population by region, which employed in sectors likely to pollute and degrade the environment (mining, Buildings and Public Works ...). Generally, more the jobs in the region are qualified of pollutants, the more their ecological footprint will be important.
- Quality of Habitat (QH): Apprehended by the percentage of houses by region not belonging to buildings. This indicator allows us to capture the impact of horizontal buildings that destroy the surface of land on the ecological footprint.

All data are derived from different surveys of the National Institute of Statistics (INS) in Tunisia and from the Global Footprint Network (GFN). Thus, we estimate the following model:

$$EE = \alpha_0 + \alpha_1 LC + \alpha_2 QE + \alpha_3 QH + \alpha_4 QP + \varepsilon$$

The main estimation results by Eviews software are displayed in **Table 2**.

Table 2: Main results of estimation

Variable	Coefficient	Prob.
Level of Consumption	0.16	0.0438*
Quality of Employments	0.001	0.098 **
Quality of Habitat	1.05	0.0221 *
Quality of Population	-0.45	0.0124 *
R-squared	0.97	
Prob(F-statistic)	0.0056	

Source: Own estimation.

*= Significant variable at = 5% ; ** = Significant variable at = 10%

Such an estimate shows that the model admits a high explanatory power ($R^2 = 0.97$), and significant coefficients at different scales. Similarly, the signs of the coefficients attached to variables corroborate with our logic of reasoning. Indeed, it turned out that any increase of 1% horizontal constructions, that destroy the surface of the land leads to an

increase of 1.05% of the ecological footprint of population. In addition, the 1% increase in the level of consumption of the population, synonymous with an increase in the use of agricultural land, it leads to an increase in ecological footprint of 0.16%. For employments that cause pollution, it turned out that they lead to swelling of the ecological footprint, but with low proportions, so that any 1% increase in the proportion of the population employed in polluting activities, an increase of the footprint of 0.001% is observed. The estimate also reveals that the increase of 1% of the educated population leads to a reduction in the footprint of 0.45%. In other words, the more the number of educated people is important, the more the behaviour will be rational, and the ecological footprint will be reduced.

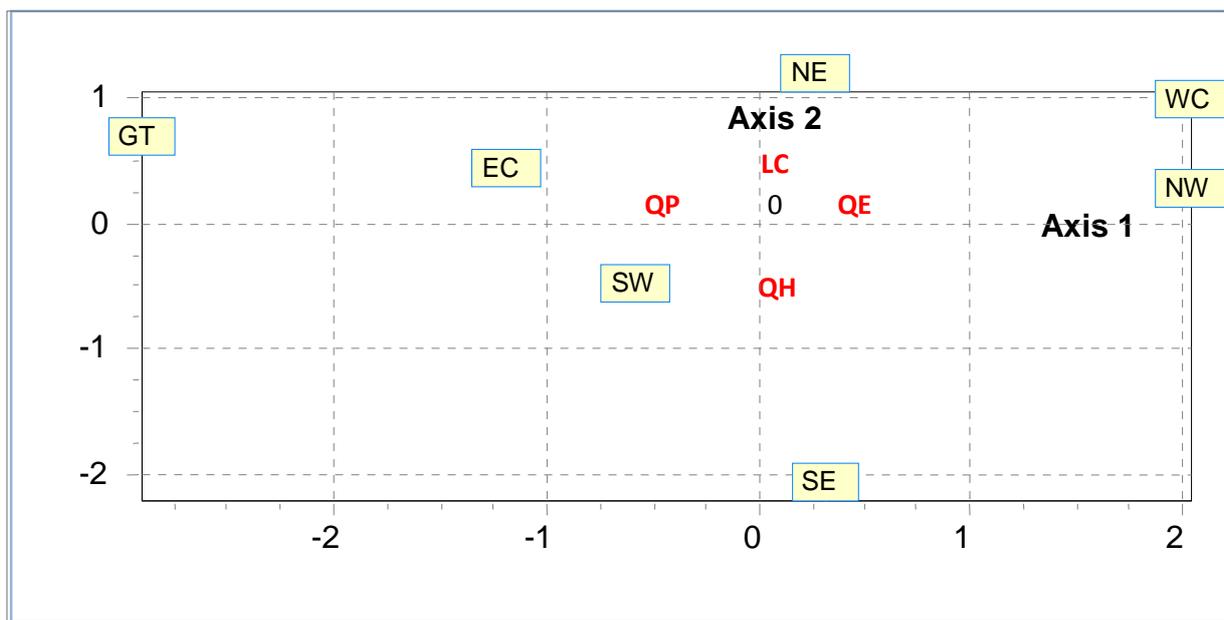
Following this analysis, we can affirm that the exploitation of environmental resources in Tunisian regions, is the combination of the level and quality effects of the Tunisian population. Indeed, such environmental degradation is attributed primarily to massive a consumption of goods, bad land management by building horizontal and to a lesser extent, to the presence of the polluting employments. But the awareness of the educated population of environmental issues causes a rational behaviour for a footprint reduction. In this case, the level of ecological footprint is conditioned by the aspects, both qualitative and quantitative of the corresponding population. For this reason, and in order to better control the ecological footprint of any population, regional policies should be recommended and targeted according to the specificities of each region. This will be the object of an analysis applied to the Tunisian case.

4. The Control of the Ecological Footprint: The Political Targeting

In order to rationalize the use of natural resources, Tunisia should envisage appropriate policies to every one of its region. In other words, it should detect for each region, the main sources responsible of the swelling of their ecological footprint, whereby the policies will be shaped. For this reason, we use the techniques of data analysis, more specifically, the Principal Component Analysis (PCA). This technique will allow us to regroup the areas characterized by a common behavior with the components of their ecological footprints. Indeed, the investigations carried out allowed us to obtain a graphical representation of the points cloud of the individuals (7 regions), and this following the selected axes (**Figure 2**).

By analyzing Figure 2, we can identify that axis 1 opposes the variable of Employment Quality (QE) to the variable of Quality of Population (QP). Indeed, we can infer that the North-East, North-West, South-East, and West-Center regions, are characterized by high levels of pollutants employment and a population with low levels of education, but it is the opposite for the Greater-Tunis, East-Center, and South-West regions. As regards the Axis 2, the variable of Level of Consumption (LC) opposes the variable of Quality of Habitat (QH). Within this framework, we find that the Greater-Tunis, North-East, North-West, West-Center and East-Center regions are characterized by a high level of consumer and a low horizontal constructions. Vice versa for South-East and South-West regions, where the level of consumption of their population is low, but the majority of the buildings are of horizontal type, destructive of the land surface. Thus, we can draw the following table, identifying the main causes of increasing of ecological footprint for each region, and on which the different policies to be adopted can be formulated.

Figure 2: The points cloud of the individuals along the principal axes



Source: Own estimation

Table 3: Identification of the main application areas of policies by region.

Region	Massive consumption	Polluting employments	Unconscious populations	Bad land management
Greater- Tunis	*		*	*
North-East	*	*		*
North-West		*		*
East- Center	*		*	*
West-Center	*	*		*
South-East		*		*
South-West			*	*

Source: Own investigations from Figure 2.

5. Conclusion

By an application to the case of Tunisia, it turned out that the ecological footprint of a population is influenced by qualitative and quantitative determinants relating to the population considered. Indeed, the study of ecological footprint in Tunisia reveals that the latter suffers from an ecological deficit. Such overexploitation of its natural resources proved to be the result of a massive consumption of goods and, on the other hand, assigned to negative qualities namely: mismanagement of the territory by building horizontal and the presence of polluting employments. However, Tunisia should master such an abuse of its ecosystem, by developing policies taking into account the specificity of each region, in order to compression its footprint.

References:

- Ewing, B., Reed, A., Rizk, S., Galli, A., Wackernagel, M. and J. Kitzes (2008): *Calculation Methodology for the National Footprint Accounts*, 2008 Edition, Global Footprint Network, USA.
- Fudge, C. and J. Rowe (1996): Ecological modernisation as a framework for sustainable development: a case study in Sweden, *SAIS Review*, Vol. 16, No. 2 / Summer-Fall.
- Global Footprint Network (2007): *National Ecological Footprint and Biocapacity Account – Tunisie*, spreadsheet v2.57.
- Institut National de la Statistique (2006): *Recensement Général de la Population et d'Habitat de 2004: Région du Nord Est*, Tunisia.
- Institut National de la Statistique (2006): *Recensement Général de la Population et d'Habitat de 2004: Région du Nord Ouest*, Tunisia.
- Institut National de la Statistique (2006): *Recensement Général de la Population et d'Habitat de 2004: Région du Centre Est*, Tunisia.
- Institut National de la Statistique (2006): *Recensement Général de la Population et d'Habitat de 2004: Région du Centre Ouest*, Tunisia.
- Institut National de la Statistique (2006): *Recensement Général de la Population et d'Habitat de 2004: Région du Sud*, Tunisia.
- Institut National de la Statistique (2007): *Enquête nationale sur le budget, la consommation et le niveau de vie des ménages -2005*, Volume A, Tunisia.
- Kitzes, J., Galli, A., Rizk, S.M., Reed, A. and M. Wackernagel (2008): *Guidebook to the National Footprint Accounts*, 2008 Edition, Global Footprint Network, US.
- Rees, W.E. (1992): Ecological footprints and appropriated carrying capacity: what urban economics leaves out, *Environment and Urbanization*, Vol 4, No. 2, October.
- Van, N.J. (2005): *Méthodologie empreinte écologique: aperçu*, Institut Angenius, July 2005.
- Wackernagel, M (1994): Ecological Footprint and Appropriated Carrying Capacity: A Tool for Planning Toward Sustainability, Ph.D. Thesis, School of Community and Regional Planning. The University of British Columbia, Canada.
- Wackernagel, M. and W.E. Rees (1996): *Our Ecological Footprint: Reducing Human Impact on the Earth*, Gabriola Island, BC: New Society Publishers, Canada.
- Wackernagel, M. And W.E. Rees (1999): *Notre empreinte écologique*, Les Éditions Ecosociété, Montréal, Canada.
- World Wildlife Fund (2006): *Planète vivante Report 2006*, Gland, Switzerland.