Deriving environmental management practices with the Ecological Footprint Analysis: a case study for the Abruzzo Region

V. Niccolucci[1], A. Galli[2,3] & S. Bastianoni[1]
[1]*Department of Chemistry, University of Siena, Siena, Italy*
[2]*Global Footprint Network, Oakland, CA, USA*
[3]*Emirates Wildlife Society (EWS-WWF), Abu Dhabi, UAE*

Abstract

In order to implement a sustainability-based land management, a preliminary diagnosis of the health of a system is necessary. The Ecological Footprint Analysis (EFA) introduced by Wackernagel and Rees in the early 1990s, is a convenient way to appraise all energy and material flows, in a common basis. The EFA is used to show the environmental consequences of human use of resources therefore enabling to understand where and how human pressure can be reduced. The paper applies the EFA to a sub-national case study: the Abruzzo Region, one of the twenty Italian regions, centre-east located on the Adriatic Sea. Following the Footprint Standards promoted by Global Footprint Network a Process-Based approach was chosen and applied to the Region. Results show that the Ecological Footprint of an average resident is 3.95 *g*ha, with more than 50% due to carbon Footprint. The Biocapacity, 1.80 *g*ha per resident, is not enough to support local human demand. These results can be interpreted to derive environmental management practices for the Abruzzo Region.

Keywords: Ecological Footprint, Biocapacity, land use, environmental management.

1 Introduction

Today the planning of robust environmental policies for a territorial system should be inspired to the complex and multidisciplinary concept of sustainable development. In this sense, a "sustainability diagnosis" to check the health of a territory is becoming a necessary (but not sufficient) preliminary condition to

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improve the knowledge on the environmental platform on which human activities depend and to design appropriate long-term choices [1]. An accurate diagnosis is neither easy nor immediate [2]. It is an ambitious task that can be performed by:

- monitoring as relevant aspects as possible of the systems - such as natural (material and energy) resources consumption and the related emissions, with respect to the historical time - as suggested by H. Daly through its famous sustainability principles [3];
- the use of suitable tools, i.e. sustainability indicators, as strongly recommended by Agenda 21 (art.40), the programmatic document of the first "Earth Summit" held in Rio in 1992 [4];
- the availability of robust and consistent environmental data.

A sound diagnosis should be able to help decision making in highlighting *where* major "weakness points" are present and in supporting *how* to heal them (sustainability therapy). Furthermore, they help to identify challenges, set targets, track progress and derive policies for sustainability.

Literature offers a wide set of sustainability indicators that produce useful indication, from several point of views, for defining the sustainability diagnosis. The more scientific robust and consistent are, for example, those based on Emergy Evaluation [5], Material and Energy Flow Accounting [6], Ecological Footprint [7], and Life Cycle Assessment [8]. These tools present some features in commons:

- most of them are thermodynamic based,
- have an holistic vision necessary to analyze complex systems such as territorial systems,
- produce synthetic information in different units,
- their adoption from scientific as well as policy communities is constantly increasing.

The aim of this paper is to show the possibility to derive environmental management practices from a preliminary diagnosis based on an Ecological Footprint Analysis. The territorial system under study is the Abruzzo Region, one of the twenty regions in which Italy is administratively divided. The Abruzzo Region, center-east located on the Adriatic Sea, covers about 10,795 km² almost 65% of which is mountainous while the remainder land consists of hills sloping. Two different paths of development can be distinguished in the Region: the inland area, with a low population density, is essentially devoted to agriculture while along the highly populated coast, important industrial and tourism centers are located. The structure and functioning of the local economy strongly relies on the foodstuffs, textile, furniture, metallurgic and mechanic sector.

2 Methods

The Ecological Footprint Analysis (EFA) is an environmental accounting tool providing either static snapshots or time trends of human demand on natural resources and ecosystem services [9, 10]. Like an 'ecological camera', it

documents the amount of bioproductive area directly and indirectly demanded to maintain a population's lifestyle or to sustain an economy compared to the biosphere's ability to meet this demand [11]. Six land-use categories are included in the calculation [12]: cropland, pastureland, forest, energy land (usually named 'carbon Footprint'), built up land and fishing ground.

All consumed resources and produced wastes are converted into the corresponding area of land/water ecosystems needed to produce the resources or assimilate the emissions. As each land type is characterized by a different productivity, these areas are further converted to their global hectare (*g*ha) equivalents by means of yield (YF) and equivalence (EQF) factors [13, 14]. Each global hectare is thus defined as a standardized and productivity-weighted hectare of global average productivity.

The supply side of the methodology is given by the biocapacity, which represents the maximum amount of the biosphere's regenerative capacity annually available for human use. As for the Footprint, biocapacity is measured in global hectares and used for benchmarking purposes [9, 13].

A population Footprint can thus be compared to the biocapacity that is available to support that population, as expenditure is compared against income in financial terms. The resulting ecological balance can show an ecological reserve or deficit situation. Countries with an ecological reserve may use their available biocapacity to satisfy their own domestic consumptions or export ecological resources to other nations. Conversely, countries with an ecological deficit must rely on biocapacity from outside its own borders or draw down its own natural budget [15].

In global level, if the Ecological Footprint is above global biocapacity, then the operation of the world's economy must be unsustainable, literally unable to be sustained, in the long term. As the surface of the biosphere is finite, the annual amount of resources it can produce and wastes it can absorb is finite as well and acknowledging the resource limitations of the one planet we have is fundamental for environmental management and planning purposes at both global and local level.

2.1 Application: from the national to the sub-national level

In the last decade, the Ecological Footprint method has been widely used to demonstrate the (un)sustainability of consumption patterns on individual, local, national and global scale [10, 16]. Despite this wide range of applicability, nation-level Ecological Footprint assessments are often regarded as the most complete, and Global Footprint Network's National Footprint Accounts as the most reliable and widely used methodology today [10].

According to the most updated methodology [18, 19], the Ecological Footprint of nations reports the apparent consumption of resources and production of wastes. The Footprint of local domestic production and imports are added to the final Footprint while the resources used for the production of exported good and services are subtracted and counted in the Footprint of the country where these products are consumed.

As highlighted in a recently published paper compiled by a community of active Ecological Footprint practitioners and users [10], *"... national Ecological Footprint accounts are applied directly as a communication and policy tool* […]*, and data extracted from these accounts often serve as a starting point for smaller scale analyses…"*.

Sub-national applications also use a consumer approach to assess the environmental consequences of local populations' consumption of resources, although the lack of data availability, especially on imports and exports from a sub-national region makes the usual methodology hardly applicable at this level.

As a consequence, *"…to ensure that the assessment is consistent with the Global Footprint Network's National Footprint Accounts (NFA) for the country in which the assessment is made…"* Ecological Footprint Standards [20] for sub-national applications were released in 2006. The break down of Global Footprint Network's calculated national Footprint values and the use of the same set of conversion factors used in the national calculations were highlighted as fundamental requirements for sub-national Footprint applications.

Two general types of top-down, scaling methods have been developed: the Process-based and the Input-Output method [10, 21]

The Ecological Footprint assessment of the Abruzzo Region reported in this study was performed through the Process-Based method. The Ecological Footprint of an average inhabitant of the Abruzzo Region for the year 2005 was thus derived from that of an average Italian resident in 2003 [17] by using a life cycle approach. Few steps were required to derive the final Footprint value for the Abruzzo Region:

- local and national statistics on population [22], land use [23] as well as energy use [24], fuel use [25], waste production [26, 27], and household consumption [28], were used to divide the total 2003 national Footprint value into various consumption categories (e.g., food, housing, mobility, goods, and services).
- the 2003 Footprint of the Abruzzo Region was then calculated by scaling the Footprint of each consumption category upward or downward according to the ratio of consumption between the average resident of the Abruzzo Region and that of the average Italian resident.
- the 2005 Footprint value of the Abruzzo Region was finally calculated by using the same estimation technique (2003 vs. 2005 comparison).

3 Results and discussion

3.1 Biocapacity

Results from the biocapacity calculation show that the regional bioproductive area (2,336,853 *g*ha) is almost double than the physical area (1,045,812 ha). This is due to the high contribution (almost 80% of the total area) of cropland (primary and secondary) and forestland. As a matter of fact, according to the Footprint methodology these areas are the most bioproductive land types. The available biocapacity for each local resident is 1.80 *g*ha, consistently greater than

the average Italian biocapacity of 1.01 *g*ha [17]. This is essentially referable to two main factors: a low population density (120 *vs* 192 inhab./km^2) and a quite different composition of the land use. The breakdown of the biocapacity reported in Figure 1 shows a heterogenic situation where the mountainous province (less populated and with a large contribution of forest) has a significant value (2.98 *g*ha per person) opposite to the coastline provinces with lower values. A particular low value characterizes the Province of Pescara (1.00 *g*ha per person), which is the smallest, most populated and industrialized of all of the four Abruzzo provinces. The map of biocapacity's density (see Figure 1) reports information on the bioproductivity of an area compared to its physical dimension. The three costal provinces show similar values due to a quite similar land use composition, with a prevalence of cropland. The internal province, on the contrary, shows a lower value due to the net predominance of land types other than cropland (mainly forest).

3.2 Ecological Footprint

Once the ecological budget locally available has been set, we focused on the demand site. Results from the Footprint calculations show an average Footprint value for the local resident of 3.95 *g*ha per capita. The average regional value is quite similar to those of Italy (4.15 *g*ha per capita) and the EU-25 (4.90 *g*ha per capita) and approximately double than the world average value (1.8 *g*ha per capita) as reported in the Living Planet Report 2006 [17]. The Footprint disaggregation by land category shows that carbon Footprint (55%) is the most contributing components. Energy land is required for both direct and indirect consumption of food, goods and services as well as for transportation (see Figure 2).

Data in Figure 2 confirms that the well-being of Abruzzo residents is strictly related to:

- the high consumption of food and goods, and
- the energy-intensive nature of the adopted life-style.

3.3 Ecological Balances

The Ecological Balance (as an Economic Balance) derives from the comparison of the supply of (biocapacity) with the demand on (Footprint) natural capital (financial capital). Results show the presence of an ecological deficit when the local Footprint value is compared with both local (-2.15 gha per person) and world-average per capita biocapacity (-2.17 gha per person). The presence of these two types of deficit sounds as a worrying alarm bell for the ecosystem. The global ecological balance is a measure of the distance from the global sustainability. A high value means that the territory is quite far from the target. Also, the local balance assumes a strategic importance as actions and environmental policies aiming at a future territorial sustainability can be implemented at this very geographic and administrative level. The higher is the local deficit, the higher the dependence from natural resources from outside the system boundaries. An average inhabitant of Abruzzo region requires twice

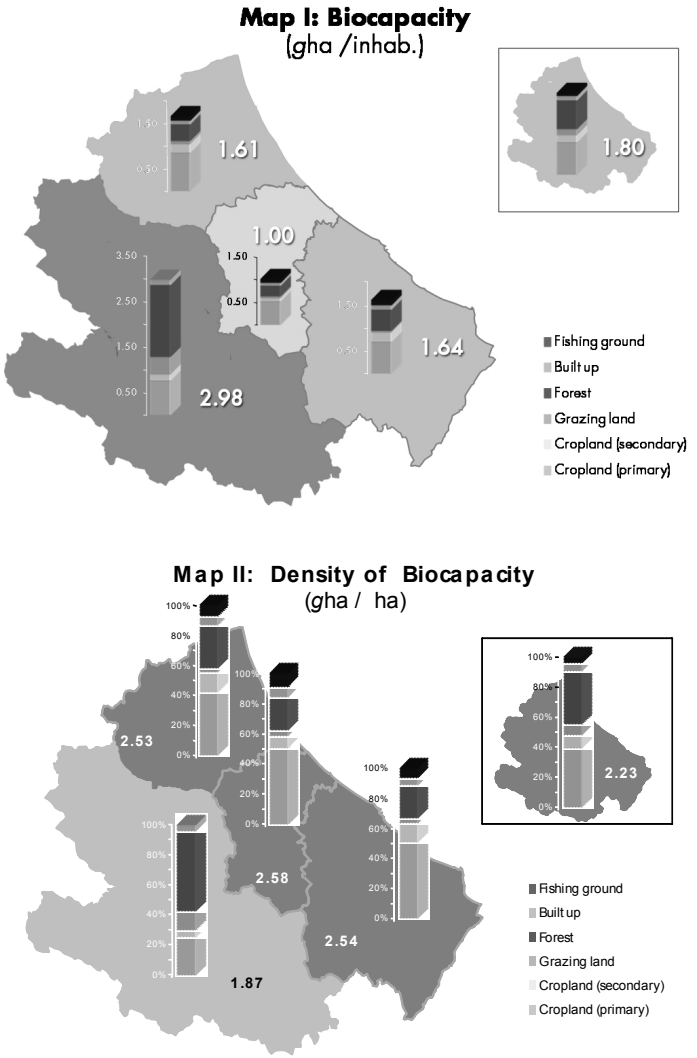

Figure 1: The biocapacity map (upper) and the density of biocapacity map (lower) of the Abruzzo Region.

natural resources and ecological services than locally available. In other words, if every inhabitants of the Earth consumed as an Abruzzo inhabitant, 2.2 planets would be necessary to maintain all world population.

By revealing the ecological demand associated with human consumption, Footprint accounts shed light on the region's constraints or future liabilities and identify opportunities to defend or improve the local quality of life.

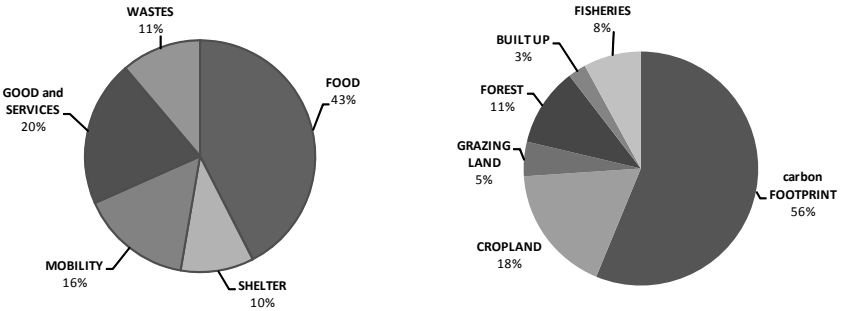

Figure 2: Ecological Footprint of an average Abruzzo resident by consumption (left) and land (right) category.

A priority target of any territorial system should be to reduce the fragility of the territory by reducing the dependence of goods and services imported from outside and, in turn, the import of carrying capacity in order not to overload the Earth. A look at the pies reported in Figure 2 provides information on the possible areas of action which decision makers can influence and restructure to reduce human pressure.

- reduce human consumption while preserving local quality of life. For example, reducing the need for fossil fuels by making cities pedestrian or public transportation friendly, promoting the consumption of seasonal and biologic food with zero kilometers and applying the energy efficient technology;
- invest in natural capital. For example, increasing the land's biological productivity;
- explore the possibilities for climate change mitigation.

It is also possible to focus on the responsibility role of Public Administration and final consumers of the total Footprint. Most of the citizen choices are dependent from past administration choices. A society should be able to offer a variety of solution for its citizen in order for them to choose the most sustainable.

Figure 3 shows that 68% of the overall Ecological Footprint is indirectly related to people daily choices while the remaining 32% is influenced by the Public Administration. These results show that, from one hand, final consumers can help reducing the Footprint of the Abruzzo Region by changing their life style and consumption pattern (for example by opting for locally produced and organic food or for less packaged products). They can also contribute to the reduction of the regional Footprint by optimizing energy use and increase housing efficiency. From the other hand, the Public Administration and decision makers can support this shift towards sustainable life styles by rethinking and re-organizing the waste sector as well as the public transport sector and other services.

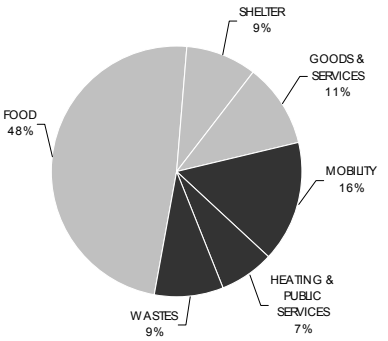

Figure 3: Ecological Footprint by area of "potential" influence: Public Administration (in dark grey) and citizen (in light grey).

4 Conclusion

The environment management has a relevant role in the territorial plan strategy of a territory. Up to date, sustainability indicators are the best suitable tools available to make a diagnosis, to deepen the "knowledge" and to build up correct environmental policies. This paper has presented the implementation of the Ecological Footprint Analysis to an Italian region called Abruzzo. The aim was to provide an example of how from this resource accounting methodology is possible to highlight the most important hot spots and to derive some advices to reduce human's pressure. The information derived from such an Ecological Footprint assessment could be included in the future planning of the territory to promote more competitive lifestyles, resource-efficient strategy and a more effective management of our ecological assets.

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