INTERREG V-A COOPERATION PROGRAMME

GREECE – BULGARIA 2014 – 2020

Reinforcing Protected Areas Capacity through an Innovative Methodology for Sustainability

– BIO2CARE –

(Reg. No: 1890)

WP3

Deliverable 3.2

One (1) methodological framework for assessing the environmental status of the examined area through the estimation of holistic environmental sustainability indicators

Contributing Partners

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The project is co-funded by the European Regional Development Fund and by national funds of the countries participating in the Programme.

Table of Contents

Chapter 1 - Introduction

Sustainability expresses the ability of a system to remain productive indefinitely. It is often confused with the concept of sustainable development which focuses on how our current needs can be satisfied while ensuring the quality of life and needs of future generations through the restoration of existing damage to the ecosystem and the minimization of the impact of anthropogenic activities. In essence, these two concepts can be considered as the two sides of the same coin. Sustainability's ultimate goal is sustaining life on Earth while sustainable development is related to the strategy for achieving that goal. By extension, both terms are directly related to the objectives of establishing and managing protected areas.

Sustainability as a concept has existed for several decades. The key political milestones that have affected the emergence and evolution of sustainable development are summarized by Quental et al. (2011). According to their research, there is an unstable course of governance related to sustainable development characterized by two periods of significant achievements (1979 and 1987-1995) and by two other less successful periods (1980-1986 and 1995). Currently, sustainability is once again at the forefront of global politics and constitutes a framework for international cooperation (e.g. through the 2030 Agenda for Sustainable Development and SDGs, Covenant of Mayors Initiative and other initiatives). In Figure 1, the most important initiatives at a political level in terms of sustainability are summarized.

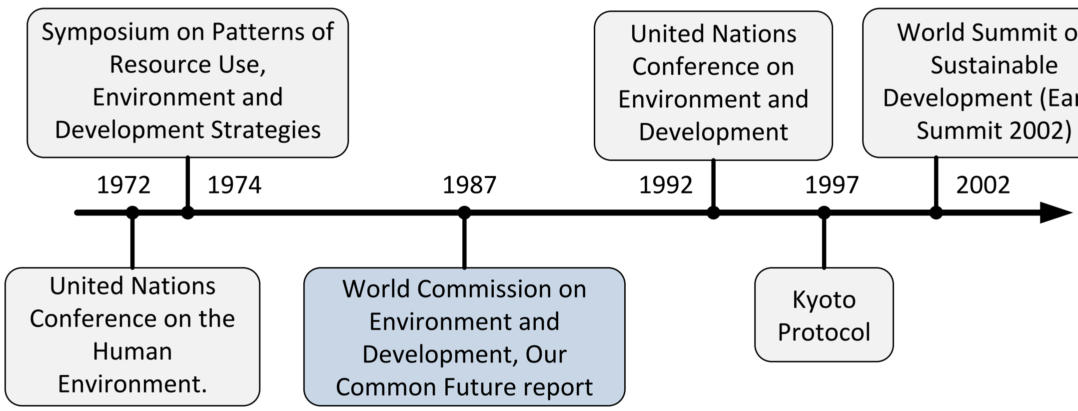


Figure 1-1: Milestones of political agenda regarding sustainable development.

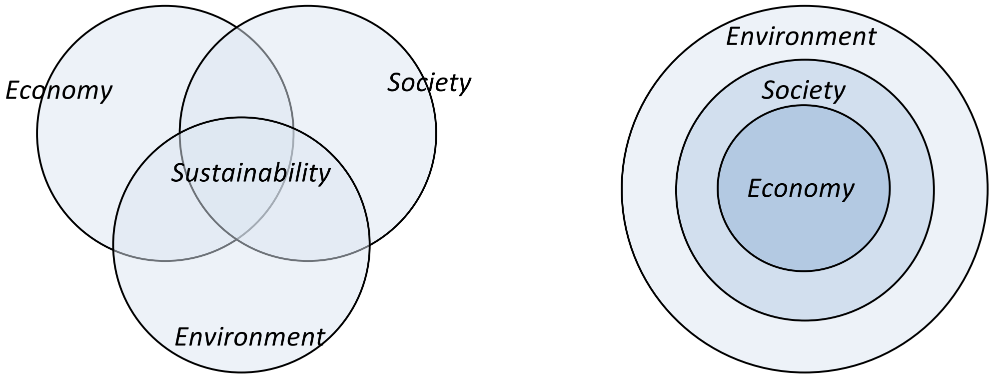
The results during the World Commission on Environment and Development (WCED, 1987) had a particular contribution to the promotion of policies and actions relevant to sustainability. This Committee was set up under the auspices of the United Nations and consisted of specialized scientists and government officials chaired by the then Prime Minister of Norway, Gro Harlem Brundtland. The aim of the Committee was to propose long-term environmental strategies for achieving sustainability. The results of the Committee's work were summarized in the report "*Our Common Future*" (WCED, 1987). The key points of the report were that there is interdependence between people and the environment to a much greater extent than the mere exploitation of resources, while environmental problems are not only local but global and the environmental impacts should be taken into account in a wider context to ensure that the problems will not be transferred elsewhere (Hopwood et al., 2005).

It is difficult to define sustainability in a practical manner, a difficulty which lies in the ambiguity of the term (such as the words love, freedom etc.) until it is implemented in a concrete way (Pope et al., 2004). So far there is not a commonly accepted definition of sustainability. How someone understands and determines sustainability depends on many factors such as his/her knowledge, experiences, perceptions and the values that distinguish him/her, something that has led to the development of numerous definitions. Indicatively, in a relevant study the author (Hasna, 2010) has identified and describes in detail more than 60 definitions of sustainability.

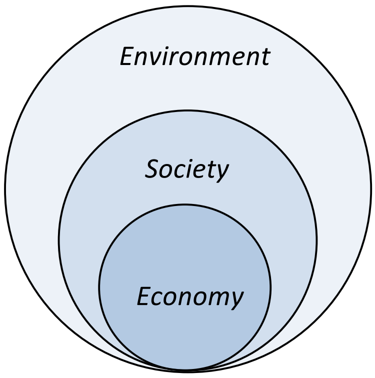
The definition of sustainable development as described in Brundtland report is currently the most widely used definition *"…is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Bell and Morse, 2008). Initially, definitions of sustainability focused on two axes – development and environment. However the concept of sustainable development adopted the three axes approach according to which development is divided into social and economic factors – axes. The reason for separating economic and social factors lies in the fact that the acquisition of economic goods does not necessarily guarantee social well-being.

The majority of definitions of sustainability raise three key questions (Costanza and Patten, 1995): 1) which systems/sub-systems should be maintained?, 2) for how long? and 3) when should we evaluate if the system was actually maintained? The answer to these questions reinforces the introduction of strategies contributing to sustainable development. The definition of sustainability should explicitly specify the general context and time and space boundaries to be useful (Brown et al. 1987). It is important to clarify not only the context but also specific features of the sustainability definition on the basis of which the analysis and evaluation will be performed.

In an attempt to make the concept of sustainable development more understandable to non-experts, various visual depictions have been developed from time to time, attempting to represent the relationship among the three aspects of sustainability (environment, economy, society). As in the case of sustainability definitions, depictions vary according to the developer's experience, knowledge and perceptions. Most of the times, the different axes of sustainability are represented as Venn diagrams. In Figure 2, the three most commonly used representations are presented (Lozano, 2008).



a. Sustainability as a Venn diagram. b. Sustainability as three concentric circles.



c. Sustainability as three adjacent circles.

Figure 1-2: Key representations of sustainability notion.
(Adapted from: Lozano, 2008).

In Figure 2a sustainability is illustrated as the intersection of three circles (each circle representing an axis of sustainability). A more ecological approach of sustainability could be illustrated by three concentric or adjacent circles (Figures 2b and 2c) of which the external circle would represent the environment, the middle one the society and the internal one the economy (Gibson, 2001). This particular representation is based on the view that natural resources are not abundant and therefore all actions should take into account the **Carrying Capacity** of the ecosystem. The specific approach will be adopted in this study for developing the methodological framework for assessing the environmental status of the protected areas.

Costanza and Patten (1995) argue that since we can assess sustainability after the event, achieving sustainability is a predominant problem rather than a definition problem. Consequently, it is necessary to continuously recheck the adequacy and efficiency of the objectives set in order to meet this goal. In that aspect, the proposed framework should be implemented regularly (e.g. at least every 2-4 years). Hopwood et al. (2005) have identified three different approaches for achieving sustainability in line with the changes required in socio-economic structures and human – environment relationship:

- According to the first approach (status quo), sustainability can be achieved within the existing structural framework. This view is mainly adopted by governments and businesses who believe that development will solve current and future problems.

- According to the second approach (reform), a fundamental reform of the existing structures is required, while retaining some of the existing regulations. This view is mainly adopted by academics and non-governmental organizations which recognize a need for change in politics and modern lifestyle.

- According to the third approach (transformation), a radical change is needed in the economy and society to achieve sustainability. This view is mainly adopted by environmentalists who argue that human and environment relationships should be drastically changed, whereas the concept of justice is important (basic principle: not everyone contributes the same to environmental problems, but their impact affects us all).

No matter what approach will be followed; achieving sustainability requires actions at different spatial and time levels and by different actors. In Table 1 four indicative examples of actions to reduce carbon footprint at different levels are presented. Carbon footprint (the amount of greenhouse gases expressed as equivalent carbon dioxide emitted into the atmosphere by a system) is a key contributor to climate change and thus affecting the achievement of sustainability. Every action will positively contribute to the reduction of carbon footprint but it is necessary to combine actions at all levels to substantially move towards sustainability.

Table 1-1: Indicative actions to reduce carbon footprint in various levels.

Level	Relevant body	Action
Worldwide	International organization	• Setting Carbon Footprint reduction targets over a specific time horizon (e.g. 2030).
National	Government	• Developing a strategy for improving the national energy mix by increasing the share of RES
Local	Management Body of Protected Area	• Actions for raising awareness of residents-visitors regarding to improve their energy behavior. **Utilization of methodologies for assessing the environmental**

		sustainability of the protected areas.
Personal	Human (individual)	• Reduce energy consumption through the adoption of energy-saving systems.

The aim of the specific study is to develop and present a methodological framework that will be able to assess the environmental status and sustainability of protected areas through the estimation of holistic environmental sustainability indicators. In Chapter 2, a literature review was conducted and is presented to serve as the theoretical basis for developing the relevant framework and strengthen its apprehension by the reader. In Chapter 3 the methodological framework including specific procedures of estimation per indicator is presented to enable its applicability by interested agents. A number of key conclusions are summarized in Chapter 4.

Chapter 2 - Literature review

2.1 Sustainability assessment of protected areas

In Chapter 1 the notion and significance of sustainability was introduced. Since the achievement of sustainability is a primary goal of modern society, the assessment of whether we move towards sustainability is crucial. Sustainability assessment can be defined as "*a process that guides decision making towards sustainability*" (Hacking and Guthrie, 2008). Devuyst et al. (2001), have defined sustainability assessment as "*a tool that helps decision and policy makers to decide what actions should follow or not, in an attempt to make society more sustainable*". Sustainability assessment is being evolved mostly as a decision making tool (Pope et al., 2004). Despite the proven growth of issues related to sustainability, significant criticisms do exist (Hasna, 2010). It is even argued that environmental sustainability cannot be achieved under increasing production (Hueting, 2010). According to Ehrenfeld (2005), the only way to bring a firm into a truly sustainable path is to change the rules of competition through relative legislation and/or voluntary cooperative action. Additionally, the utilization of methods and relevant frameworks for assessing the progress towards sustainability is essential.

Consequently, the number of current methods that try to assess the sustainability of a system is very extensive (Poveda and Lipsett, 2011). Several studies have attempted to summarize and evaluate relevant methods (Angelakoglou and Gaidajis 2015). Ness et al. (2007) provide a collection of sustainability assessment methods with a view to categorize them according to their focus and their special characteristics. Gasparatos et al. (2008) have performed a comprehensive review of sustainability evaluation tools including their feasibility of integrating them within a sustainability assessment framework. In another study by Poveda and Lipsett (2011), a range of sustainability assessment methods is discussed, focusing on the development of environmental and sustainable rating systems. Singh et al. (2012) have identified and analyzed various sustainability assessment methodologies which can be implemented to measure sustainable development at different levels. Cucek et al. (2012) present an overview of footprint based tools for monitoring impacts on sustainability.

For the purpose of this study we have defined a methodological framework for assessing the environmental status of an examined area as *"a procedure which can provide quantitative information that can potentially help protected areas to assess their environmental sustainability"*. According to Hueting (2010) environmental sustainability is defined as *"the situation in which vital environmental functions are safeguard for future generations"*. In order to clarify the scope of this work a distinction is made between environmental performance assessment and environmental sustainability assessment. More specifically, it is considered that environmental sustainability refers to wider time scales (e.g. long-term, progress over time) and covers broader environmental issues in various scales (e.g. national, worldwide) (Wehrmeyer and Tyteca, 1998).

In a relevant study, Angelakoglou and Gaidajis (2015) provide five key criteria that should be taken into account while developing a methodology for assessing the environmental sustainability of a system and present an evaluation process for assessing the efficiency of the final procedure (Tables 2 and 3). The information presented in this study, will be capitalized to develop the methodological framework.

Table 2-1: Key criteria-characteristics to take into account while developing a sustainability assessment framework.

Criterion	Description
Ability to promote actions of improvement	Sustainability oriented assessments, should not only focus on the evaluation of the current situation, but should also promote desired behavior. An effective environmental sustainability assessment method should be able to promote actions that reduce environmental impact, enhance communication of its performance, increase resource and energy efficiency and strengthen the identification of environmentally innovative processes.
Ability to help decision making	Environmental sustainability methods should provide all the information that is necessary to strengthen decision making in various levels (e.g. administrative, managerial, executive). The specific information should be able to support the identification of key environmental hot spots (where is the problem?) and the current distance from a commonly accepted environmental sustainability target. Additionally methods should help decision makers to better adapt to current and future legislation since legislation is reformed to promote sustainable development.
Potential for benchmarking	A way to make environmental sustainability methods appealing to users is by offering them the chance to benchmark their performance with other similar systems and/or their performance over consecutive years. *During the BIO2CARE project, the methodological framework will be applied in two case studies (one in GR and one in BG) to examine its potential for benchmarking purposes.*
Applicability and ease of use	Most users will use the most practical and cost-effective methods at hand. However, the development of a merely simplistic method will

	not cover significant aspects of sustainability, whereas a too complicated one will fail in its basic goal which is to be applied by as many users as possible. As a result, environmental sustainability assessment methods should involve various levels of application to varying capacities. The availability of analytical guidelines, supporting tools and relative software that can help perform the assessment is an efficient way to further increase the applicability and ease of use of the method. *During the BIO2CARE project the methodological framework that will be developed will be translated into relevant software (WP4) that will significantly facilitate its implementation by non-experts.*
Integration of wider spatial and temporal characteristics	The environmental sustainability performance of an area is highly related with its geographical region and its spatial characteristics. In that aspect, environmental sustainability assessment methods should assess not only the performance/accountability of the examined system, but also the concern/impact in regional, national and international level. The special characteristics of the systems such as the large amounts of incoming and outgoing materials, the proximity to areas with high environmental concern, the water and energy abundance and so forth, should be taken into account while assessing their environmental sustainability. The specific parameters should be regularly revaluated due to their dynamic nature whereas a long term vision should be supported.

Table 2-2: Evaluation process for assessing the efficiency of the methodological framework (adapted from: Angelakoglou and Gaidajis, 2015).

Evaluation criteria and relevant questions	Checklist
Criterion 1: Ability to promote actions of improvement	
Q.1.1: Can methods promote actions that reduce environmental impact?	*Y/N*
Q.1.2: Can methods promote the development of environmentally sustainable products?	*Y/N*
Q.1.3: Can methods promote corporate image and communication strategies?	*Y/N*
Q.1.4: Can methods promote energy and resource efficiency?	*Y/N*
Criterion 2: Ability to help decision making	
Q.2.1: Do methods assess an adequate number of environmental issues?	*Y/N*
Q.2.2: Do methods include specific thresholds/targets of sustainable performance?	*Y/N*
Q.2.3: Can methods identify specific environmental “hot spots”?	*Y/N*
Q.2.4: Can methods support the achievement of environmental regulations?	*Y/N*

Criterion 3: Potential for benchmarking	
Q.3.1: Can methods aggregate the results into single scores?	*Y/N*
Q.3.2: Are methods able to evaluate progress over time?	*Y/N*
Q.3.3: Can results be applied for cross-comparisons among different areas?	*Y/N*
Q.3.4: Can methods be applied/updated to compare overall sustainability performance?	*Y/N*
Criterion 4: Applicability and ease of use	
Q.4.1: Can methods be easily applied by non-experts?	*Y/N*
Q.4.2: Can methods be easily applied by areas that lack capacity (staff/data/cost involved)?	*Y/N*
Q.4.3: Do methods include clear guidelines of implementation (freely available)?	*Y/N*
Q.4.4: Are there supporting tools/software to help implementation?	*Y/N*
Criterion 5: *Integration of wider spatial and temporal characteristics*	
Q.5.1: Do methods integrate wider spatial characteristics/concerns in the assessment?	*Y/N*
Q.5.2: Do methods integrate special characteristics/concerns in the assessment?	*Y/N*
Q.5.3: Do methods assess environmental impacts at wider levels (e.g. national, global)?	*Y/N*
Q.5.4: Do methods integrate long-term concerns in the assessment?	*Y/N*

An effective way to assess the sustainability of an area is through the quantification of the pressures that are placed on its ecosystem and are caused by human activities (e.g. through production and consumption of resources and energy, emission generation etc.) occurring within or affecting the area based on known and documented limits of these pressures. To assess these pressures, it is necessary to evaluate the current situation and define sustainability indicators relevant to the activities in question. Sustainability requires anthropogenic systems to act within certain "ecological" limits to ensure the continuous supply of goods and resources to current and future generations (Daily, 1997). In other words, the sustainability of an area (protected or not) depends on whether the impact of human activities is within the "ecological" limits including those activities that take place outside the area of examination but their impact affect this area (Graymore et al., 2010).

From 1990, the sustainable development of protected areas has been directly linked to the Carrying Capacity (CC) concept for two main reasons (Saarinen, 2006): a) the concept of sustainability entails a "limit", as in the case of Carrying Capacity, b) both concepts share the same challenges in formulating the objectives and the procedures for their evaluation. CC is a concept defined on a case-by-case basis and depends on the nature of the problem and the objectives set by the researcher. For this reason, as in the case of sustainability, various definitions are available in literature depending on the objectives of the study. A generic definition of the Carrying Capacity of ecosystems was given by Rees (1997) according to which "*CC is the maximum population of specific species that can be hosted by an environment without causing permanent damage to the productivity of the system under examination*".

Studies regarding the CC of a national park/protected area (Prato, 2001; Lawson et al., 2003; Prato, 2009; Needham et al., 2011) focus mainly in the field of tourism and are usually limited to finding the optimal level of recreational use that the area under consideration can accommodate without harming its biodiversity and visitors' pleasure (National Park Service, 1997; PAC/RAC, 2003).

However, national parks such as the National Park of Eastern Macedonia and Thrace (GR) and protected areas, sometimes include zones where apart from tourism, other anthropogenic activities take place such as agricultural, industrial, residential etc. These activities exert additional pressure on the area and not taking them into account while assessing the sustainability of this area leads to an underestimation of the environmental impacts and/or incomplete conclusions. Thus, the estimation of the CC of a protected area should take into account the impact of all activities taking place within the boundaries of this area and/or affect it.
In areas where anthropogenic activities take place, regional strategies usually aim at increasing the number of businesses, products locally produced, population and tourists visiting this area. By default, this leads to increased energy and water consumption, highest utilization of raw materials and increased environmental impacts. As a result, we face the great challenge of improving the environmental sustainability of an area alongside with the economic growth of the region. To do so, it is necessary to move from traditional environmental protection and management approaches to modern ones that take into account the characteristics of sustainable development (Table 3). The BIO2CARE project attempts to adopt and promote the modern approach of environmental protection through the development of holistic decision support systems and by taking into account the objectives of sustainable development.

Table 2-3: Moving from traditional environmental protection and management to a modern – sustainable approach.

Characteristics	"Traditional" environmental protection	"Modern" environmental protection
Political background	Risk control	Sustainability (Three axes of development – Environment – Economy – Society)
Key agent-facilitator	Governments	Society
Regulatory factor	Confrontation	Prevention and Cooperation
Actions	Separation of works – independent solutions	Overlapping works – systemic solutions
Principle of action	Reactive	Proactive
Spatial range	Local, national	International

Focus	Production	Product
Environment	Focus on one pollutant	Life cycle approach
Environmental technology	Distinct processes, end-of-pipe approach	Integrated processes, innovation

To meet this challenge we will define the **Carrying Capacity** (CC) as the maximum number of persons (in our case both visitors and residents) that the protected area can sustain without permanent damage to the productivity of the environment and without considerably diminishing the capacity of future generations to meet their needs.

In order to estimate the CC and further assess the sustainability of a protected area it is necessary to extract the following three footprints:

- The **Ecological Footprint** (EF) is the amount of theoretical land (expressed in hectares – Gha) that is needed for a population to produce in a sustainable way all the natural resources it consumes and assimilate the waste it produces. The EF calculation method is necessary to convert the energy and food consumption needs in land requirements in order to compare them with the Biocapacity of the examined system (actual production from available lands) and thus find the CC of the area.

- The **Carbon Footprint** (CF) is the quantity of greenhouse gases (expressed in tones of carbon dioxide equivalent emissions – tons CO_2) emitted to the atmosphere by the examined system. It can be considered a sub-indicator of the EF, but it is essential to quantify and assess it on its own, since it provides a much clearer image of Global Warming Potential and Climate Change impacts.

- The **Water Footprint** (WF) is the total fresh water volume (expressed in m^3/year) that is used to produce products and services within the examined system. Although WF is not directly utilized to estimate the CC of a protected area, we will estimate it in order to increase the utility of our decision support system by integrating water sufficiency related issues in our assessment.

A detailed description of the three footprints as well as the concept of Carrying Capacity is provided in Chapters 2.2, 2.3, 2.4 and 2.5.

The methodological framework that was developed and is presented in Chapter 3, includes all necessary steps-actions and guidance to estimate and assess the CC and the three footprints for the two areas (GR and BG side). During this process we will adapt already available methodologies according to protected areas' needs, simplify and standardize procedures so that in the future decision makers and relevant agents can utilize BIO2CARE framework by importing predefined data.

The quantification and evaluation of the above parameters/footprints for a protected area implies significant benefits for both the management body of the park and other stakeholders who are interested in assessing the environmental sustainability performance of the park-area through:

- ✓ Strengthening decision making process and developing sustainable strategies: Knowing the Carrying Capacity and relevant footprints helps to identify activities of particular interest with high environmental impact while reinforcing the development of sustainable strategies through the determination of specific and quantified objectives. In this way, the management and monitoring of the environmental performance of the area is becoming more effective.

- ✓ Better and more direct adaptation to current and future legislation: Legislation at both national and international level is being reformed to promote sustainable development. In this context, indicators such as the carbon footprint may be obligatory in the future for assessing and reporting the sustainability of a protected area.

- ✓ Easier access to funding sources (government grants, international programs): The awareness of the above parameters provides a significant strategic advantage over other proposals to funding opportunities for improving the environmental performance of the park, since relevant objectives and priorities can be more accurately supported.

- ✓ Market benefits due to higher demand of ecologically sensitive "green" products: The production of goods within areas that meet their Carrying Capacity and present a relatively low carbon and water footprint creates an environmentally friendly product profile.

2.2 The concept of Carrying Capacity

2.2.1 Introduction

It is not unfamiliar that the nowadays human civilization lives in a quite unbalanced way. According to WWF Living Planet Report (2008), in the period 1970-2005 Earth's biodiversity decreased by almost 1/3, while the amount of Nature's goods and services, required by humanity for a unit of time became doubled. The rapid exponential growth of population in the last 60-70 years has raised questions and discussions about the abilities of our planet to sustain living in satisfactory standards. The increasing pressure on ecosystems and natural resources has been leading to decrease in biodiversity and shortage of resources. Life on Earth possesses the unique ability to renew, reproduce and recover. We use this constantly in agriculture. The hydrological cycle provides us with water which is vital for the survival of any living creature. However, the renovation of any resource on our planet requires a certain amount of time. If the rates at which we consume resources exceed the time required for their regeneration, a shortage of those resources will occur. This has happened many times on various locations, and the usual solutions are to import the lacking resources from other region of Earth, or to use alternatives. But what happens when it comes to shortage of resources on global, planetary level?

The concern of scientists and society on these issues resulted in the development of the concept of sustainability as a prerequisite for a balanced existence, and the way for humanity to avoid the destruction of Earth's nature and the collapse of civilization. Sustainability is such a mode of living, in which the balance between consumption of resources and their regeneration is maintained in a long-term sense, thus preserving the natural planetary systems. Initially, the term 'sustainable development' was introduced by the Brundtland Report for the World Commission on Environment and Development (1992), as: "The development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

A national sustainable development strategy can be defined as "a coordinated, participatory and iterative process of thoughts and actions to achieve economic, environmental and social objectives in a balanced and integrative manner" (UNDESA, 2002). The following goals are defined in the National sustainable development strategy of Bulgaria: slowdown of climate change and introduction of clean energies; provision of sufficient amounts of water (in quantity and quality); healthier environment and better quality of life; encouraging of sustainable manufacturing and consumption; limitation of biodiversity losses; formation of environmentally friendly moods and habits in society (National Environment Strategy, 2009-2018).

Beyond pure definitions, the concept of sustainable development needs to be supported by instruments for quantitative assessment of its elements, which will help us to know what exactly sustainable development is, and how it is expressed in figures. This is the reason for the creation of the concepts of carrying capacity and the related ecological footprint.

In modern ecology, carrying capacity is the number of people, animals, or crops which a region can support without environmental degradation. In the case of protected areas, the Carrying Capacity (CC) can be understood as the maximum number of persons (both visitors and residents) that the protected area can sustain without permanent damage to the productivity of the environment and without considerably diminishing the capacity of future generations to meet their needs.

Originally, the term 'carrying capacity' was used to determine the number of animals that could graze on a segment of land without destroying it (The Sustainable Scale Project, 2017). Biologists studied a number of animal species (especially grazing animals) in respect to the carrying capacities of specific areas. The term started to be addressed to people later, in the 1960s.

The early work on carrying capacity has since blossomed into an extended literature on the environmental and social impacts of outdoor recreation and their application to carrying capacity (Wagar, 1964; Lime, 1970; Lime & Stankey, 1971; Frissell & Stankey, 1972; Stankey & Lime, 1973; Graefe, et al., 1984 Manning, 1985, 1999; Shelby & Heberlein, 1986; Kuss, et al., 1990; Manning, 1999, 2000; Hammitt and Cole, 1998). Manning (2002) summarized the VERP (Visitor Experience and Resource Protection Framework), introduced in some national parks in the USA, which involves also visitors as an active side in determining carrying capacities, presenting a case study at Arches National Park, Utah (Hof, et al., 1994; Manning, et al., 1995; Manning, et al., 1996a; Belnap, 1998; Manning, 2001). Frissell and Stankey (1972) and Stankey, et al. (1985) define the Limits of Acceptable Change (LAC) as a line of compromise between conservation and social functions of protected areas. A widely used classification of carrying capacities was introduced by Getz (1983), who distinguished ecological, psychological, social, economical and political carrying capacity. However, some researchers (e. g. McCool and Lime, 2001) such a fragmentation of the concept makes it less applicable. Cifuentes et al. (1990) divided physical, real and effective carrying capacities.

In general, there is more limited experience with the application of CC in the management of tourist destinations in Europe. This probably reflects the ambiguities involved with the concept and/or the difficulties in its practical implementation. Another reason could be that overall there is little experience on the ground with the use of tools and methods for that purpose. The concept approaches and methodology of tourism carrying capacity in European countries were on the focus of the project "Defining, measuring and evaluating carrying capacity in European tourist destinations", implemented by researchers from the Environmental Planning Laboratory of the University of the Aegean, Greece (Project Final Report, 2001). Results from a study of carrying capacity in the protected area of the Danube delta were published in 2014 (Danube Parks Project, 2014).

In Bulgaria, Mitova (2016) proposed a model for estimating of ecological carrying capacity in Vitosha Nature Park (Bulgaria) based on assessment on landscape level. In relation to protected areas, in which economical activities are banned or strongly reduced the term 'tourist carrying capacity' is applied. In is often divided into physical (ecological), economic and social (Danube Parks Project, 2014).

These concepts provide instruments to express the relations between humanity and environment, between available resources and their consumption, using particular, measurable parametres. They can be applied to research the balance in the use of resources throughout the economy and explore the sustainability of individual lifestyles, organizations, industry sectors, neighborhoods, cities, regions and even nations. In general they are used to assess the human impact on the most important element of environment: land, water, carbon (fossil fuels).

2.2.2. The concept of carrying capacity in ecology (flora and fauna)

In ecology the concept of *"carrying capacity"* concerns the ability of certain regions (ecosystems) to support life of different species that inhabit them and relates to the population growth patterns of these species. "Carrying capacity" is defined as "the upper level, beyond which no major population increase can occur" (Odum, 1971). It represents the maximum sustainable density of populations that have density dependent population growth. These populations tend to be self-limited because the rate of their growth reduces when the density increases (Odum, 1985). For a short period of time a population can exceed the carrying capacity by using up the stored resources (ie natural capital) of its environment, but sooner or later the 'overshoot' will catch up. When the resources available are exhausted the population declines. Sometimes it can happen very rapidly and can lead to the near extinction of an entire species (Population matters, 2011).

All developed systems (man made systems, including cities, that exist thanks to additional input of energy from fossil or other concentrated fuels) posses the ability to exceed their optimum size at the expense of natural systems. That happens because quite often the economic costs of maintenance of developed systems can not be foreseen and the useful work of natural systems is completely underestimated (Odum and Odum, 1972). The human population growth increases with increasing density, in contrast to the population growth of most organisms, because the effects of overuse of a resource and the crowding effects are felt after quite a long period of time (Odum, 1971). The possibility of overshooting the carrying capacity of a region, however, is just temporal. Unlimited population growth is not possible. Although it might be beneficial for human populations to exceed the carrying capacity of a certain region, which can lead for example to short-term increases in per capita supply of goods, this is not sustainable in a long term and can cause irreversible degradation of natural environment - loss of biological diversity, deforestation, pollution and so on. The negative effects on the environment in a given region caused largely by the rapid population growth, diminish the carrying capacity of that region. Thanks to technological advances and trade, however, human populations are able also to expand to a substantial extent the carrying capacity of a region (through increasing the productivity of natural resources or the efficiency of their conversion into goods, or by exchanging resources with other regions). But technologies and trade "ultimately reach diminishing returns" and make the unlimited population growth impossible (Ledec et al, 1985).

Of course, it is very difficult to determine the human carrying capacity of certain regions but it is an important measure of the ability of these regions to support human populations. Ultimately the carrying capacity is determined by the availability of the scarcest vital resource in a given region - food, fuel, water, living space, space for waste disposal and others. Difficulties on defining and measuring the carrying capacity of natural systems come to a great extent from the people's ability to manage the resources which they use and from the differences in per capita resource consumption within the same society or among different societies (Ledec et al, 1985). The carrying capacity of a given environment is much greater for people living at a subsistence level than it is for people who live in Western Europe or North America. Furthermore the different geographic regions have a greater or smaller carrying capacity (Population matters, 2011).

It is even more difficult to set limits to the population growth and economical development of man in order to attain an optimum population size, density and configuration. Some regions and even whole countries are so densely populated that no undeveloped land has left on their territories. Although the annual growth rate of human population is declining, the current world population is 7.6 billion as of May 2018 and will continue to increase. In the late 1960s the growth rate reached its peak which was on the average, about 2 percent per year. The rate of increase has nearly halved since then and population in the world is currently growing at a rate of around 1.09% per year (Worldometers. 2018). Odum (1971) points out that "it would be safer and much more pleasant if man accepted the idea that there is a desirable degree of ecological dependence, which means sharing the world with many other organisms instead of looking at each square inch as a possible source of food and wealth or as a site to make over into something artificial". Odum (1971) claims, as well, that "the time has come for man to manage his own population" and that man must "be prepared to accept “cultural regulation” where “natural regulation” is inoperative (or insufficient or too late)".

The applicability of carrying capacity concept in the national park planning and management was first suggested in the mid–1930s but it did not happen until the 1960s (National Park Service, 1997; Manning, 2002; Sayan and Atik, 2011). Research and experience has led to development of several frameworks for analyzing and managing the carrying capacity of parks and related areas. At first, the focus was placed on the visitors’ impact on the environment as the increasing numbers of visitors causes greater environmental impact. Later, another dimension of carrying capacity dealing with social aspects of the visitor experience was indicated. So, applied to national parks, carrying capacity has two components: environmental and social (Manning, 2002).

Since the 1970s a variety of planning and management frameworks have been developed, using qualitative methodologies. Among them are: Limits of Acceptable Change (LAC), Visitor Impact Management (VIM), Visitor Experience Resource Protection (VERP), Management Process for Visitor Activities (VAMP), Recreation Opportunity Spectrum (ROS), Tourism Optimization Management Model (TOMM). These frameworks could be considered as different aspects of a specific monitoring and management strategy (Attallah, 2015). As Attallah (2015) pointed out: “*These frameworks set standards or ranges of acceptable change and describe a methodology for determining these standards, measuring impacts and identifying* *management strategies or controlling negative impacts*". VERP for example is specifically designed to identify and manage carrying capacity in the U.S. national park system by defining desired resource and social conditions by means of a series of indicators and standards of quality. Indicator variables are monitored over time to ensure that standards of quality are maintained. If standards of quality are violated, the VERP process requires that management action be taken (National Park Service, 1997; Manning, 2002).

A number of different forms of carrying capacity referred to tourism have been formulated. The most commonly used were summarized by Attallah (2015) as follows:
*The **physical carrying capacity*** is the maximum number that a tourist attraction is able to support. This carrying capacity is often used as a managerial tool that defines a threshold beyond which environmental changes, disturbance and problems occur.
*The **economic carrying capacity*** relates to a level of unacceptable change within the local economy of a tourist destination. It is the extent to which a tourist destination is able to accommodate tourist functions without the loss of local activities.
*The **social carrying capacity*** concerns the negative socio-cultural effects related to tourism development. It defines the amount of effects resulting from tourists on the host societies, as well as, the density tolerance rate of tourists.
The ***biophysical carrying capacity*** deals with the extent to which the natural environment is able to tolerate interference from tourists. In other words, it is the limit where the damage exceeds the habitat's ability to regenerate.
*The **environmental carrying capacity*** refers to ecological and physical parameters, capacity of resources, ecosystems and infrastructure.
*The **psychological (conceptual) carrying capacity*** refers to the maximum number of visitors for whom an area is able to provide a quality experience at any one time
*The **tourism carrying capacity*** is a specific type of environmental carrying capacity and refers to the (biophysical and social) environment with respect to tourist activity and development.

In 1994, the World Tourism Organization (WTO) proposed the following definition of ***tourism carrying capacity***: "*The maximum number of* people *that may visit a tourist destination at the same time, without causing destruction of the physical, economic, socio-cultural environment and an unacceptable decrease in the quality of visitors' satisfaction"* (Sayan and Atik, 2011; Attallah, 2015).

In 1998, Hens defined the ***tourism carrying capacity*** as the maximum number of people that use a tourist site without causing negative effects on environmental resources while meeting the demands of tourists (Attallah, 2015).

Physical, real, and effective carrying capacities were assessed by using Cifuentes's (Cifuentes 1992) which was (Ceballos-Lascuráin 1996)

The most widely used methodology for the assessment of carrying capacity is the one proposed by Cifuentes in 1992 (Sayan and Atik, 2011; Attallah, 2015). This method was suggested for application by the IUCN (Sayan and Atik, 2011). The aim is to determine the maximum number of tourists that an area can tolerate, based on its physical, biological and management conditions. This is accomplished by by considering three main levels:

The **physical carrying capacity (PCC)**: is the maximum number of visitors who can attend physically into a defined space, over a particular time. it is important to consider tourist flows, the size of the area, the optimum space available for each tourist to move freely and the visiting time (Sayan and Atik, 2011; Attallah, 2015).

The **real carrying capacity (RCC**): is the maximum permissible number of visits to a specific site, which is calculated according to the limiting factors resulting from specific conditions of that place and influence of these factors on the physical carrying capacity. These limiting or corrective factors are not necessarily the same for each site; and only the negative factors which hinder or affect tourism activities are considered, among which the environmental factors are usually the most important. These factors are then translated into quantitative values (Sayan and Atik, 2011; Attallah, 2015).

The **effective or permissible carrying capacity (ECC)**: is the maximum number of visits that a site can sustain considering the RCC and the management capacity (Sayan and Atik, 2011; Attallah, 2015).

Each subsequent level constitutes a corrected or reduced level of the previous one, i.e. PCC is always greater than RCC and RCC is greater or equal to ECC.

The PCC can be expressed according to following formula:
PCC = A x V/a x Rf
Where: A = available area for public use
V/a = area required per user
Rf = Open period / Average time of one visit

The RCC is determined by the following equation
RCC = PCC x 100- Cf1/ 100 x 100- Cf2/100 x … 100 - Cfn/100, where
Cf = (M1 / Mt) x 100
Cf1- Cfn are the corrective factors, they are expressed as a percentage

M1 = limiting magnitude of variable
Mt = total magnitude of variable

The ECC is calculated as follows:
ECC = RCC x MC where:
MC = management capacity. Measuring MC is not easy, as it involves many variables, including policy measures, legislation, infrastructure, facilities, amenities and equipment, staff (both number and competency), funding, available budget, etc. (Sayan and Atik, 2011; Attallah, 2015). This methodology was used to estimate the carrying capacity for Termessos National Park in southern Turkey with consideration for its specific natural and cultural resources (Sayan and Atik, 2011).

2.2.3. The concept of carrying capacity in water resources evaluation

The concept of carrying capacity is well known in the field of demography, biology, and applied ecology (Clarke, 2002). In ecology, carrying capacity is defined as the maximum population of a species that a habitat can support without permanent impairment of the habitat's productivity (Rees, 1997). With the increasing constraints on regional sustainable development by resource scarcity, different concepts for carrying capacity of natural resources were introduced such as land (Chen et al., 1996), environment (Arrow et al., 1995) agriculture (Duarte et al., 2003), and water (Liu et al., 2012). Water resources carrying capacity (WRCC) is a new concept that has become very popular recently based on the scarce and an even distribution of the world fresh water resources. The water has been playing an increasingly important role in current social and economic development, that is why the methodology for estimation of water resources carrying capacity (WRCC) has attracted considerable attention.

Despite of the increase role of the water in every aspect of the human live Internationally, not many breakthroughs have been achieved in the WRCC research; the topic has only been considered briefly in theories of sustainable development (Ofoezie, 2002). Some scientiest have used terms such as sustainable water utilization, the ecological limits of water resources, or the natural system limits of water resources to express te meaning of WRCC (Hunter, 1998; Falkenmark and Lundqvist, 1998). Studies that considers the methodology for calculation of WRCC have been conducted predominantly in China. The concept of WRCC was first applied to the Urumqi River Basin in China in 1989 (Shi and Qu, 1992; Feng et al., 2006). It has been a topic of significant debate since 2001, and represents a new academic frontier (Long et al., 2004).

WRCC is based on the carrying capacity theory and the exploration of response mechanisms between human activities and water resources. Some researchers consider WRCC to be the capacity of water resources to sustain a society at a defined good standard of living, while others consider it the threshold level of water resources at which an environment is capable of supporting the activities of human beings (Seidl and Tisdell, 1999; Li et al., 2000). WRCC rationally evaluates the socio-economic scale threshold that can be sustained by the local water resources. However, the definition of WRCC is still not so clear yet. Some studies consider the WRCC to be a capacity to sustain a society with a good standard of living in a favorable water resource system (Feng et al., 2008); some define it as the maximum bearing capacity of water resources for human activity in a certain stage of socio-economic development or a certain living standard in a favorable ecological system (Song et al., 2011). Others consider it a threshold value, for example, the capacity to support the activities of human beings (Li et al., 2000).

According (Guanghua et al., 2016) There are two types of WRCC: current WRCC and future WRCC. To calculate the current WRCC is easier because the data about the current situation of water resources and socio-economic development are easily accessible. However, the WRCC is not static, but a dynamic indicator and it changes through time. For the future WRCC, the future amount of water resources and the socio-economic development mode are unknown and need to be estimated in advance, which will cause a lot of uncertainty (Guanghua et al., 2016).

Other possible definition of water resources carrying capacity is the one given by Dou et al. (2010) where WRCC is the maximum sustainable socioeconomic scale based on available water resources and maintenance of good, defined environmental conditions. The socioeconomic scale is the overall size of a regional socioeconomic system in a certain period and can be represented by a series of socioeconomic indices (such as total population, urbanization ratio, industrial structure, and grainyield) Dou et al. (2010). Good environmental conditions mean a suitable living environment for human beings and the ecological system, in particular good water quality and a healthy aquatic environment (Dou et al., 2010). WRCC is an indicator of regional sustainability, and achieving regional sustainability is important because social institutions and ecological functioning are closely linked at this scale (Graymore et al., 2009). Because of that, the methodology on Water resources carrying capacity estimation have to be build on two principals: First, it have to sustain the normal operation of a regional social and economic system, and as a result researchers must calculate the quantity of water resources required to sustain these social service functions. Second, it is necessary to evaluate the maximum socioeconomic scale that water resources can sustain after meeting the needs of the ecosystem (Ming et al. 2015).

Regional carrying capacity depends on water resources. There have been many theoretical studies of carrying capacity based on regional water resources because this concept is most often considered within a larger theoretical context of sustainable development. For example the extream water shortage in some parts of China have forced the Chinese government to initiate a series of studies to determine the carrying capacity based on regional water resources in arid and semi-arid areas in the Western China and Northen China Plain (Xia and Zhu, 2002; Dou et al., 2010; Zai et al., 2011). Also, recently because of the serious water pollution, similar studies have been conducted in eastern China, where opposite to the Western and Northen China the water resources are abundant (Liu and Borthwick, 2011; Liu, 2012). Furthermore, Falkenmark and Lundqvist (1998) have used estimates of the maximum global use of water resources to study how carrying capacity is determined by regional water resources. The National Research Council (NRC) (2002) studied the Florida Keys Basin's carrying capacity in the United States under different land-use scenarios. Lane et al. (2014) offered a Carrying Capacity Dashboard (QUT, 2012) to highlight one way in which some basic resource-based parameters have been utilized. In practice, carrying capacity is often estimated by comparing stress on the environment (e.g., demand of natural resources) against environmental thresholds (e.g., available natural resources) (Clarke, 2002; Ohet al., 2005).

Research on WRCC involves many disciplines, including hydrology, ecology, environmental sciences, economics, sociology, and management science (Zhang et al., 2010). Many methods can be used, of which the most common are trend analysis (Liu, 2012), the fuzzy comprehensive evaluation method (Prato, 2009), system dynamics (Feng et al., 2008; Dang and Guo, 2012), multi-objective decision-making and analysis (Xu and Cheng, 2000), the large-scale system theory, the optimization method, and the projection pursuit approach (Zhang and Guo, 2006; Liu and Borthwick, 2011).

As a conclusion can be stated that the goals of the current studies on WRCC are to achieve a full harmonization between the demands of socioeconomic development and the available supplies of water resources. Regional socioeconomic and water resources systems are often represented in geographically well defined areas such as river catchment areas, which allow scholars to invistigate the systems' internal structures, functions, and processes which allow WRCC to be precisely determined. On the regional socioeconomic scale may be determined by the urban population growth rate and economic development goals. Constraints imposed by the availability of water and other natural resources are rarely considered in planning, which may explain why most cities in the world are facing severe water shortages and experiencing environmental problems (Zhang et al., 2010). Because of that is necessary to be develop a suitable methodology which will help to be manage effectively the hydro-economic interactions in highly populated regions and to choose the best political strategies to soften the contradictions between socioeconomic development and the use of available water resources.

2.2.4 The concept of carrying capacity in energy production and consumption

In the context of sustainability, sustainable energy is an energy system that serves the needs of the present without compromising the ability of future generations to meet their needs (Lemaire, 2010). Renewable energy is not the same as sustainable energy. While renewable energy is defined as one that is naturally replenished on a human timescale, sustainable (often referred to as 'clean') energy is one the use of which will not compromise the system in which it is adopted to the point of not being fit to provide needs in the future. According to those definitions sustainable energy includes renewable energy sources (such as hydroelectricity, solar energy, wind energy, wave power, geothermal energy, bioenergy, tidal power and others), and also technologies designed to improve the efficiency of traditional energy sources.

According to Renewables in Energy Supply (2009) there are three generations of renewable technologies reaching back more than 100 years. First-generation technologies emerged from the industrial revolution at the end of the 19th century and include hydropower, biomass combustion, and geothermal power and heat. Some of them are still in widespread use. Second-generation technologies include solar heating and cooling, wind power, modern forms of bioenergy, and solar photovoltaics. These are now entering markets as a result of technological development since the 1980s. Many of the technologies reflect revolutionary advancements in materials. Third-generation technologies are still under development and include concentrating solar power, ocean energy, enhanced geothermal systems, and integrated bioenergy systems.

Energy is strongly related to the expression of ecological footprint. Fossil fuels are the main source for the increasing carbon content in the atmosphere and hydrosphere. Results of the disturbed carbon balance are the rising air temperatures and acidification of ocean waters.

One approach to reduce the ecological footprint is to introduce and stimulate the development of the so called “green energy”, coming from natural sources like wind, water and sunlight (IGS Energy).

The balance of energy production in Bulgaria for 2015 from traditional sources includes 34% nuclear energy, 51% energy from fossil fuels (coal and gas, the share of coal being 98%), hardly 7% from hydroenergy, and 8% from renewable fuels and waste recycling (Bulletin for the state and development of energetics in Bulgaria, 2017). Coal, which has greatest share among fossil fuels, produces great pollution to the atmosphere, while gas has lower impact. Apart from the high risks concerned to accidents, the main negative consequence of nuclear energy production is the thermal pollution of waters. The heat wave, released in the Danube from Kozloduy NPP has temperatures 7.5-8.5°C higher than ambient water temperature, and the zone with +3°C extends 2.3 do 10.6 km downriver (Mecheva and Dimitrova, 2013). Production of hydroenergy in not directly associated with pollution, but the construction and functioning of hydropower plants have many negative effects on river courses and habitats. Rivers like Arda and Vucha are the worst affected by hydropower construction. However, the ratio of environmental damage vs. energetic benefits is much greater at the small (micro-) hydropower plants, in which a very small amount of produced energy is made possible with alteration (devastation) of hundreds of metres of the river course. In many such HPPs the required regulations for maintenance of operative fish passages and the requirements for minimum water volumes which should be released to preserve habitats, are violated. Such violations make the correct calculations of ecological footprints problematic.

In Bulgaria, the share of renewable energy in the total energy production rose from 9.5% in 2005 to around 16% in 2014 (Zhechev, 2014) and 17% in 2016 (Bulletin for the state and development of energetics in

Bulgaria, 2017). However, the share of renewable energy other than hydropower in particular in Blagoevgrad municipality and the Rila NP is negligible.

The other important issue is energy efficiency. Increasing of energy efficiency can greatly reduce ecological footprint and all its components. The optimistic fact is that energy use per unit of economic output in the industrial sector fell by nearly 20% between 2000 and 2016, and the magnitude of the declines is similar both in IEA member countries and major emerging economies. Global energy intensity – measured as the amount of primary energy demand needed to produce one unit of gross domestic product (GDP) – fell by 1.8% in 2016. Since 2010, intensity has declined at an average rate of 2.1% per year, which is a significant increase from the average rate of 1.3% between 1970 and 2010 (Energy efficiency, 2017). Falling energy intensity resulted in the flattening of global energy-related greenhouse gas emissions since 2014. Lower energy intensity, driven largely by efficiency improvements, is combining with the ongoing shift to renewables and other low-emission fuels to offset the impact of GDP growth on emissions (Energy efficiency, 2017).

2.2.5. The concept of carrying capacity in demography

Carrying capacity – an equilibrium state where a maximum number of individuals / population can be maintained by the given ecosystem in the long run. The change in the population of a species is the result of disturbing the dynamic balance between its biological potential and the environmental resistance.

The disturbed equilibrium leads to the so-called de concentration of the environment - the reduction of one species, while another (controlled by it) grows (mice, locusts, etc.). Reducing the population below a certain critical number of individuals leads to its destruction.

The maximum number of individuals that can be supported sustainably by a given environment is known as its "**carrying capacity**". For most non-human species, the concept is quite simple. If carrying capacity is exceeded, the population declines because its environment can no longer support the excess numbers. In many situations this can happen very rapidly because excessive demand degrades or even devastates the environment and there is a sudden and catastrophic feedback effect. Such a feedback effect can not only eradicate those numbers of population in excess of the carrying capacity of an environment but under certain circumstances it can cause the near extinction of an entire species.

A population can exceed the carrying capacity of its environment for a short while by using up the stored resources of its environment, but sooner or later the overshoot will catch up. Once the capital is exhausted,

population numbers inevitably fall because there are no longer enough resources available to support the number of individuals.
In the case of human populations, there is a large variation in per capita consumption levels between poor and affluent communities, so the basic definition of carrying capacity needs to be qualified and the given level of per capita consumption and waste generation needs to be taken into consideration. The carrying capacity of a given environment is much greater for people living at a subsistence level than it is for people with a typical Western European or North American lifestyle.

Important to note that different geographic regions have a greater or smaller **carrying capacity**. Climate and local geography area both play a crucial part. In some parts of the world, endemic species recover swiftly following a drop in population, whereas in other areas of the world recovery is measured in tens or hundreds of years. Polynesian settlers who crossed the Pacific left behind a landscape which responded well to burning (they used fire to clear land and refresh forest growth) but the lands they settled did not. The decline in tree cover on Easter Island, Hawaii and New Zealand is attributed to a fundamental misunderstanding of the localized conditions by the newly arriving people.

Similarly, the Viking community which settled in Greenland experienced a parallel collapse when they attempted to farm the marginal lands in the same manner they had done with other lands where they settled, but without taking account of local conditions. The lesson is that we cannot assume that any particular agricultural method is sustainable in all circumstances.

Another case where a human community is believed to have exceeded its carrying capacity is that of the Mayans. It appears that population pressure forced them to cultivate more and more marginal land, leading to a reduction of carrying capacity in their ecosystem. The forest land was not amenable to long-term intense cultivation, leading to topsoil erosion on a large scale. This in turn led to conflict between Mayan cities to compete for land which inevitably could not support the rising populations; conflict and gradual collapse of their society ensued.

In a number of other instances where peoples have disappeared, this has been at least in part attributed to their populations exceeding the **carrying capacity** of their local ecosystems. However, where the evidence is archaeological rather than historically documented, it is often difficult to determine with any certainty the extent to which overpopulation rather than other factors such as climate change, conflict, social unrest, etc, was the principal cause of the collapse. The fact that declining welfare of communities can be the result of a combination of factors also means that the symptoms of a population being near to exceeding its carrying capacity are often misread. For example starvation following a poor harvest may be attributed only to the poor harvest rather than the population size.

In ecological tourism and the carry capacity indicator is used to determine the anthropogenic pressure through the maximum number of tourists who can stay in a given territory. According to the methodology adopted by Stankov, G. et al., 1985, the carrying capacity is determined by the formula:

$$P = \frac{S.N}{k}$$

Wherever:

P - Carrying capacity in number of people per day;

S – Area in hectares;

N - Normative area - person per hectare (in protected areas 100per./ha).

The coefficient of carrying capacity also depends on the attractiveness coefficient-**k**. It is determined by score in balls with numbers from 0 to 4. 0- unfavorable ecotourism conditions; 1- a little favorable; 2-on average favorable; 3- favorable; 4- most pleased.

The assessment is made by 5 components - landscape attractiveness, climatic, hydrological, bio-attractiveness and anthropogenic changes and attractiveness and a total of 13 criteria (by Roupetzova, 2004) (Table 1).

Table 2-4: Rating in balls for attractiveness

Point	Coefficient	landscape attractiveness			Climate attractive	Hydro-attractiveness		Bio Attractiveness			Anthropogenic changes and attractiveness			
		A	B	C		D	E	F	G	H	J	K	L	M

Legend: Coefficient of attractiveness: it is formed by the cumulative assessment on the number of indicators; landscape attractiveness: A- rock, B- summit and slopes, C- greenswards; Hydroattractiveness: D - lakes, rivers, beaches, E- karst springs, fountains; Bioattractiveness: F - forest, pastures and meadows, G - herbs, mushrooms, berries , H--hunting, fishing; Anthropogenic changes and attractiveness: J- cultural-historical and religious sites, K- transport accessibility, L - agricultural land, M material-technical base.

Carrying capacity is determined by the formation of a correction coefficient - k, depending on their attractiveness. It has values of 0.6 to 1 and is inversely proportional to the area of the territory and the normative area per person per day -for protected areas -100 persons/ha.

The choice of ecotourism sites consists of discovering the best conservation and nature conservation combinations in the protected areas and is directly dependent on the attractiveness of the site and the sustainability of the landscape and biodiversity

Since the antiquity has began the interaction between man and nature, and with the time it is constantly expanding and deepening. The changes that people have made with the environment they inhabit lead to its root change. This has led to the emergence, development and strengthening of the society as an antipod of the natural environment.

Nowadays, more and more territories and aquatic areas of our planet Earth have changed. After 1900, the world's population entered a new phase of growth, defined by science as "the demographic boom / explosion." This extreme increase in the world's population also leads to the expansion of the interaction with nature, which acquires parameters that threaten the state and the future of the natural environment and its resources. Natural areas are constantly decreasing, resources are exhausted, and the future of our common home Earth is becoming increasingly vague and uncertain.

The scientific community from all over the world unites its efforts in trying to find a solution and an outcome of the situation. Under such conditions, the concept of sustainable development, which we all well know, has been created. Over the years, it has been expandin and enriching, its popularity among the world community is steadily rising. A number of positive results have also been achieved. But this should not calm anyone but motivate every inhabitant on the planet to work for the future of Earth because the unsolved problems are much more than those that have already found the right way to solve them.

The modern man spends an increasing amount of time in the urbanized territories, bearing the consequences of this. In order to survive in the physical and mental sense, he has an increasing need to relax in nature. The desire and need for a more frequent and extended stay in the natural environment is increasing and encompassing more and more people. The steadily growing process of involving more and more people in the system of recreational activities determines a constant expansion of the territories covered to one or another degree of the recreation. With even faster rates is developing the process of intensification of the use of the existing recreation territories, which leads to an increase of the level of the impact of people (tourists) on the natural territories (Neshev, 2008).

In this relation arises the problem of optimization of recreational load of the natural territories, including those with some form of conservation and protection, in order to prevent their degredation and conceiving the comfortable conditions for the recreational activity for the people. The essence of this problem is to justify the ecological burden of natural territories (not exceeding the boundaries of their natural restoration capabilities) by establishing norms for recreational recitation on them (Neshev, 2008).

To the problem of the norms for the recreational load of the natural territories is dedicated an enormous literature. In the world practice for recreational use of the natural territories are observed great differences in the norms. For example, the beach area norm of one recreant in the developed countries is falling from 5 to 15 m2. In the protected territories, used for tourism purposes, the norm of area, which must be for one visitor, varies from 0.5 to 1 hectare (Rayers and Stylemark, 1998).

In Poland the concentration of tourists hesitates from 75 to 115 people per hectare, as the norm for the centers for short-tern camping reaches 200 people per hectare, and for the long-term - 55-70 people per hectare. In the case of the designing of the landscapes for a short-term camp "Pisch", near Bugapesta is adopted a norm of 5 people per hectare in the forest park and of 2 people per hectare in the commercially exploited forest. For the Belgian cost is accepted a norm of 9,3 m2 per visitor. In some countries is accepted as a measure also the ratio between the local population and the number of tourists. Usually it is 1: 1 or 3: 1 (Kostov, 1992).

The differences in the norms for the recreational load of the natural territories are due to the uneven sustainability of these complexes within the different natural conditions. This requires commenting on some terminological isues. Under sustainabilty of the natural and territorial complex (PKK) against the recreational load is understood its ability to oppose this load to a certain limit, above which there is a loss of its ability to recreate itself.

Under recreational load is understood the attendance (the observed amount of tourists in the territory for a determined period) per unit of natural-territorial complex per a unit of time (Neshev, 2008). The load, that causes in the natural complexes irreversible changes, is called critical. A load, that is near the critical, but does not cause irreversible changes, is called acceptable (Neshev, 2008). Recreational carrying abilities, also referred to as carrying capacity of the natural-territorial complex, are usually determined on the basis of the acceplտable load. In the norming of the recreational areas for tourist attractiveness, besides the natural factor, namely the sustainability of the natural complex, account is taken of the psychological factors. It is about the psychological atmosphere that is created by the presence of the tourists in the recreational territory. This issue deals with a special scientific field called "Applied Hodology". The term was proposed in the 1960s in the Netherlands and originates from the word "hodos" - "road" (Reimers and Stylemark, 1998).

The applied hodology determines the psychological barrier over which a person does not feel comfortable in a given natural environment. This science asserts that people are attracted by: the places around the main entrance of the parks, by the waterfalls, by the mountain peaks etc., which are called focus objects; the border areas between two streams (boundary effect) such as, for example between land and water; objects with "island effect" such as for example a forest amoung an open space, or a grass meadow amoung the treas and bushes in the forest. It is these places that create an increased mood in the people ("Reimers" and "Shilmark", 1998). At the same time, there is a traumatic effect from the homogenious environment, such as for example a dense forest or dense bushes. They lower the mood of the visitors. All of these psychological factors are taken into account in the norming of the areas for recreational load.

In Bulgaria norms have been created for recreational territories mainly intended for short-term rest, which in our country lasts for 6 days. The notion of long-term rest isconsidered to be from 7 or more days (Brumarov and Robev, 1994).

The territory of the Municipality of Blagoevgrad in its mountainous part is used precisely for short-term rest. On this basis, we comment on the norms for recreational territories, designed for short-term rest. The presence of a large city like Blagoevgrad with its demographic resources are the main potential and real users. The population restores their mental and physical strength and working capacity in the natural territories situated in the eastern part of the municipality, covering part of the Rila Mountain (Brumarov, 1990).

The magnitude of the norms for recreational load is determined after a careful assessment of the sanitary and hygienic conditions available, the requirements for preservation of the natural environment, the frequency and intensity of the visits of people and their preferences to different places and types of short-term rest, the permissible maximum load on the territory according to its carrying capacity etc.
The actual capacity of one zone for short-term rest is determined by the maximum number of people (tourists) who can spend at the same time on the day of the period with the most intense visit without harming the natural environment and with provided a normal pace of life and rest in the area. According to Iv. Brumbarov and R. Robev (1994), the determination of the capacity of a certain territory for a visit by people (tourists), under our conditions can best be done on the formula proposed by P. Stanev (1976):

$$\mathbf{K} = \frac{\mathbf{S} \cdot \mathbf{K}_0}{\mathbf{N}} \qquad \mathbf{K} = \mathbf{S} \cdot \mathbf{K}_0 \,/\, \mathbf{N}$$

K - maximum capacity of the territory (people);

S - total area of the territory (m 2);

K_0 - a correction coefficient, whose value varies from 0.8 to 1.0 and is determined by the peculiarities of the relief, with engineering, geological, hydrological, landscaping and other considerations;

N - normative area per visitor (m 2 / person)

In Bulgaria, this normative area is defined to be 1200 m 2 / person (Brumarov and Robev, 1994).

In surveys of the areas suitable for short-term rest, even if they are not protected areas, it is necessary to make such an assessment based on the permissible load regulations and according to their primary purpose. For example, for different types of sports, rest and tourism to be determined their maximum carrying capacity. For Bulgaria, such norms have been developed and adopted (Table 2).

Table 2-5. Norms for activities and facilities in the territories fot rest and tourism

Activities and facilities in the territory	**Norms**
A) For a general sizing of the territories	
For the construction of beaches for visitors	8 – 10 m^2
For bathing	8 – 10 m^2/visitor
For walks in the pine forest	1 h/hectare

For walks in mixed forest	2 – 3 h/hectare
Villa zones	250 m^2/v
B) The ratio between the elements of park and forest park areas should be consisted of:	
Landscaped and wooded areas	85 – 90 %
Roads, alleys, paths	2.5 – 4 %
Water areas	5 – 6 %
Facilities	1 – 2 %
C) The required area of the accommodations should be sized according to the following normative criterias:	
Hotels	75 – 100 m^2/v
Motels	100 – 125 m^2/v
Campsites	125 – 150 m^2/v
Tourist bases and huts	60 m^2/v
D) the norms for dining and entertainment establishments as seating places per 1000 people are 100, with the most appropriate structure:	
Establishments for dining and entertainment	20 %
Establishments for addtitional dining	40 %
Establishments for mass meal	40 %
E) for the trade network the norm is 200 m^2 area per 1000 people:	
Stationary trade network	40% (30% for food, 10% for industrial goods)
Non-permanent trade network	30% (20% for food , 10% for industrial goods)
Mobile trade network	15%
Automats	15%
F) **For the sizing of sports and tourist facilities and cultural and entertainment establishments:**	
Sports and touristic facilities	In rest areas with more than 200 people
Cultural and entertainment establishments	In rest areas with more than 1000 people
Kids and universal playgrounds	Every 200 visitors
Sport complexes	In rest areas with capacity over 400 people

Source: (Brambarov, I., R. Robev, 1994)

It should be considered that the application of these norms mainly in the design of the structure of the rest area helps to a great extent to avoid the negative consequences of the presence and stay of people (tourists) in the natural areas. It is known that at a later stage during the operation of the constructed base and facilities, these norms are often violated due to the business interests of the owners. Approved good practices suggest that it is advisable to develop these norms for a particular recreational territory, according to the sustainability of its natural-territorial complexes (Fizizov, 2007; Zhechev and Stoilov, 1999).

The limiting recreational loads are determined on the basis of complex calculations, differentiated allowable load scales for long-term and short-term rest, taking into account the time factor and the accumulation of changes in biogeocenoses, geobotanic correlations etc.

In many countries, similar norms for the maximum allowable load on recreational territories are also applied in practice. For example, in Lithuania in the area of the "Kurshska koca" protected area, it is permissible to have no more than 3000 tourists. Passes for the attraction are issued by the town municipality of the neighboring town Nering.For the largest national park in the country with an area of 300 000 hectares has been set up a norm for visit of 4000-5000 people a day. The compliance of the norm is controlled by public autority for conservation of the Lithuanian environment. In the US Yellowstone park was designed a plan for reducing the excessive influx of visitors in order to stop the future destruction of the nature. Some restaurants and hotes in the area are removed and are bulit five big touristics centers outside its borders, near the entrancing roads. In them everyone can stay overnight, eat, and receive some information. From these centers the visitors are heading to the inside of the park with the park vehicles (Lavery, 1974).

Regardless of the achieved positive results from the introduction of the norms for recreational load, among the specialists there is no single positive opinion on the issue. The critical considerations according to J. Kringöff are down to the following:

- there are no general operational norms for the full determination of the capacity of the territories, visited by tourists;
- the methods that have been used until now are related to numbers affecting the territory, i.e. the physical capacity;
- all land standarts are not sufficiently empirically checked, therefore they can be used as guides;
- the use of numberscreates an impresion for "scientific accuracy", but still the subjectivism prevailes;
- under the previous criteria it is supposed a uniform distribution of the use of the territories, but in practise this is not true. There are always places with higher concentration, i.e. preferred by the people to a greater extent (citation by Dasmann, 1999).

2.2.6. The concept of carrying capacity in Agriculture

Carrying capacity (CC) in the context of Indian agriculture denotes the number of people and livestock an area can support on a sustainable basis. CC is dynamic in nature, varying from time to time based on utilization of resources, technology application and management. In India, rainfed agriculture occupies nearly 58% of the cultivated area, contributes 40% of country's food production, and supports 40% of the human and 60% of the livestock population. The food grains production has increased several folds in the last four decades. During the last decade (TE 1998–99 to TE 2008–09) the production in coarse cereals, oilseeds and pulses increased by 20 %, 16 % and 3 % respectively, primarily due to the yield gains. There is a need to further increase food production substantially for meeting the requirements of the ever-increasing population. This will put tremendous strain on natural resources which are already under stress due to unsustainable utilization. Continuous decline in groundwater levels, growing deficiency of major and micronutrients, declining factor productivity and looming threat of climate change are some of the issues which will have a bearing on food production in the near future. However, the large realizable yield gaps in many rainfed crops, opportunities to increase yields through rainwater harvesting and recycling, soil fertility improvement, crop diversification and effective dissemination of technologies give a hope that future requirements of food can be met, but it requires substantial resources. This article discusses issues constraining rainfed crop production and possible ways to enhance productivity in a sustainable manner – (Venkateswarlu, Prasad 2012).

The carrying capacity of Indian agriculture to support oilseeds production to meet the vegetable oil needs of the Indian population has been considered in the context of available sources of oil from oilseed and nonoilseed origins. India needs to produce 17.84 Mt of vegetable oils to meet the nutritional fat needs of projected population of 1685 million by 2050. This can be easily achieved from various sources like annual oilseeds and also from supplementary sources of oil like rice bran, cottonseed, coconut, oil palm, corn, etc. However, the actual vegetable oil consumption has already exceeded the nutritional needs by a large margin and is likely to further go up sharply in the years to come in response to income growth. This requirement will be difficult to meet by the Indian agriculture given the current status of resources, technology and management – (Hegde, 2012).

Growing population and rise in income level will lead to increase in demand of high-value agriculture (HVA) produce that includes fruits, vegetables, meat, eggs, milk, fish and value-added food products. The annual growth rate in domestic demands for fruits and vegetables is estimated at 3.34% and 3.03% respectively. The required growth rates to meet projected demands in the horticulture sub-sector for 2050 may be lower than the growth already achieved during 1998–99 to 2006–07. Economic considerations could lead to diversification of cereal land to high value crops like horticultural crops, as in the southern parts of the country, where cultivation of spices generates more income than food crops for the farmers. This is not likely to happen in the northern states of Punjab, Haryana and Uttar Pradesh that contribute to the food security as buffer stocks of wheat and rice in reserve. Expected climatic changes may increase the overall productivity of coconut in the coastal areas, except in the northern parts. Cultivation of temperate fruits like apples may move to further – (Ghosh, 2012).

Carrying capacity of Indian agriculture: pulse crops – (Masood, Gupta, 2012).
India is the largest producer, consumer, importer and processor of pulses in the world. Ironically, the country's pulse production has been hovering around 14–15 Mt, coming from a near-stagnated area of 22–23 M ha, since 1990–91. For meeting the demand of the growing population, the country is importing pulses to the tune of 2.5–3.5 Mt every year. Strong upward trend in the import of pulses is a cause of concern, since an increase in demand from India has shown to have cascading effect on international prices, thus draining the precious foreign exchange. By 2050, the domestic requirements would be 26.50 Mt, necessitating stepping up production by 81.50%, i.e. 11.9 Mt additional produce at 1.86% annual growth rate. This uphill task has to be accomplished under more severe production constraints, especially abiotic stresses, abrupt climatic changes, emergence of new species/strains of insect-pests and diseases, and increasing deficiency of secondary and micronutrients in the soil. This requires a two-pronged proactive strategy, i.e. improving per unit productivity and reducing cost of production. This article describes the present availability of pulses, demand projections in different timeframes, future challenges, and technology drivers for increasing pulse production in the country. A scheme has also been suggested for achieving self-sufficiency in pulses by 2050.

An FAO-sponsored Expert Workshop on Site Selection and Carrying Capacities for Inland and Coastal Aquaculture was held at the Institute of Aquaculture, University of Stirling, the United Kingdom of Great Britain and Northern Ireland – (Ross, L.G., Telfer, T.C., Falconer, L., Soto, D. & Aguilar-Manjarrez, J., eds. 2013).

Seven global reviews and ten regional reviews on site selection and carrying capacity encompassing inland aquaculture and coastal aquaculture were presented and discussed at the workshop. Supplementary inputs were provided by the experts who were unable to attend the workshop for the reviews on "Environmental Impact, Site Selection and Carrying Capacity Estimation for Small-scale Aquaculture in Asia" and "Guidelines for Aquaculture Site Selection and Carrying Capacity for Inland and Coastal Aquaculture in Mid- and Northern Europe".

Definitions of carrying capacity appropriate for different types of ecosystems were discussed and agreed based upon four categories: physical, production, ecological and social. The range and capability of modelling tools, including spatial tools, available for addressing these capacities were discussed. The prioritization and sequence for addressing site selection and the different categories of carrying capacity were considered in detail in terms of both regional or national priorities and site-specific considerations.

Carrying capacity is an important concept for ecosystem-based management, which helps set the upper limits of aquaculture production given the environmental limits and social acceptability of aquaculture, thus avoiding "unacceptable change" to both the natural ecosystem and the social functions and structures. In general terms, carrying capacity for any sector can be defined as the level of resource use both by humans or animals that can be sustained over the long term by the natural regenerative power of the environment. This is complementary to assimilative capacity, which is defined as "the ability of an area to maintain a healthy environment and accommodate wastes" (Fernandes et al., 2001), and to environmental capacity, which is defined as "the ability of the environment to accommodate a particular activity or rate of activity without unacceptable impact" (GESAMP, 1986). In addition to the above, Davies and McLeod (2003) defined carrying capacity as "the potential maximum production a species or population can maintain in relation to available food resources". Assessment of carrying capacity is one of the most important tools for technical assessment of not only the environmental sustainability of agricultural systems as it is not limited to farm or population sizes issues, but it can also be applied at ecosystem, watershed and global scales. Although these general views of carrying capacity for agricultural systems are based solely on production, they have been developed further into a more comprehensive four-category approach based on physical, production, ecological and social carrying capacity (Inglis, Hayden and Ross, 2000; McKindsey et al., 2006).

- ✓ *Physical carrying capacity* is based on the suitability for development of a given activity, taking into account the physical factors of the environment and the farming system. In its simplest form, it determines development potential in any location, but is not normally designed to evaluate that against regulations or limitations of any kind. In this context, this can also be considered as identification of sites or potential agricultural zones from which a subsequent more specific site selection can be made for actual development.
- ✓ This capacity considers the entire waterbody, or waterbodies, and identifies the total area suitable for aquaculture. Inglis, Hayden and Ross (2000) and McKindsey *et al.* (2006) note that physical carrying capacity does not indicate at what density cultured organisms are stocked or their production biomass. Physical carrying capacity is useful to quantify potential adequate and available areas for aquaculture in the ecosystem, but it offers little information on aquaculture's limits at the waterbody or watershed level within the EAA. In terrestrial aquaculture, it can define the capacity of the area for the construction of ponds or the availability of water supply.
- ✓ *Production carrying capacity* estimates the maximum agricultural systems production and is typically considered at the farm scale. For the culture of bivalves, this is the stocking density at which harvests are maximized. However, production biomass calculated at production carrying capacity could be restricted to smaller areas within a water basin so that the total production biomass of the water basin does not exceed that of the ecological carrying capacity, for example, fish cage culture in a lake.

- ✓ Estimates of this capacity are dependent upon the technology, production system and the investment required, with investment being defined by Gibbs (2009) as an "economic" capacity, being the biomass at a particular location for which investment can be secured.
- ✓ *Ecological carrying capacity* is defined as the magnitude of agricultural systems production that can be supported without leading to significant changes to ecological processes, services, species, populations or communities in the environment.
- ✓ *Social carrying capacity* has been defined as the amount of agricultural systems that can be developed without adverse social impacts. Byron *et al.* (2011) have stated that the ultimate goal of determinations of social carrying capacity is to quantify the value of the involvement of stakeholders in a science-based effort to determine the proper limits to aquaculture in their local waters. Ecological degradation or adverse changes to ecosystems attributed to aquaculture may inhibit social uses. According to Byron *et al.* (2011), the point at which alternative social uses become prohibitive due to the level, density or placement of aquaculture farms is the social carrying capacity of aquaculture. Angel and Freeman (2009) refer to social carrying capacity as the concept reflecting the trade-offs among all stakeholders using common property resources and as the most difficult to quantify, but as the most critical from the management perspective. For example, if there is widespread opposition to agricultural systems in a particular place, the prospects for its expansion will be limited.

According to Little *et al*. (2012), aquaculture has the potential to exert significant social and economic impacts through upstream and downstream links around the use of water, seed, feed, chemicals, wastes expelled, etc. This incorporates a broad section of people as stakeholders. Similarly, employment along the value chains, both upstream and downstream, brings benefits to many people not directly involved in farming. Such implications can make the setting of boundaries for the estimation of social carrying capacity very challenging.

The ecosystem approach to agricultural systems as a framework for carrying capacity

FAO proposed an ecosystem approach to aquaculture (EAA) and agricultural systems, defined as a strategy for the integration of aquaculture within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems - (Soto, Aguilar-Manjarrez and Hishamunda, 2008; FAO, 2010). The strategy is guided by three key principles, namely:

- ✓ Principle 1: Aquaculture development and management should take account of the full range of ecosystem functions and services and should not threaten the sustained delivery of these to society.
- ✓ Principle 2: Agricultural systems should improve human well-being and equity for all relevant stakeholders.
- ✓ Principle 3: Agricultural systems should be developed in the context of other sectors, policies and goals.

The application of the EAA at different geographical scales requires the harmonization of three objectives that comply with the EAA principles: (i) environmental; (ii) socio-economic; and (iii) governance, including multisectoral planning (FAO, 2010). These three objectives and their relative weights can differ among countries and across world regions, making it challenging to define a single standard for uniform compliance with respect to limits and thresholds.

The four carrying capacity categories as defined by McKindsey et al. (2006) can be weighted according to region and aquaculture system. Thus, the three core objectives of EAA can be mapped onto the four categories of carrying capacity and illustrated as the overlap of these (Fig. 1). The social category covers the socio-economic and governance objectives of the EAA as indicated above. The importance (size) of each circle represented will vary regionally or with culture system and will develop through time based on the feedback society provides. However, the need for harmonization of the three EAA objectives for the long-term sustainability of agricultural systems must be kept in mind.

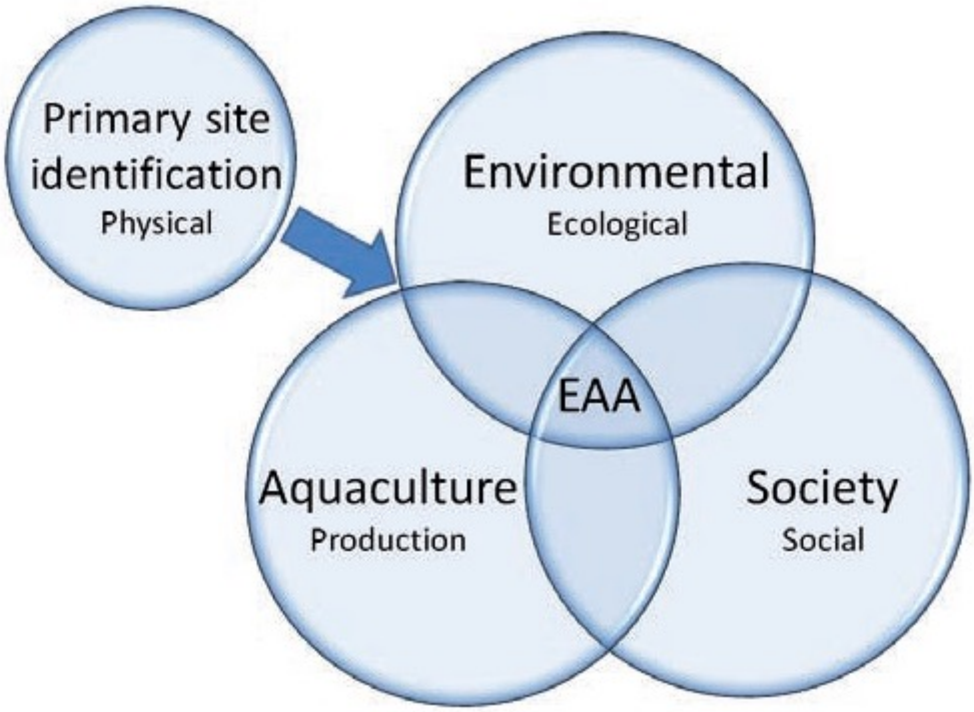


Fig. 2-1. Interaction of different categories of site identification and carrying capacity to arrive an ecosystems approach to agricultural systems and aquaculture. After primary site identification the process can pass to any or all of the tree other areas.
The same figure is obtained, if we replace the production from aquaculture with agriculture production.

Spatial modelling for site selection and carrying capacity

The deployment of spatial planning tools for analysis, decision-making, modelling and data management is an essential element for the implementation of the EAA. Spatial analysis enables definition of boundaries relevant to carrying capacities, enhancement of existing ecosystem data by incorporation of data specific to the needs of aquaculture, and integration and analysis of the environmental, administrative, social and economic components of the ecosystem. Defining ecosystems and production systems spatially is essential to the EAA to raise the awareness of aquaculture planners and practitioners to issues that must be taken into account for the further development of aquaculture and for the mitigation of the potential impacts of aquaculture on the environment.

Geographic information systems are spatial modelling frameworks designed for use at different scales, as they can provide both general and site-specific information and investigate issues at both local and waterbody or watershed scale (Silvert and Cromey, 2001). GIS is particularly useful as an environmental management tool because the system organizes, analyses and presents geographical data in a useful and efficient manner using standard data formats. In terms of aquaculture development, the advantage of GIS is that the impact from several farms could be analysed on a larger scale (aquaculture zone, waterbody), as well as taking into account inputs from other sources; therefore, the results are truly representative of the activities taking place in the area and the subsequent environmental conditions.

Spatial models can also be used together with other models as part of an overall process to provide decision support for site selection and assessment of carrying capacity. This was highlighted in the Sustainable Options for People, Catchment and Aquatic Resources (SPEAR) project (Ferreira et al., 2008b), which aimed to provide guidance to aquaculture administrators on sustainable carrying capacity in two areas in the People’s Republic of China. Multiple models were used at different scales to assess the key processes and interactions between the main issues relevant to carrying capacity, including economical, environmental and management strategies. GIS was used throughout the project to provide the geographic context for key variables used in modelling, as a platform for communication between different model components, in verification, and for visualization and spatial analyses of model results.

It is important to acknowledge that spatial models are not solely used by scientists and others with technological backgrounds. They can have an important practical influence on day-to-day business operations, such as aquaculture and agriculture, where the majority of stakeholders, farmers and producers do not have sufficient mathematical or scientific backgrounds to understand the modelling complexities. Fortunately, GIS can be used to simplify the process, and web-based spatial systems are becoming more prevalent. Internet map servers and Web-based programmes are becoming more popular because they are an efficient way to share models and a valuable platform to test models with stakeholder participation.

The protected areas of NATURA 2000 are presented on Fig. 2 – (http://natura2000.moew.government.bg). The protected areas of NATURA 2000 are 7609.034 ha, or 27.45 % of the catchment of the Blagoevgrad Bistritsa territory – Fig. 2.

The protected areas of NATURA 2000 fall into RILA National Park (Rila National Park Management Plan 2015-2024) in the northern and eastern part of the catchment of the Blagoevgrad Bistritsa River. The protected areas of NATURA 2000 are 7609.034 ha, or 27.45 % of the catchment of the Blagoevgrad Bistritsa territory.

Protected areas NATURA 2000

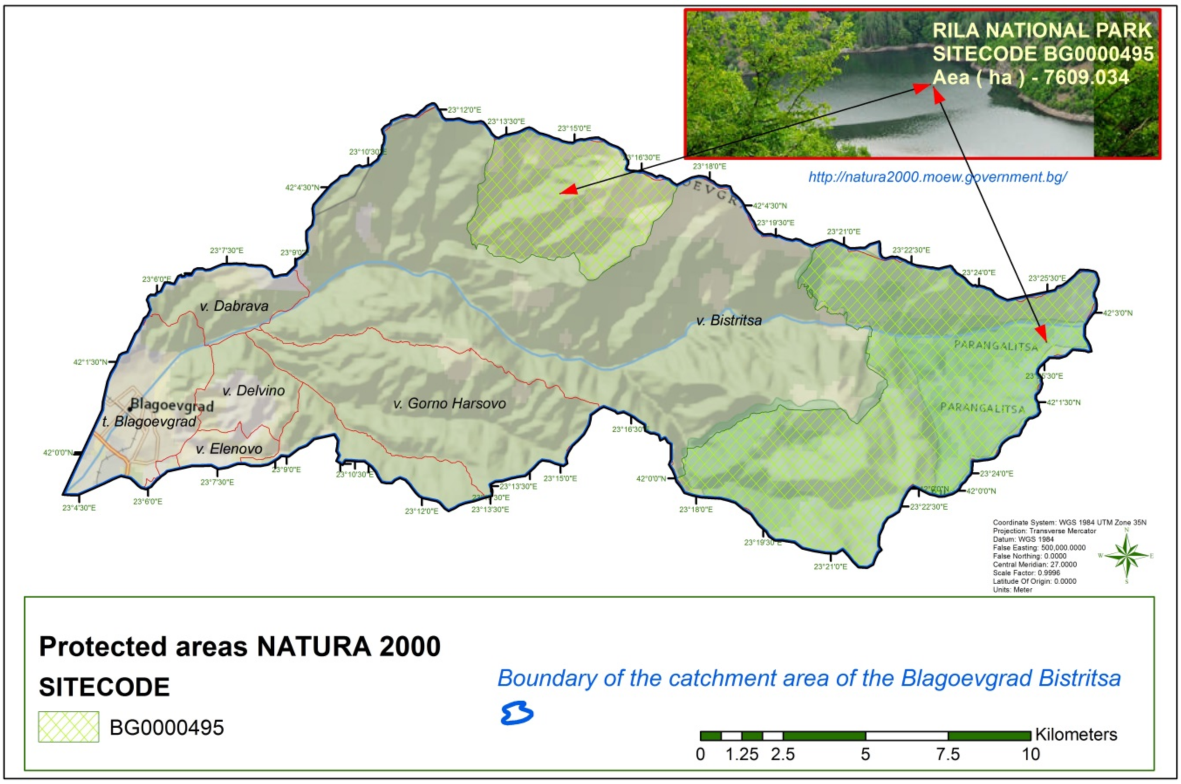


Figure 2-2. Protected areas of NATURA 2000 in the catchment of the Blagoevgrad Bistritsa.

2.2.7. The concept of carrying capacity in forestry

Carrying capacity of forests

The permissible use of biological species by humans is related to the distinguishing of two concepts in ecological studies: carrying capacity and population equilibrium. They in inverse dependence and the increase or decrease of one leads to the opposite effect in the other. Defining the carrying capacity as the environment's maximum load, the paradox will not arise (Hui, C., 2006). By defining the environment's maximum load (or perhaps more correctly "environment's maximal acceptable load") for certain populations within the ecosystem, the maximum permissible load of the species can be used as a regulating factor for the development of their population. By calculation of this environment's maximum load the main goal should be aimed at ensuring the development of the population infinitely. Today, the preservation and evolution of biodiversity acts as a corrective to the extent of the environment's maximum load of the ecosystems, which is still only a theoretical model. In order to apply this corrective, a wide range of complex analyzes, performed over an extended period of time, are required (Groom et al., 2006).

The carrying capacity of the tree aggregates in forest ecosystems can be determined as the maximum amount of biomass that can be taken away from a plantation once in a certain period of time and this not to prevent the ability of the ecosystem to maintain itself indefinitely.

In this case, the main economic activity in the forestry sector of the area concerned is wood extraction. The quantity of the removed wood mass (biomass) is obtained by cutting part of the trees and exportation part of the wood out of the forest's territory. The result is the regulation of the density of tree populations in forest ecosystems by number, volume and species diversity to levels that should ensure their development indefinitely over time. It is necessary to clarify that influence on population equilibrium. Building a forest road network, the usage of large-scale forestry machinery for logging and timber transportation and reducing the density of trees for the extraction of fallen trees additionally reduces the density of tree populations. This should be taken into account when determining the carrying capacity of the forest.

Research on modern foreign surveys for calculating the carrying capacity of forests.

Studies on the carrying capacity of forests are extremely diverse, but to a lesser extent complex. This is due to the exceptional diversity of forest ecosystems in regard to: species, geographic conditions, anthropogenic influence, etcand the existence of a tremendous combination of interrelations in ecosystems that are always complex. Surveys always cover a local geographic area with specific geographic features, specific forest ecosystems with specific tree species, forest ecosystems of different conservation status and economic importance and other differentiating factors. The majority of them are directed towards the acceptable tourist or recreational maximum capacity and the permissible load on animal species hunted.

Part of the studies on the permissible forest load for the harvesting of wood materials cover territories from other biogeographical regions and even other biogeographical kingdoms and biomes (KEITH et al., 2010; Mashayekhan et al., 2014; Luna et al., 2009 and others), different than the subject of this study. This limits the possibility of their application in the surveyed territory.

During the research on foreign studies on the carrying capacity of the forests were ascertained studies concerning forest ecosystems with similar geographic characteristics, economic and ecological significance. Their research objectives differ, but complement, obtaining methodological solutions to increase the carrying capacity of forest ecosystems through human participation. This can be achieved in both aspects of forest management – increase their productivity and sustainable use during the extraction of forest products. Two studies are of interest for this research.

The first study is focused on maximizing the carrying capacity of forest ecosystems through modelling and formation of the most productive stands by the authors Kairiukstis and Juodvalkis (Kairiukstis et al., 1986). The core of this study is focused on the extremely important activity in growing young forests and thus to the creation of mature plants with higher quantitative and qualitative indicators. Activity that takes place in a limited volume in forests, which are subject to economic activity, in the catchment area of Blagoevgrad Bistritsa River. On the basis of more than 30 years of research in more than 400 experimental sections, the authors offer new methods for maintaining the optimal density of young plantations turning them into mature forest with maximum productivity. Different optimal density of plantations has been identified at the different stages of their development. An increase in productivity of 15-20% has been achieved.

In this way, a double effect on the increase of the carrying capacity on forest ecosystems is obtained. On the one hand, through intermediate cutting during the growing of young plantations, wood materials are harvested. They can be used by the local population or for economic purposes. On the other hand, as a result of this activity, the formation of mature forests with higher economic and ecological capacity is achieved. This allows higher yields of quality wood material.

Bulgarian legislation ensures the development of forest management plans (forest management projects) for each territory by declaring them obligatory. The means of thinning (the selective removal of trees) or intermediate cutting are a priority in the planning of forest management activities in them and are based on good scientific methodology. In practice, however, the cultivation of young plantations is largely underestimated in Bulgaria and in particular in the forests of Blagoevgrad Bistritsa River. Reasons for this are: low economic efficiency, disinterest because of prevailing state ownership, difficult terrain, etc. Nevertheless, they are a great untapped potential to meet the needs of wood materials and achieving **sustainable use** of forest resources in the catchment area of Blagoevgrad Bistritsa River.

The **second** study focuses on environmental sustainability of bio-energy production (Martirea et al., 2014). The study propose a GIS-based decision support system (DSS) and methodology for calculating the biomass availability while supporting the local resource planning. In fact, applying the DSS, it is possible to calculate three indicators: operational carrying capacity (OCC), chip potential (CP) and technical potential (TP). Two case studies on alpine mountain areas are presented and discussed in light of contributing to face the challenge of energy planning at local scale.

Firewood can be a decisive source of energy on a local scale. Surveys on their sustainable use through yield from forest ecosystems are of great importance to the local population. In the aforementioned study an extended assessment on the carrying capacity is made, taking into account a wide range of characteristics, specific to the certain oibject. Within the study are bound: the amount of available wood in forests according to local plans, the average annual growth of wood, the total available biomass and the current consumption by the local population.

A contribution of the study is the definition of the term "operational carrying capacity" (OCC) and its content for particular forest plantations. By calculating it, it is possible to determine the amount of wood mass (biomass) that can be collected annually, without affecting the regeneration capabilities of the forest and its ecological functions. The approach is specific for the different tree species. A valuable corrective is the limitation of the degree of use by taking into account the different functions of the forests – water supplying, protective, productive, recreational etc. The usage of this approach **unifies** forestry activities, and it could also be applicable in protected areas, without affecting negatively their environmental status and evolutionary perspectives. It would be of great importance for Bulgaria where there are significant protected areas with a ban on forestry activities.

The idea of dynamic calculation of chip potential (CP) of the forest is innovative. The possibility of **changing the ratio** between the quantities of timber produced and the extracted firewood, specifically for each year, depending on the needs of the local population, is extremely valuable. In forest management plans (forest management projects) for forest governance in Bulgaria, as a fundamental principle is enshrined the economic efficiency of the yielding of the more expensive construction timber at the expense of the firewood extraction. In many cases, this is detrimental to the local population.

The authors report difficulties in applying the developed decision support system in the area under consideration due to the lack of data on how each forest area is managed. The reason for this is the wide variety of property types and a large number of owners. The situation in Bulgaria is different, where ownership is primarily state-owned and the forests are well-organized. The same applies to forests in the catchment area of Blagoevgrad Bistritsa river. This means that it is applicable for our forests.

The correct direction for determining the levels of carrying capacity on different types of forests is reducing the total load of forests through different types of felling. In this way a higher density of forest populations is achieved, which is one factor for increasing the effectiveness of forest ecosystems for fixing and reducing the carbon dioxide content in the atmosphere (Yingchun et al., 2012).

Understanding the extremely complex nature of interactions in forest ecosystems, most scientists are confined to studying forest processes through the methodology of traditional forestry disciplines, such as forest development, forest measurement, forest crops, forest mechanization and others. In many cases they are not aimed at determining the carrying capacity, but are aimed at increasing the economic efficiency of forestry activities. These researches are reviewed in the next section of this study.

Methods of determination of the carrying capacity of forests in Bulgaria for achievement of sustainable use. Oportunities for implementation of new methods

The research on the contemporary foreign studies for calculation the carrying capacity of forest ecosystems done so far, showed a limited number of studies in general and even less for forest types characteristic for the catchment area of Blagoevgrad Bistritsa river and National Park Rila. The reason for this is the difficult disclosure of complex interrelations in the ecosystem and the long observation period required to establish them. Silviculture continues to be **the only compromise alternative** for planning activities in forests which could maintain them in high capacity and good perspective.

Silviculture in Bulgaria (Dakov, M., Vl. Vlasev, 1979) has a long history (over 120 years) and its forests are among the best organized in the world. A full division of forests has been achieved, including their hierarchical division from the largest spatial units (forestry sections) to the smallest (plantations). This is the result of an understanding of their enormous role and the long-term legislative policy of protection and prevention of all types of forests - protected and of economic importance. This also applies to the forests in the catchment area of Blagoevgrad Bistritsa river and Rila National Park. This long period and the continuous research on development of forests during it, provide a good theoretical and practical basis for forest management.

As a complex discipline, forest management is based on the achievements of many other major disciplines exploring forests, such as: forest planning (Bogdanov, 1981); forest measurement (Mihov, 2005); forest pedology (Zhelyazkov and Ivanov, 1987); dendrology (Stefanov and Ganchev, 1958); selective forest management (Rafailov, 2003); forest crops (Koemdzhieva and Buzov, 2004) and others. Of course, as mentioned in the previous section, forestry still **does not fully meet** today's understanding of forests carrying capacity. But due to the use of a complex approach in their management only it can guarantee results, close to the expected sustainable use of forest ecosystems indefinitely.

2.2.8. The concept of carrying capacity in transport sector

The concept of carrying capacity in transport sector can be used in two directions first as a mechanism for urban planning and second as a instrument for modeling the amount of visitors in the national parks. In environmental researches, carrying capacity is the ability of the environment to support all members of the ecosystem. Analogically, in transportation, carrying capacity is the ability of the whole transport system to accommodate trip volume at the level in which a reasonable level of service is maintained. Since we understand that land use development implies additional trip volume, then it should be stopped at the level in which its implication on transport system start to threat the reasonable level of service. (e.g. by using VCR/volume to capacity ratio criteria).

According Warpani (2002) transport level of service is the reflection of volume to capacity ratio and Solving the problems that comes from an imbalance proportion between volume and capacity can be solved in following ways:

1. Adding supply capacity by building new roads or widening existing roads. This method may not be carried out continuously since there is certainly limitations of the space for road widening as well as economic-social-cultural problems.
2. Reducing the volume of traffic by reducing the number of vehicles through land use management, public transport provision, etc.
3. Combining the first and the second method through traffic management.

By implementing this three-way analysis can be build an analytical model of using the transport carrying capacity as the basis for urban land use development control. Land use development and the control of the transport carrying capacity can also be approached by supply and demand management. According to Massachusetts Highway Department (2016) and Setiawan (2016), traffic management is a process of setting on supply and demand in existing road system for specific purpose without adding new infrastructure, through the reduction and regulation of traffic movement. From that definition, it is clear that traffic management is done by optimizing the supply and controlling the demand (Putranto, 2008).
Based on this Miharja et al. (2017) developed a model for urban lend use development based on transport carrying capacity concept as a function of demand and supply fig. 3

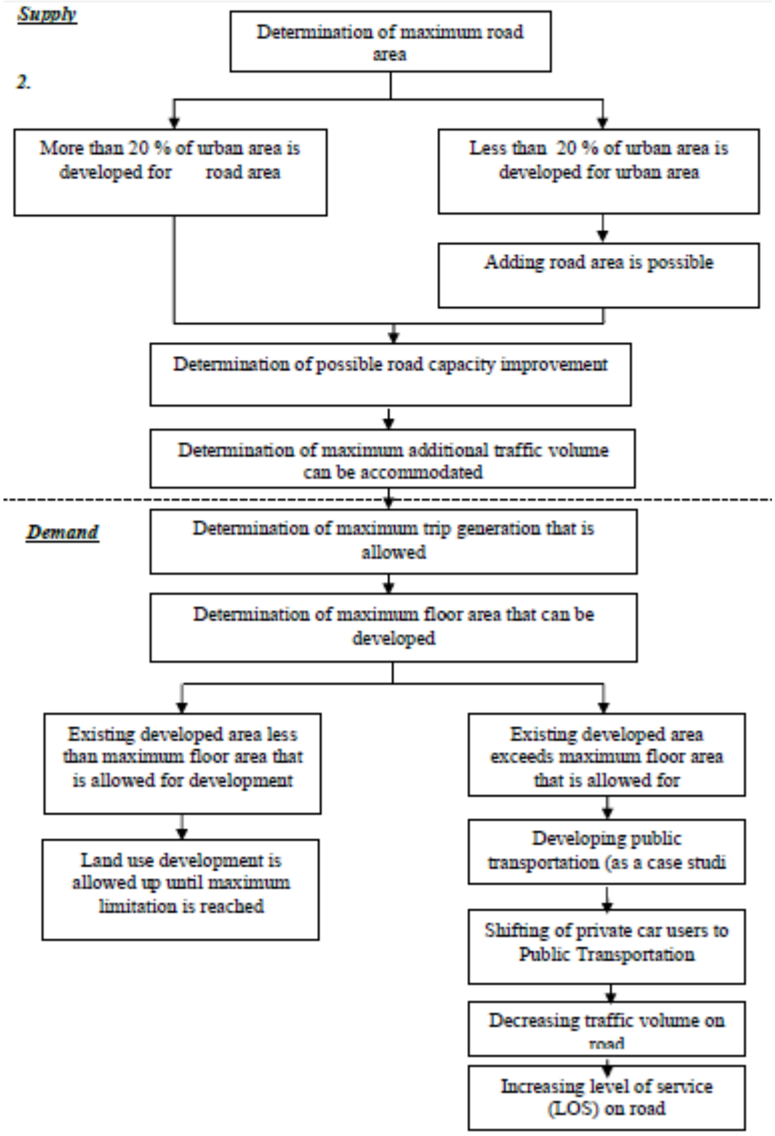


Fig. 2-3. Analysis of transport carrying capacity for urban development control (Miharja et al. (2017)

According Miharja et al. (2017) Urban land use development control based on transport carrying capacity is very crucial to assure that urban physical development would not imply a severe transportation problem.

The concept of transport carrying capacity and management of protected areas

National parks are charged with the dual and conflicting missions of providing public access while protecting park's natural resources. When visiting demand is high, fulfillment of this two conflicting missions can be vary difficult. Example of such conflict situation is Yosemite National Park, which receiving over four million visits per year. According Manning et al. (2003); Lawso et al. (2009); NPS (2012) the majority of the visitors are concentrated at iconic attraction sites, as for example up to 15,000 visitors occupying the narrow and confined Yosemite Valley each day.

Manning (2007) suggest that the inherent tension between public access to parks and protection of resource and experiential quality can be discussed in terms of carrying capacity. Originating in the study of biological habitat and range management, carrying capacity's applicability to parks and outdoor recreation has been widely recognized and investigated (Wagar 1964; Whittaker et al. 2011). Carrying capacities can be understood as the amounts and types of visitor use that can be sustained without unacceptable impacts to park resources or the quality of recreation experiences (Grafe et al. 2011; Whittaker et al. 2011). In fact, examination of the recreational carrying capacity is a strategic management decision that have to be made by parks government authorities and based on scientific researches and public discutions.

Transportation and recreation

According Daigle (2008); Hallo and Manning (2009); Pettengill et al. (2012) transportation and recreation are directly linked in many national parks. This is particularly true for parks where much of the visitor use is concentrated along roads, trails, and public transit routes. For example, the spatial and temporal distribution of visitor use in Yosemite is largely a function of the transportation system (Manning et al. 2003; Youngs et al. 2008; Lawson etal. 2009). The extent of road and trail networks, vehicle parking lots, and location of transit routes are the main factors of where and how much visitor use can occurs throughout the park. The dependence of the visitors on transportation can be an additional challenge for management, because the visitors are concentrated within relatively small areas of the park. However, the influence transportation exerts on visitor use also provides powerful leverage for carrying capacity management. If the connections between transportation system performance and the quality of recreation experiences can be understood, transportation can be used as a tool to manage visitor use, maintaining high experiential quality and mitigating some of the challenges of carrying capacity (Lawson et al. 2009; Lawson et al. 2011). These connections are reflected in the Integrated Transportation and Capacity Assessment (ITCA) conceptual models.

Modeling transportation and the park experience

Recreation experiences in popular recreation sites easily accessible by road network, typically follow a pattern of arrival, distribution, and destination. Visitors arrive at recreation sites, via road and trail networks. Upon arrival, perhaps by disembarking from a parked car or alighting from a shuttle bus, visitors distribute themselves throughout recreation sites. They walk paths and negotiate routes to explore rocks and rivers, search for photogenic views, and engage with interpretive installations. While such distribution and activity is part of their recreation experience, visitors are often destined for focal attractions or other essential features within recreation sites. Such destinations can include viewing platforms adjacent to natural features, beaches and swimming holes along rivers, and quintessential trails. This pattern of arrival, distribution, and destination can be broadly interpreted to represent many types of park visits and distills key elements of the park's complex use systems. Indicators of quality, such as the number of hikers encountered along trails or the number of other visitors sharing a viewing platform, capture and express important qualities of the visitor experience at these destinations (Manning 2011). Standards of quality, identified by park managers and informed by visitors, evaluate the acceptability of indicator variable conditions (Manning 2011). Coupling the progression of arrival, distribution, and destination with indicators and standards of quality, levels of visitor use flowing from the transportation system to recreation destinations can be systematically quantified, modeled, and evaluated.

Modeling arrival, distribution, destination at Yosemite national park

Reigner et al. (2012) presented a model for managing the number if visitors in Yosemite national park based on modeling the arrival and distribution of the visitors in different destinations at Yosemite national park. According Reigner et al. (2012) visitors arrive at recreation sites within Yosemite via the park's transportation system. This system includes the modes by which visitors enter and move among locations within the park. Thus, the delivery of visitors by the transportation system is a key determinant of use levels and experiential quality at recreation sites (Lawson et al. 2009; Lawson et al 2011). The arrival of visitors from the transportation system initiates this study's conceptual modeling and is its analytical origin (Figure 4). Reigner et al. (2012) suggest that the arriving visitors have to be counted as they entered recreation sites as the counts are divided by increments of time - by weekday and weekend/holiday and hour of the day. With these divisions, the arrival counts generate both the volume and temporal distribution of visitor use at recreation sites. Using regression models Reigner et al. (2012), related the recreation site arrival patterns to transportation system use and performance. In the model of Reigner et al. (2012), entrances to the park and vehicular use on road sections such as Southside Drive in Yosemite Valley were used as independent variables to estimate the amount of visitor use any particular site received. This statistical connection is a primary point of the integration between transportation and recreation experience quality. According Reigner et al. (2012) after arriving, visitors distribute themselves throughout recreation sites and to destinations. The experiential conditions induced by these distributions, such as the numbers of hikers on trails or the numbers of visitors on viewing platforms, were modeled with computer simulations. A simulation model was built for each recreation site. Using the rate of visitor arrivals, and observations of visitor routing and travel speed collected on-site, the simulations replicate where visitors go and how long they spend there. Beginning with transportation system arrivals, the simulations distribute visitors and estimate the levels of visitor use that can be expected within the sites. These estimates document the numbers of visitors present at destinations such as viewing platforms and beaches, and along trails.

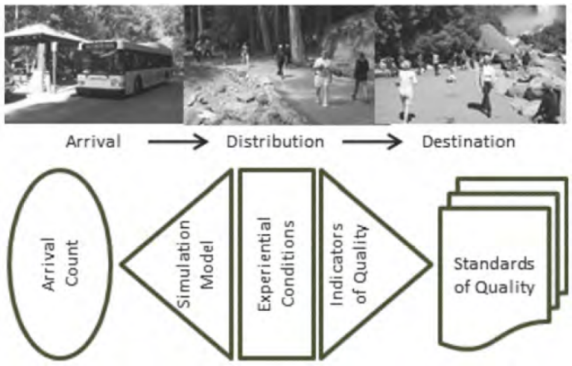


Fig. 2-4 Conceptual and methodological models integrating transportation and recreation.

2.2.9. The concept of carrying capacity in industrial sector

The concept of carrying capacity is rooted in demography, biology, and applied ecology (Clarke et al, 2002). In ecology, carrying capacity is defined as the maximum population of a species that a habitat can support without permanently impairing the habitat's productivity (Rees, 1997). Carrying capacity is an indicator of regional sustainability, and achieving regional sustainability is important because social institutions and ecological functions are closely linked at this scale (Graymore, 2009). The concept of a sustainable carrying capacity is defined by a regional ecosystem's characteristics based on two premises. First, it must be possible to sustain the regional ecosystem's normal operations. Therefore, researchers must calculate the quantity of resources and environmental capacity required to sustain these functions. Second, it is necessary to evaluate the regional population and intensity of activities that the natural resources can support after considering the needs of the ecosystem. This approach prioritizes the health of the regional ecosystem and potentially avoids defects related to overcomplicated calculations due to the more limited scope of the analysis (Kang et al. 2012).

Research on contemporary foreign surveys for calculating the carrying capacity of industrial areas.

Industrialization can also result in serious environmental and water pollution, especially in the region encompassed by industrial parks. Additionally, water resources are limited, so the water carrying capacity of a region, which includes environmental self-purification capacity and resource supply capacity, becomes a significant factor in regional sustainable development (Sutthichaimethee and Tanoamchard, 2015).

A sustainable development require a society to define sustainability constraints or environmental limits, environmental carrying capacity. Environmental carrying capacity can be defined as "the level of human activity which a region can sustain at acceptable level of quality of life". This concept of environmental carrying capacity has several important applications to sustainable city planning and management. If the limitation of a human activity can be supported by a scientific data on carrying capacity, the resulting decision and actions could more easily win public support for a sustainable development.

There has been three uses of the concept of environmental carrying capacity for environmental planning and management. The first use of the concept of carrying capacity is in studies to determine the threshold of human activities that will cause ecological damage to a natural environment. The second is the development of impact thresholds such as air and water quality standards. The last use of the concpet is to calculate the sustained yields of renewal resources that are possible without damaging the resource base for the future (Baldwin, 1985).

Populations generally discharge pollution, but they also promote economic development. The circle represents, accompanied with incensement of domestic water usage, the pressure on saving water is amplifying. In the economy subsystem, the total industrial value is the state variable, and the variation of the total industrial value both affects the investment used to treat industrial pollution and is largely decisive on the industrial water usage volume and pollutant discharge. The total sewage discharge volume can be determined by the discharge volume and treatment volume of domestic and industrial sewage (Kang et al. 2012).

2.3 The concept of Ecological Footprint

Protected areas are the most widely applied policy tool for biodiversity conservation. However, effective management of protected areas is often obstructed by conflicts mainly associated with the social impacts imposed on local communities and other users by their establishment (Jones et al., 2017).

One aspect of sustainable development in protected areas is related to tourism. From the ecological viewpoint, sustainable tourism aims to ensure that the environmental values, the functioning of ecological systems, and the occurrence of species native to the area are not compromised. In order to assess sustainability, factors such as wear of the hiking terrain, air pollution, energy efficiency and the impacts of tourism on threatened species should be monitored on a regular basis in tourist areas. Also zonation within protected areas should be dome on a scientific basis and geography principles, to define zones with different levels of access, depending on the vulnerability of environment.

The other aspect of sustainability is to monitor the state of environment (Hay-Edie and Bulus, 2010) and its reactions on the changes of regional and global levels: global warming, air and water pollution, diseases and epidemies in plant and and animal communities, the related loss of biodiversity and productivity. To develop and initiate scientific activities which would find effective solutions to the above mentioned treats and problems.

According to Drumm (2008) the way to sustainability goes through ensuring adequate investment in five key management capacity areas: 1) impact monitoring; 2) basic infrastructure; 3) security; 4) interpretation and information; and 5) staff salaries and training. These elements should be built into a sustainable finance plan for each protected area, and must be an integral part of annual park budgets as long as public use remains authorized. We can begin to determine what minimum tourism revenues should be only when we know the financial cost of managing tourism sustainably.

The Ecological Footprint (EF) is the amount of theoretical land (in global hectares – Gha) that is needed for a population to produce in a sustainable way all the natural resources it consumes and assimilate the waste it produces. The simplest way to define ecological footprint would be to call it the impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated. More simply, it is the amount of the environment necessary to produce the goods and services necessary to support a particular lifestyle (WWF Global). Ecological footprint can be assigned to persons, social groups, factories, cities, nations, or be averaged for the whole humanity.
The concept was firstly conceived in 1990 by Mathis Wackernagel and William Rees from the University of British Columbia, Canada (Rees and Wackernagel, 1994; Wackernagel and Rees, 1996). They first defined the term and attempted to calculate what would be the equivalent unit of area needed by each

human to maintain that individual's current style of life. They called these units global hectares. A global hectare takes into consideration cropland, grazing area, forest lands, fish habitat, carbon output and urban space requirements to sustain a human. Since 1993 there has been continuous monitoring of EF (Global Footprint Network, 21st Century Tech).

The major advantage of the ecological footprint concept over some other indicators like environmental space (Moffatt, 1996; McLaren et al., 1998) is that EF gives a clear, unambiguous message in an easily digested form. This is an important function of any indicator for both policy makers and the general public. The calculation upon which the EF is based is relatively easy to undertake and much of the data is available at different spatial scales. Third, more detailed calculations do include trade within the ecological footprint. Fourth, the measure is simply stated as a stock, for example, x units of land per capita. It is obvious that each areal unit can also supply a flow of goods, information, natural and manmade capital as well as pollution into and out of the region (Moffatt, 2000). Main limitations of EF are related to the question whether a purely spatial parametre (area) can measure adequately human impact on the environment (Selman, 1996); some authors (Van den Bergh and Verbruggen, 1999) have argued for the need to consider spatial flows of trade in the derivation of indicators of sustainable development. Furthermore, as currently constructed, the ecological footprint is a static measure. It is possible to examine the dynamics of this measure by recourse to viewing the ecological footprint through historical time. Nowadays it is very important to develop a dynamic approach for exploring different scenarios of development (Moffatt, 1996; Lange, 1999) if we wish for development to be made sustainable. In its present definition the EF does not take into account technological changes (advancing of technologies can significantly reduce anthropogenic pressure), neither is considers the oceans and underground resources including water.

The website of the Global Footprint Network (www.footprintnetwork.org) provides basic information about the concept of Ecological footprint, as well as tools and resources for research at regional and local levels.

In fact, the carrying capacity of a given area is reached, when the ecological footprint becomes equal to the area's biocapacity. This means that at this point the population on that territory consumes all the amount of goods and services which the environment can provide for a unit of time. If the ecological footprint is greater than the biocapacity of an area, this area suffers an ecological deficit, and to sustain the current standard of living, the population must either import food or goods, or overconsume from its resources, which gradually causes their depletion (unbalanced cutting of forests, overgrazing or overfishing, exhausting of mineral resources, air pollution), or both. On the contrary, when the biocapacity of a given area exceeds the ecological footprint, this area has an ecological reserve. It could either sustain a larger population without harm to environment, or export goods and services to other areas.

2.4 The concept of Carbon Footprint

The Global Footprint Networks considers carbon footprint as a specific part of EF. The concept of carbon footprint has developed through years. Definitions of the term are found in Wackernagel and Rees (1996), Wackernagel et al. (2005), Carbon Trust (2006), British Sky Broadcasting (2006), Energetics (2007), Global Footprint Network (2007), Grub and Ellis (2007), Parliamentary office of Science and Technology (2006), Wiedman and Minx (2007). Carbon footprint (CF) assessment was the subject of the works by Hammond (2007), Haven (2007), Eckel (2007).

According to Wiedman and Minx (2007) CF is measure of the exclusive total amount of CO_2 emissions (in fact tons of greenhouse gasses expressed in CO_2 equivalent) that are directly or indirectly caused by an activity or is accumulated over the life stages of a product. They consider carbon footprint as not the sole parametre for assessment of greenhouse gas production, but the most concise and informative one. In fact, carbon footprint is interpreted and understood as “fossil fuel footprint”. It is also defined as “the demand of biocapacity required to sequester the carbon dioxide emissions from fossil fuel combustion”. It includes the capacity of unharvested forests needed to absorb that fraction of fossil carbon dioxide that is not absorbed by the ocean.

Although CF is considered a sub-indicator of the EF, it is essential to quantify and assess it on its own, since it provides a much clearer image of Global Warming Potential and Climate Change impacts.

In fact, the carrying capacity for greenhouse gasses is reached when the carbon footprint of an area becomes equal to the capacity of its environment to absorb or store carbon dioxide. Beyond the carrying capacity threshold the surplus CO_2 start to build up in the atmosphere, enhancing the green-house effect.

Estimation of populations’ behaviour in the context of carrying capacity is much simpler when it comes to animals, especially if single species are studied. Starting from a low number of individuals there are two different (major) patterns that show how various species reach the CC. In the first one the population number increases rapidly until food and space are abundant, and after a certain point the growth slows down as regulatory factors such as lower birth rate and reduced food supplies come into force. As the population growth diminishes to zero, the population achieves a fairly stable level. This pattern is referred to as K (constant) selected species (The Sustainable Scale Project, 2017). The second pattern is similar to the first one just in the initial phase, when population is still small. But here the regulatory factors do not come into force and the number increases rapidly until a point is reached, in which the resources become completely exhausted. At this point mortality becomes the primary regulatory factor, and the population collapses to a low level. When resources recover, the population number may start growing again. Such species are referred to as R-selected species.

Applied for human population, the concept of carrying capacity becomes much more complicated, because people have quite different and even contrasting ways of living and consumption, and are much more adaptable than animals.

Generally, the estimation of CC for human population firstly followed the so called IPAT equation, which takes into account not only population number, but also the differing levels of consumption and economic development: I = P x A x T, where I is the environmental impact, P is the population, A is affluence, and T is the level of technology. Later, with the considerable increase of population, it was considered more correct to assign a different weight to each of the mentioned factors. Schulze (2002) stated that the IPAT equation was particularly useful as a starting point for disentangling the determinants of per capita impact, but was concerned that the equation had failed to give sufficient weight to the role of behaviour (B), and suggested to modify I =PAT to I = PBAT.

One variable, which best counts for human carrying capacity, is the food availability. The food production data can be converted to "maximum population" values, i.e., the number of individuals that the resources can support. In identifying human food as the resource that accounts for human carrying capacity, a measure of global food availability must be calculated.

The FAO provides data from official and semiofficial reports of crop yields, area under production, and livestock numbers (World Development Indicators, 2002). The increase of food production in time should be accounted in calculating carrying capacities. In his analysis of the relations between carrying capacity and the evolution of global population (based also on the works of Hinrichsen, 1997; Calhoun, 1962; Hopfenberg & Pimentel, 2001) Hopfenberg (2003) concludes that on global scale the issues of starvation and malnutrition are not a function of worldwide food production but a function of distribution complexities, i. e., of the contrasts in food availability which increase with rising global population. As Cohen (1995) concludes, Earth's capacity to support people is determined both by natural constrains and by human choices concerning economics, environment, culture, and demography, and is thus quite dynamic and uncertain. Because of the discussed complexity of human carrying capacity calculations, the estimations of global (planetary) carrying capacity vary greatly: from half a billion (lowest) to 800 billion people (highest). Of course, the most marginal of these estimations are not based on scientific principles and data, but are rather of an ideological character (The Sustainable Scale Project, 2017).

The main challenge for the sustainable development of protected areas is considered the regulation of the flow of visitors (tourists) and their behaviour (Sommer, 2012). The need is to combine the protection of nature and cultural resources with the fulfillment of visitor expectations to ensure visitor satisfaction.
Carrying capacity has obvious parallels and intuitive appeal in the field of park management. In fact, it was first suggested in the mid-1930s as a park management concept in the context of national parks (Sumner, 1936). However, the first rigorous applications of CC to park management did not occur until the 1960s. Despite the large number of studies, efforts to determine and apply carrying capacity to

areas such as national parks are principally difficult, because it is hard to determine how much impact, such as soil compaction and crowding, is too much. Theoretical development, backed up by empirical research, generally confirms that increasing use levels can lead to increased environmental and social impacts (Hammitt and Cole, 1998; Manning, 1999). But how much impact should be allowed in the national park? This basic question is often referred to as the "limits of acceptable change" (Lime, 1970; Frissell & Stankey, 1972). This is one of the several planning frameworks that have been established and tested in protected areas, along with Visitor Impact Management (VIM) (Graefe, Kuss, 1990), Visitor Experience and Resource Protection (US Department of the Interior, 1997), Visitor Activity Management Planning (VAMP) (Nilsen, Grant, 1998) and the Tourism Optimization Management Model (TOMM) (Manidis Roberts Consultants, 1997). These frameworks have been used in a variety of protected area situations but further application, testing and modification are warranted. A major difference between these suggestions and carrying capacity is that they are decision-making frameworks, not a scientific theory.

Cifuentes et al. (1990, 1992) proposed a method for estimation of carrying capacity on trails in protected areas, which states that the maximum number of visits that a NPA can receive, and takes into account the physical, biological and management conditions of the area and consist on three phases: Physical Carrying Capacity (FCC), Real Carrying Capacity (RCC) and Effective Carrying Capacity (ECC). FCC refers to the maximum limit of visits that physically could be done in a day. It is defined by the relationship between the opening hours of the NPA and the time needed to each visit, the visitation available space, the needed space for visitors and the type of trail (circular or linear):

FCC = (S/SP*NV), (1)

where S is available surface in linear meters (1 m), SP is the surface used by a person (1m ^{2}), and NV is the number of times the site can be visited by the same person in one day. For the calculation of RCC, FCC was modified by a series of correction factors such as, Social (FCsoc), erodibility (FCero), accessibility (FCacc), precipitation (FCpre) of flooding (FCane), biological (FCbio) and vegetation (FCveg). The factors are calculated with the following general expression:

FCx = 1- Mlx/Mtx, (2)

Where, FCx is the correction factor for the variable x, Mlx is the limiting magnitude of the variable x, Mtx is the total magnitude of the variable x. For the social factor (FCsoc) which refers to the quality of visitation such as the number of visitors per guide, the distance required between groups to avoid crowding. Obtained the correction factors, the RCC is calculated:

CCR= CCF *(FCsoc*FCero*FCacc*FCpre* FCane* FCbiol* FCveget). (3)

Finally, ECC is calculated, which represents the maximum number of visitors allowed at the area, and relates the CCR with the management capacity (MC; defined as the best condition that the administration should have to practice the activities and meet the goals in a satisfactory way) by the expression:

ECC= RCC*MC (4)

United Nations Environment Programme (UNEP) (PAP/RAC, 1997) emphasizes the fact that a good carrying capacity assessment method must: 1) keep in mind the priorities of the targeted area; 2) identify local limitations for tourism development by balancing the demand for new infrastructure with the need for environmental protection; 3) highlight a set of indicators to be used by all operators and administrators in the tourism sector; and 4) define destination development scenarios.

In protected areas such as national parks, the following approaches are recommended for the proper carrying capacity assessment: 1) a detail study of environment which outlines the main features on the territory and their spatial distribution; 2) zonation - differentiation within the territory of zones with different function and level of restriction of human activities (reserve, visitors, economic); 3) assessment of carrying capacities (ecological, economical, social) for each particular zone (including mapping); 4) projecting of park management activities on the basis of the carrying capacity.

The EF calculation method is necessary to convert the energy and food consumption needs in land requirements in order to compare them with the Biocapacity of the examined system (actual production from available lands) and thus find the carrying capacity of the area. Unique way to estimate human demand compared to ecosystem's carrying capacity is "ecological footprint" accounting. Rather than speculating about future possibilities and limitations imposed by carrying capacity constraints, Ecological Footprint accounting provides empirical, non-speculative assessments of the past. It compares historic regeneration rates, biocapacity, against historical human demand, ecological footprint, in the same year (Ewing et al., 2010).

Ecological Footprint accounting is based on six fundamental assumptions (adapted from Wackernagel et al. 2002): 1) The majority of the resources people consume and the wastes they generate can be quantified and tracked; 2) An important subset of these resource and waste flows can be measured in terms of the biologically productive area necessary to maintain flows. Resource and waste flows that cannot be measured are excluded from the assessment, leading to a systematic underestimate of humanity's true Ecological Footprint; 3) By weighting each area in proportion to its bioproductivity, different types of areas can be converted into the common unit of global hectares, hectares with world average bioproductivity; 4) Because a single global hectare represents a single use, and each global hectare in any given year represents the same amount of bioproductivity, they can be added up to obtain an aggregate indicator of Ecological Footprint or biocapacity; 5) Human demand, expressed as the Ecological Footprint, can be directly compared to nature's supply, biocapacity, when both are expressed in global hectares; and 6) Area demanded can exceed area supplied if demand on an ecosystem exceeds that ecosystems regenerative capacity.

The Ecological Footprint measures appropriated biocapacity, expressed in global average bioproductive hectares, across five distinct land use types, in addition to one category of indirect demand for biocapacity in the form of absorptive capacity for carbon dioxide emissions. The Ecological Footprint of production, EFP, represents primary demand for biocapacity and is calculated as

$$EF_p = (P/Y_n) . YF . EQF, \quad (5)$$

where P is the amount of a product harvested or carbon dioxide emitted, Y_n is the national average yield for P (or its carbon uptake capacity), and YF and EQF are the yield factor and equivalence factor, respectively, for the land use type in question. Yield factors capture the difference between local and world average productivity for usable products within a given land use type. They are calculated as the ratio of national average to world average yields and thus vary by country, land use type, and year within the National Footprint Accounts. Equivalence factors translate the area of a specific land use type available or demanded into units of world average biologically productive area. Thus, it varies by land use type and year. Equivalence factors are calculated as the ratio of the maximum potential ecological productivity of world average land of a specific land use type (e.g. cropland) and the average productivity of all biologically productive lands on Earth.

In order to keep track of both the direct and indirect biocapacity needed to support people's consumption patterns, the Ecological Footprint methodology uses a consumer-based approach; for each land use type, the Ecological Footprint of consumption (EF_C) is thus calculated as:

$$EF_C = EF_P + EF_I + EF_E, \quad (6)$$

where EF_P is the Ecological Footprint of production and EF_I and EF_E are the Footprints embodied in imported and exported commodity flows, respectively. The National Footprint Accounts calculate the Footprint of apparent consumption, as data on stock changes for various commodities are generally not available. One of the advantages of calculating Ecological Footprints at the national level is that this is the level of aggregation at which detailed and consistent production and trade data are most readily available. Such information is essential in properly allocating the Footprints of traded goods to their final consumers.

The final steps in calculating the EF includes the conversion of bioproductive areas from hectares into global hectares, and accounting the yeld factors (Ewing et al., 2010). Average bioproductivity differs between various land use types, as well as between countries for any given land use type. For comparability across countries and land use types, Ecological Footprint and biocapacity are usually expressed in units of world-average bioproductive area. Expressing Footprints in world average hectares also facilitates tracking the embodied bioproductivity in international trade flows, as gha measure the ecological productivity required to maintain a given flow. Global hectares provide more information than simply weight - which does not capture the extent of land and sea area used – or physical area - which does not capture how much ecological production is associated with that land. Yield factors and equivalence factors are the two coefficients needed to express results in terms of global hectares (Monfreda et al., 2004; Galli et al., 2007), thus providing comparability between various countries' Ecological Footprint as well as biocapacity values.

Calculation results based on National Footprint Accounts (Global Footprint Network) show that humanity's demand footprint has exceeded the planet's bio-capacity since the 1970s, and still in 1999 this excess was >20%. However, measurements do not take into account the depletion of the actual fossil fuels, "which would result in a carbon Footprint many hundreds of times higher than the current calculation." (World in Motion: The Globalization and the Environment Reader, Venetoulis and Talberth, 2009). Today, almost 20 years later, humanity uses the equivalent of 1.7 Earths to provide the resources we use and absorb our waste. This means that we are living in a global ecological deficit.

On national level however, since 2013 Bulgaria has been among the few countries in Europe to act as an ecological reserve: for 2014 the biocapacity exceeded ecological footprint by 0.1 gha, and for 2018 biocapacity is assessed to exceed national EF by 5% (Global Footprint Network). However, this should be addressed mostly to the severe decrease in Bulgarian population in the last decades, and the collapse of industry.

It is normal to expect that protected areas such as the national parks act as biological reserves, due to the strongly reduced human activities. Rila National Park is not an exception.

2.5 The concept of Water Footprint

The water footprint, originally proposed by (Hoekstra and Hung, 2002), in analogy of the ecological footprint (Rees, 1992), originates from the concept of virtual water proposed by (Allan, 1994). The water footprint measures the amount of water used to produce each of the goods and services that are used by any person. It can be measured for a single process, such as growing agriculture goods, for a product, such as t-shirts, for the fuel we put in our car, or for an entire cooperation. The water footprint can also gives information how much water is being consumed by a particular country – or globally – in a specific river basin or in protected area and can be measured in cubic metres per tonne of production, per hectare of cropland, per unit of currency and in other metric units. The water footprint gives an explonation for what purposes the limited freshwater resources are consumed and polluted. The impact of the water footprint depends on where and when the water is taken from. If the consumed water is extracted from a place where the water is already scarce, the consequences of that can be devastating and action will be required.

According Hoekstra et al., (2011) The water footprint has three components: green, blue and grey. Together, these components provide a comprehensive picture about the source of consumed water, either as rainfall/soil moisture or surface/groundwater, and the volume of fresh water required for assimilation of pollutants.

Fig. 2-5 Green water footprint (source: www.waterefootprint.org)

Green water footprint is water from precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants. It is particularly relevant for agricultural, horticultural and forestry products (Hoekstra et al., 2011).

Fig. 2-6 Blue water footprint (source: www.waterefootprint.org)

Blue water footprint is water that has been sourced from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time. Irrigated agriculture, industry and domestic water use can each have a blue water footprint (Hoekstra et al., 2011).

Fig. 2-7 Grey water footprint (source: www.waterefootprint.org)

Grey water footprint is the amount of fresh water required to assimilate pollutants to meet specific water quality standards. The grey water footprint considers point-source pollution discharged to a freshwater resource directly through a pipe or indirectly through runoff or leaching from the soil, impervious surfaces, or other diffuse sources (Hoekstra et al., 2011) .

The water footprint looks at both direct and indirect water use of a process, product, company or sector and includes water consumption and pollution throughout the full production cycle from the supply chain to the end-user.
It is also possible to use the water footprint to calculate the amount of water required to produce all the goods and services consumed by the individual or community, a nation or a geographical region. This also includes the water that is used directly - direct water footprint and the indirect used water – indirect water footprint – the summation of the water footprints of all the products consumed.

The relation between consumption and water use
According A. Y. Hoekstra (2002) the interest in the water footprint is rooted in the recognition that human impacts on freshwater systems can ultimately be linked to human consumption, and that issues like water shortages and pollution can be better understood and addressed by considering production and supply chains as a whole. The Water problems are directly tied to the structure of the global economy. Many countries have significantly externalized their water footprint, importing water-intensive goods from elsewhere. This puts pressure on the water resources in the exporting regions, where too often mechanisms for wise water governance and conservation are lacking. Not only governments, but also consumers, businesses and civil society communities can play a role in achieving a better management of water resources (Hoekstra, 2002).

Some facts and figures

- The production of one kilogram of beef requires approximately 15 thousand liters of water (93% green, 4% blue, 3% grey water footprint). There is a huge variation around this global average.

The precise footprint of a piece of beef depends on factors such as the type of production system and the composition and origin of the feed of the cow (Source: weterfootprint. org.)

- The water footprint of a 150-gramme soy burger produced in the Netherlands is about 160 liters. A beef burger from the same country costs on average about 1000 liters (Source: weterfootprint. org.).
- The water footprint of Chinese consumption is about 1070 cubic meters per year per capita. About 10% of the Chinese water footprint falls outside China (Source: weterfootprint. org.).
- Japan with a footprint of 1380 cubic meters per year per capita, has about 77% of its total water footprint outside the borders of the country (Source: weterfootprint. org.).
- The water footprint of US citizens is 2840 cubic meter per year per capita. About 20% of this water footprint is external. The largest external water footprint of US consumption lies in the Yangtze River Basin, China (Source: weterfootprint. org.).
- The global water footprint of humanity in the period 1996-2005 was 9087 billions of cubic meters per year (74% green, 11% blue, 15% grey). Agricultural production contributes 92% to this total footprint (Source: weterfootprint. org.).
- Water scarcity affects over 2.7 billion people for at least one month each year (Source: weterfootprint. org.)

Phases of Water Footprint Assessment:

1. Goals and Scope

Because Water Footprint Assessment can be undertaken for diverse purposes the Water Footprint Assessment begins with setting the goals and scope of the water footprint study.

The goal of the Water Footprint Assessment clarifies what have to be done in the subsequent steps: accounting, sustainability assessment and response formulation. The scope of the assessment defines the spatial and temporal scale of the study, for example whether the focus will be global or within a single catchment, whether it will span one year or multiple years, whether it will include some or all of the value chain, address one product or a facility or an entire company.

Together, the goal and scope indicate which data will be used, how each subsequent step of the assessment will be approached, and the level of detail required to achieve the desired results.

2. Accounting

Once the goal and scope of the Water Footprint Assessment have been defined, the data are collected to calculate the footprint of the relevant processes for the study.

These may come from global databases or collected locally.

3. Sustainability Assessment

Water Footprint Assessment is used to assess whether water use is environmentally sustainable, resource efficient and equitably allocated.

In the sustainability assessment step, we are assessing whether water use is balancing the needs of people and nature, if our limited water resources are being used to the greatest benefit and how fairly we are sharing the waters we use.

Environmental sustainability:
To be environmentally sustainable, water use must not exceed the maximum sustainable limits of a freshwater resource. The blue water scarcity is used to measure the environmental sustainability of the blue water footprint. It's a measure of the blue water footprint compared to the water available after considering environmental flow requirements. When the blue water footprint is larger than the available water, environmental flows are not met and over time, freshwater ecosystems degrade.
When the environmental sustainability of water use is considered from the perspective of water quality, the grey water footprint has to be compared with the available assimilation capacity to measure the water pollution level. If the grey water footprint exceeds the assimilation capacity water quality standards are violated and the quality of the water will not meet socially agreed upon purposes.
Both of these, blue water scarcity and water pollution levels, are assessing the cumulative impact of all water uses of the freshwater resource. This can be done for sub-catchment or a local aquifer all the way up to large river basins and regional groundwater reserves.

Resource efficiency:
The water footprint is an ideal measure of resource efficiency because it can be measured per unit of production, for example the cubic metres required to produce a ton of wheat. As the water footprint goes down, this indicates a more efficient use of water in producing the wheat or any other product. If the water footprint exceeds a benchmark of resource efficiency for that activity, this indicates that there is the opportunity for water footprint reduction through a change in practices or technology.

Equitable allocation:
Unlike the carbon footprint, there are benefits to having a water footprint – the production of the food we eat, the clothes we wear, the materials used in building our homes, etc., requires there to be a water footprint. In addition to ensuring that the water footprint is environmentally sustainable and resource efficient, it also needs to be fairly shared amongst all people. This can mean that the allocation of the water footprint within a river basin is a fair allocation between different water users and different sectors in a way that benefits greater societal goals. It can also mean that no individual, community or country has a larger water footprint associated with the products and services they consume than others.

4. Response Formulation
Using the information gained in the accounting and sustainability assessment steps of Water Footprint Assessment, response strategies that reduce the water footprint and improve its sustainability can be prioritised for implementation.

Response strategies can range from investing in better metering to enable improved water management, to changes in practices or investments in technology that will reduce the water footprint at any step along the value chain. It may also be important to take action collectively with others to improve the long-term sustainability of water use at the catchment or river basin level. Integrated river basin management engage a range of stakeholders in finding solutions which reduce wasteful water use and implement good water governance.

Product water footprint

The water footprint of a product is the amount of water that is consumed and polluted in all processing stages of its production. A product water footprint tells us how much pressure that product has put on freshwater resources. It can be measured in cubic metres of water per tonne of production, or litres per kilogram, gallons per pound or per bottle of milk.

By measuring the volume and source of water consumed in the production of a product and the volume of water needed to assimilate pollutants associated with the production can be identify the product contribution to the growing concerns of water scarcity and degraded water quality. It also allows us to compare different products for their relative contribution to these critical water issues.

The water footprint of a final product is the summation of the water footprint of each step, or process, required to produce that product. For example, a pair of jeans will require cotton to be grown, ginning and spinning of the fibres, weaving, sewing and wet processing of the fabric to ultimately have the finished product. Each step has a direct water footprint and an indirect water footprint. The direct water footprint of one process becomes the indirect water footprint of the next process. In this way, the full amount of water consumed or polluted is taken into account in the product water footprint.

By measuring the water footprint of a product in volumes of water per unit of production, it is possible to assess how efficiently the product has been produced or the product water footprint calculate how many units of production have resulted from each litre of water used. This measure of resource efficiency can be applied to both the amount of water consumed, the green and blue water footprint, and the amount of assimilation capacity used, the grey water footprint. If a product with a smaller grey water footprint has been produced less pressure on the freshwater resource is put and contributed less to water quality degradation.

Personal water footprint

Personnel water footprint is the amount of water that is consumed by the individuals in their daily life, including the water used to grow the food they eat, to produce the energy they use and for all of the products in their daily life – books, music, house, car, furniture and the clothes.

Understanding the water consumption can help the society to provide a solution to one of the most pressing problems: making sure there is enough water to sustain all living things on our planet.

In the global economy, each consumer on average use as much as 5 000 litres of water every day (ranging from 1 500 to 10 000 litres per day, depending where you live and what you eat). Everything that is used or consumed has a water footprint, sometimes close to the place of consumption, but often in river basins far away, even in other countries. Each ingredient in a product may come from a different place. Take, for example a cookie, which might have wheat from Bulgaria, sugar from Brazil, vanilla from Madagascar and eggs from the local farmer. This one cookie is consuming and polluting water from a number of river basins, in countries around the world.

Water is a renewable, but finite, resource and there is the same amount on earth today as there was in the past. As the population grows, pressure on the available supply is mounting. This is exacerbated by pollution and the fact that there are seasonal and geographic differences in the distribution of the water resources. Today, in many locations, people are using more fresh water than the earth's natural limits can sustain.

National water footprint

Water, like energy, is a key input into any economy. With the uneven distribution and the verity of the quality from country to country, water is a local issue. At the same time, because we use international trade in goods to meet the needs of the world's populations, water is a global resource.

The United Nations warns that water use is growing at twice the rate of population growth. Unless this trend is reversed, two-thirds of the global population will face water "stress" by 2025. Because of that sharing water fairly and sustainably amongst the world population is one of the greatest challenges the humanity face in the 21st century.

"Water is an astonishingly complex and subtle force in an economy. It is the single constraint on the expansion of every city, and bankers and corporate executives have cited it as the only natural limit to economic growth".
Margaret Catley-Carlson, Vice-Chair, World Economic Forum

A nation's water footprint can be calculated from two perspectives: *production* and *consumption*. The water footprint of production is the amount of local water resources that are used to produce goods and services within the country. This includes the water footprint of agriculture, industry and domestic water use and tells us the total volume of water and assimilation capacity consumed within the borders of the country. Water footprint can also be measured for any administrative unit such as a city, province, river basin or even the whole world.

We can also view the water footprint from the perspective of consumption. In this case, the water footprint is calculated for all the goods and services that are consumed by the people living in a country. This water footprint may be partly inside the country and partly outside of it, depending on whether the products are locally produced or imported. The water footprint of consumption can also be measured for any administrative unit.

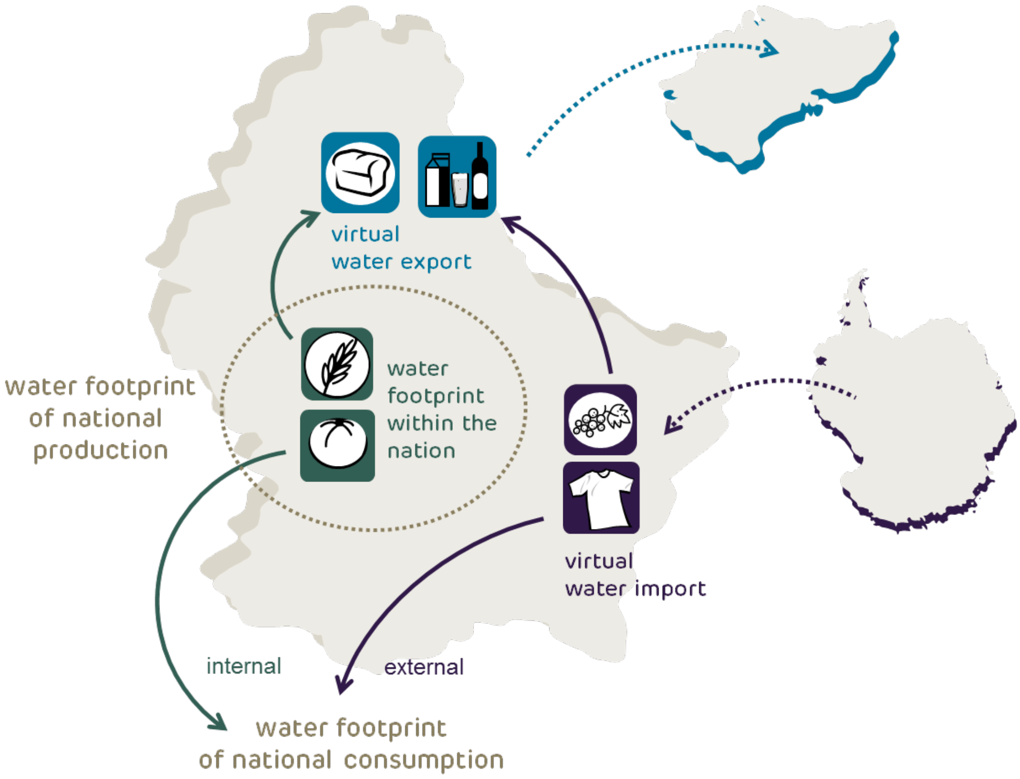


Fig. 2-8 Scheme of National water footprint (source: www.waterefootprint.org)

Countries with limited water resources such as North Africa, Mexico and the Middle East must depend on imported goods to fulfil all the needs of their populations. This is also true for countries with limited land area like Japan and Singapore. Europe, whilst rich in water resources and land area, has 40% of its water footprint outside its borders.

- There are large differences in the water footprint of consumption of nations. In the USA, the average water footprint per year per capita is as much as the water needed to fill an Olympic swimming pool (2 842 cubic metres), that is an average of 7 786 litres of water per person per day. In China, the average water footprint is 1 071 cubic metres per year per capita, or 2 934 litres of water per person per day (Source: weterfootprint. org.).

Differences in the internal and external water footprint of consumption are also large. In the Netherlands, 95% of the water footprint of consumption lies somewhere else in the world through imported goods, whereas in India and Paraguay only 3% of the national water footprint of consumption is external.

Water footprint as a holistic environmental indicator.

The ecological carrying capacity of water resources is a comprehensive concept of natural science and social science, which includes ecological society and economic society dual attributes. Since Canadian scholar Wackernagel has proposed the model of ecological footprint in 1992, it has been a popular evaluation method of ecological society sustainable development. And in the same time, it also provides a new way to analyse the capacity of regional water resources. For example Suweiset al. (2013) recently published a new research were they work on estimating the maximum sustainable population of each country around the world based on their available water resources (i.e. the nations' carrying capacity), and accounting for both local and "virtual" water resources. Their results highlight the existence of a serious global water imbalance (Suweis, S. et al. 2013). The carrying capacities in this study were estimated on the basis of water footprint calculations. Consider, for example, a country with a given population. Each inhabitant consumes a given amount food which corresponds to a particular level of water consumption *‹Wc›* which typically varies depending on the type of diet, age, cultural, and social conditions. In the absence of trade, people rely on local water resources and the local carrying capacity can be calculated as *Kloc = WFloc/‹Wc›*, where *WFloc* is the sum of the water footprints (Hoekstra, A., and A. Chapagain, 2008) of all food commodities that can be produced in that nation. To take into account the entire water budget of a country, you also have to consider the net virtual water import *WFtrade*, i.e., the sum of the water footprints of all imports minus the footprints of all exports. Using this approach, Suweis et al.(2013) estimated the number of people that can be sustained by each country's local and virtual water supplies, or the virtual carrying capacity, *KV = (WFloc + WFtrade)/‹Wc.* According Feng Shangyou (2000) the concept of carrying capacity originates from ecology and is expanded to the study of natural resources and environment to describe the ability of the eco-environment or natural resources to sustain soci-economic activities. The Water Rsources Carrying Capacity' (WRCC) is defined as the scale of economy and population that the local water resources can sustain in a region, provided with necessary requirements of eco-environment protection and a given level of technology and socio-economic development at a certain historical stage. WRCC research has received increasing attention over the past two decades in China and has become an important approach to measure water security in order to achieve sustainable development, particularly in the areas that face serious water scarcity (Xia Jun et al. 2002). The ecological footprint method has been used in assessing the carrying capacity of resource (Wacknagel et al., 2011). The method has also been used to study the complexities of varying ecological environments, technologies, and consumption patterns (Hubacek et al., 2009; Sutton et al., 2011). However, the ecological footprint is difficult to calculate based on water resource carrying capacity due to variations in fluidity form the land resource (i.e., the regular transfer of the resource via river system, water recycling, and operations of water conservancy facilities). Therefore, there is a gap between reality and the carrying capacity results of the ecological footprint method as measured by the quantifiable method, which include the average yield for freshwater, yield factor for freshwater, and equivalence factor for freshwater (Huang et al., 2008). This gap exists in many water resource carrying capacity assessments conducted for regional research, especially in metropolitan areas. Hoekstra (2003) proposed a method, and analogue of the ecological footprint, which focused on water volume requirement of water trading. This concept become known as

―embedded water or ―virtual water, and later called ―water footprint‖ (Hoekstra, 2009). However, the use of water footprint in assessing water resource carrying capacity is questioned. In fact, water footprint focusing on the consumption and the trade of the water resource has been seldom applied in assessing the latter's sustainability due to its inability to demonstrate the capacity of the water resource supply (Stoeglehner, 2011). Additionally, both the ecological and water footprints use static status in assessing the result and explanting the past and current status of the water resource, making the use of ecological and water footprints inappropriate for resource managemen.t

Chapter 3 - Development of the Methodological Framework

In the specific Chapter, the methodological framework developed for assessing the environmental status of a protected area, through the estimation of holistic environmental sustainability indicators (Carrying Capacity, Ecological Footprint, Carbon Footprint and Water Footprint), is analytically presented. Restrictive parameters for the growth of human population, such as energy and food availability, were taken into account while developing the relevant procedures and steps of implementation. The aforementioned framework provides the management bodies with a more holistic point of view regarding the current situation analysis and assists them to structure a strategic planning development in their area of responsibility.

3.1 Estimation of Carrying Capacity and Ecological Footprint

The Carrying Capacity (CC) can be estimated with the implementation of fourteen (14) distinct steps (Figure 1). These steps were selected building upon the principles of the material and energy flow analysis methods and the suggestions of the analysis of existing environmental sustainability assessment methodologies (Peters et al., 2005; 2007) adapted in such a way as to serve the needs and objectives of BIO2CARE project.

The fourteen (14) steps are divided into three (3) stages of implementation in order to gradually assess the Carrying Capacity of the system under examination:

- **First Stage: Problem definition**

The first stage of implementation consists of the steps one (1) to six (6), and includes the appropriate actions in order to define the purpose and the objectives of the study. Especially, in this stage the concepts of Carrying Capacity, Ecological Footprint and Biocapacity have to be clearly defined and the sectors that contribute to the carrying capacity of the protected area have to be selected. The implementation of the first stage provides a general picture of the problem to be solved in order to evaluate the Carrying Capacity of the protected area and to develop proposals for its improvement.

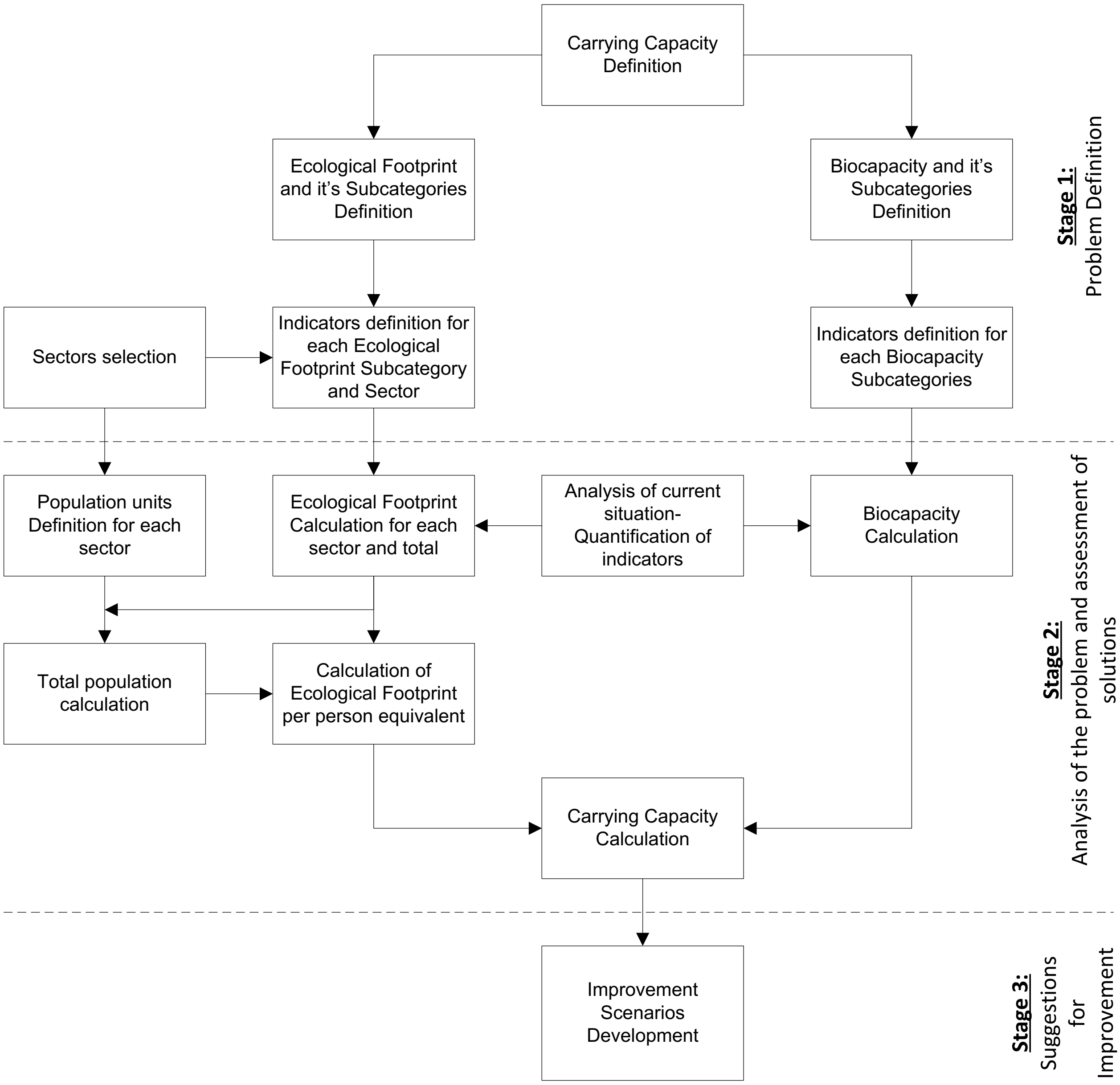


Figure 3-1: Steps to estimate the Carrying Capacity of protected areas.

- **Second Stage: Analysis of the problem and assessment of solutions**

The second stage of implementation consists of the steps seven (7) to thirteen (13) (the condition is the completion of the first stage), and includes the appropriate actions in order to assess the carrying capacity of the protected area. The implementation of the second stage results in conclusions on the current situation of Carrying Capacity of the protected area and the identification of the "weak points" that have to be improved.

- **Third Stage: Suggestions for improvement**

The third stage of the implementation consists of the step fourteen (14) (the condition is the completion of the second stage), and includes the appropriate actions in order to develop scenarios that will lead to Carrying Capacity improvement based on the strategic development plan of the protected area.

Each step includes both general and more specific guidelines for its implementation. The general guidelines can be used to improve the carrying capacity assessment of the current methods' and the specific guidelines provide all the necessary information in order to implement the carrying Capacity Assessment for a protected area. These steps are analytically described below.

3.1.1 Step 1: Definition of Carrying Capacity

The Carrying Capacity was initially introduced in the field of ecology and represents the highest number of a certain kind of living things that can be sustained by a regional ecosystem (Long and Jiang, 2003). However, CC does not only belong to the ecology, but can also be applied in the field of economics, geography, environment, and other sciences (Downs, Gates and Murray, 2008; Retzer and Reubenbach, 2005). The notion of CC in general represents the upper limit of the ability to sustain a living system, beyond it instability, degradation, or irreversible damage will occur subsequently (Lui, 2012) (see Chapter 2 for more details).

The first step for assessing the Carrying Capacity of protected areas, includes the definition of the aim and objectives (why is the study carried out and what do we want to achieve?). The specific procedure includes a clear formulation of the problem to be resolved and the Carrying Capacity definition in order to serve the aim of the study, for example, *“the maximum population that can be accommodated within the boundaries of the protected area without permanent damage to the productivity of the environment”,* as applicable in this case.

In the proposed framework, the method of Ecological Footprint was selected in order to assess Carrying Capacity, comparing the consumption's needs of a population (Ecological Footprint) to the capacity of the environment (Biocapacity), as depicted in Figure 2. In this step, the user has to determine the boundaries of the system (selection of all or part of the activities which are taking place within the boundaries of the protected area) and the reference year, according to the aforementioned aim and the objectives. In case the assessment focuses in the current situation analysis, the use of as accurate and valid as possible data is proposed.

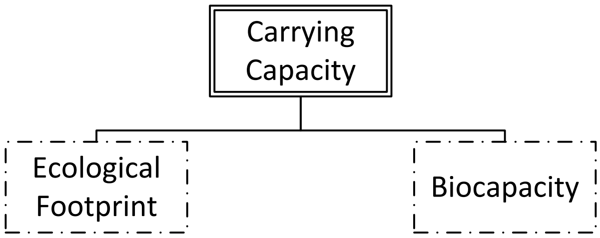


Figure 3-2: Approach to estimate the Carrying Capacity.

3.1.2 Step 2: Definition of Ecological Footprint and its subcategories

In the second step, the Ecological Footprint and its subcategories are defined. The Ecological Footprint is *"the amount of land and/or water that is necessary to a population or activity, in order to produce, in a sustainable way, all the natural resources it consumes and assimilate the waste it produces, using the available technology"*. In the aforementioned method, six (6) land uses/covering are defined, namely, cropland, grazing land, fishing ground, forest land, Carbon uptake land and built-up area. Therefore, six (6) Ecological Footprint subcategories are defined, namely, agricultural products, livestock products, fishery and aquaculture products, timber products, CO_2 emissions, and built-up surfaces (Figure 3).

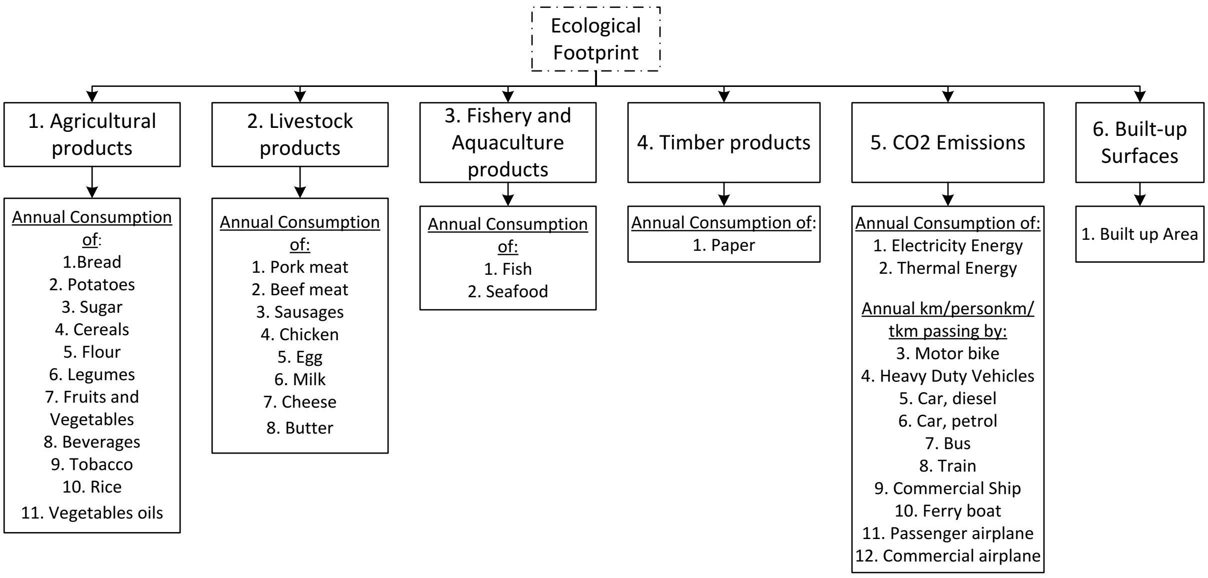


Figure 3-3: Ecological Footprint's subcategories.

The specific procedure includes a record of the parameters which have to be assessed in order to evaluate Ecological Footprint. Each parameter is relevant to one subcategory of the Ecological Footprint.

The apportionment of the parameters into subcategories is depicted in Figure 3. This step facilitates the subsequent processes of defining the individual evaluation indicators of Carrying Capacity.

3.1.3 Step 3: Definition of Biocapacity and its subcategories

The Biocapacity represent the production of natural resources from the total existing land. The division of the existing land into subcategories of the Biocapacity is based in the land uses/covering mentioned above. Thus, the Biocapacity has five (5) subcategories, namely, cropland, grazing land, fishing ground, forest and energy land and build-up area (Figure 4). The Carbon up-take land is taken into account as forest land, because the main mechanism for removing carbon dioxide from the atmosphere is the respiration of the trees. Therefore, the fourth subcategory of the Biocapacity is named forest and energy land, and includes the area under cultivation and fallow land that produces energy.

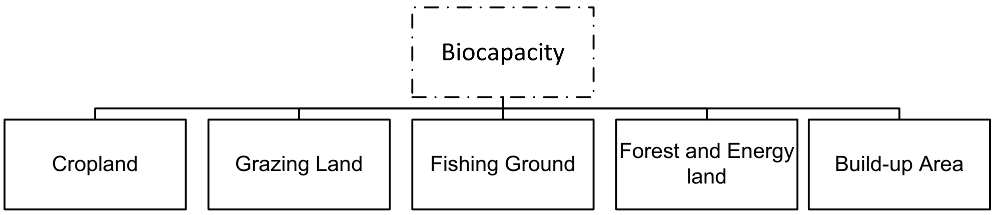


Figure 3-4: Biocapacity's subcategories.

In this step the existing land uses/covering are identified and grouped based on the above subcategories.

3.1.4 Step 4: Selection of the sectors which contribute to Ecological Footprint

In the fourth step, the sectors which contribute to Ecological Footprint are selected, according to the aim and the objectives of the study, as defined in Step 1. In Figure 5, the sectors that have been selected, based on the international literature (Scotti et al., 2009) about Ecological Footprint evaluation, are depicted. In order to ensure the maximum reliability of the results and the current energy situation analysis of the studied area, the calculations do not include sectors that are either not obligatory under the Covenant of Mayors Initiative for developing Sustainable Energy Action Plans of Municipalities (ex. industrial and agricultural emissions) and/or data and evidence that are involving high degree of uncertainty (weak documentation of data sources).

The selected sectors are households, tertiary, municipal buildings, public lighting, private transportation, public transportation, and tourism and are evaluated in order to assess their Ecological Footprint. In this way, indicators relative to energy and food consumption and applicable as appropriate to each sector are selected. The selection of the indicators is analyzed in the Step 5.

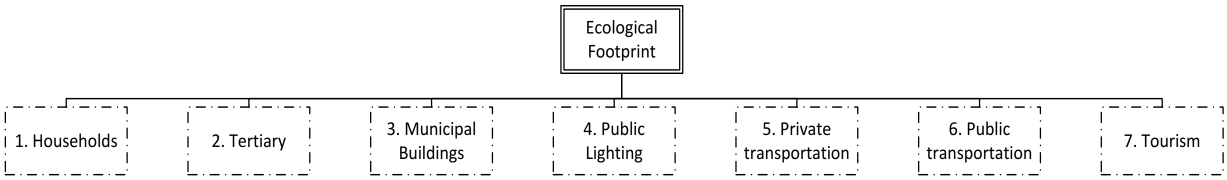


Figure 3-5: The selected sectors to estimate Ecological Footprint.

3.1.5 Step 5: Definition of indicators for each subcategory of Ecological Footprint per sector

In the fifth step, the indicators, which have to be evaluated in order to calculate the Ecological Footprint, are defined according to the pre-defined subcategories of Ecological Footprint of Step 2 and the selected sectors of Step 4. There are two (2) types of indicators, the head indicators and the sectors' indicators for each head indicator. Each head indicator is characterized by its code, belongs in one and only subcategory of Ecological Footprint and can concern to more than one sector, thus has one or more sectors' indicators. More details about the description, the unit, the calculation type, the Ecological Footprint' s subcategory it belongs, the sectors it concerns, and the required assumptions and inputs in order to be evaluated of each indicator is given in Appendix A. In Table 1, the Ecological Footprint's head indicators are represented, briefly. A short description, the subcategory it belongs and the sectors' indicators it has are given for each head indicator. The Indicator Code has the Indicator EF X.Y.Z. form, where EF stands for Ecological Footprint, X refers to the Ecological Footprint's subcategory, Y refers to the numbering of the indicators and Z refers to the sector under examination. Concerning to Z, 1 is for households, 2 is for tertiary, 3 is for municipal buildings, 4 is for public lighting, 5 is for private transportation, 6 is for public transportation, and 7 is for tourism.

Table 3-1: The Ecological Footprint's indicators.

Subcategory	Ind. Code	Description	Sectors' indicators codes
1. Agricultural Products	Ind. EF 1.1	Annual bread consumption	Ind. EF 1.1.1,Ind. EF 1.1.7
	Ind. EF 1.2	Annual potatoes consumption	Ind. EF 1.2.1,Ind. EF 1.2.7
	Ind. EF 1.3	Annual sugar consumption	Ind. EF 1.3.1,Ind. EF 1.3.7
	Ind. EF 1.4	Annual cereals consumption	Ind. EF 1.4.1,Ind. EF 1.4.7
	Ind. EF 1.5	Annual flour consumption	Ind. EF 1.5.1,Ind. EF 1.5.7
	Ind. EF 1.6	Annual legumes consumption	Ind. EF 1.6.1,Ind. EF 1.6.7
	Ind. EF 1.7	Annual fruits and vegetables consumption	Ind. EF 1.7.1,Ind. EF 1.7.7
	Ind. EF 1.8	Annual beverages consumption	Ind. EF 1.8.1,Ind. EF 1.8.7
	Ind. EF 1.9	Annual tobacco consumption	Ind. EF 1.9.1,Ind. EF 1.9.7
	Ind. EF 1.10	Annual rice consumption	Ind. EF 1.10.1,Ind. EF 1.10.7
	Ind. EF 1.11	Annual vegetable oils consumption	Ind. EF 1.11.1,Ind. EF 1.11.7
2. Livestock Products	Ind. EF 2.1	Annual pork meat consumption	Ind. EF 2.1.1,Ind. EF 2.1.7
	Ind. EF 2.2	Annual beef meat consumption	Ind. EF 2.2.1,Ind. EF 2.2.7
	Ind. EF 2.3	Annual sausages consumption	Ind. EF 2.3.1,Ind. EF 2.3.7
	Ind. EF 2.4	Annual chicken consumption	Ind. EF 2.4.1,Ind. EF 2.4.7
	Ind. EF 2.5	Annual egg consumption	Ind. EF 2.5.1,Ind. EF 2.5.7
	Ind. EF 2.6	Annual milk consumption	Ind. EF 2.6.1,Ind. EF 2.6.7
	Ind. EF 2.7	Annual cheese consumption	Ind. EF 2.7.1,Ind. EF 2.7.7
	Ind. EF 2.8	Annual butter consumption	Ind. EF 2.8.1,Ind. EF 2.8.7
3. Fishery and Aquaculture products	Ind. EF 3.1	Annual fish consumption	Ind. EF 3.1.1,Ind. EF 3.1.7
	Ind. EF 3.2	Annual seafood consumption	Ind. EF 3.2.1,Ind. EF 3.2.7
4. Timber products	Ind. EF 4.1	Annual paper consumption	Ind. EF 4.1.1
5. CO_2 emissions	Ind. EF 5.1	Annual electricity consumption	Ind. EF 5.1.1,Ind. EF 5.1.2, Ind. EF 5.1.3, Ind. EF 5.1.4, Ind. EF 5.1.7
	Ind. EF 5.2	Annual thermal energy consumption	Ind. EF 5.2.1,Ind EF 5.2.2, Ind. EF 5.2.3, Ind. EF 5.2.7
	Ind. EF 5.3	Annual km passing by motorbike	Ind. EF 5.3.5,Ind. EF 5.3.6
	Ind. EF 5.4	Annual km passing by heavy duty vehicle	Ind. EF 5.4.5,Ind. EF 5.4.6

	Ind. EF 5.5	Annual km passing by car fueled by diesel	Ind. EF 5.5.5,Ind. EF 5.5.6
	Ind. EF 5.6	Annual km passing by car fueled by petrol	Ind. EF 5.6.5,Ind. EF 5.6.6
	Ind. EF 5.7	Annual km passing by bus	Ind. EF 5.7.6
	Ind. EF 5.8	Annual personkm passing by train	Ind. EF 5.8.6
	Ind. EF 5.9	Annual tkm passing by commercial ship	Ind. EF 5.9.6
	Ind. EF 5.10	Annual tkm passing by ferry boat	Ind. EF 5.10.6
	Ind. EF 5.11	Annual personkm passing by passenger aircraft	Ind. EF 5.11.6
	Ind. EF 5.12	Annual tkm passing by commercial aircraft	Ind. EF 5.11.6
6. Build-up surfaces	Ind. EF 6.1	Build-up areas within the boundaries of the protected area	

The Indicator EF 6.1 is calculated with the assistance of Indicator BC 5.1 in total of the protected area. The indicators that used per sector in order to evaluate its Ecological Footprint are depicted in Figures 6 to 12.

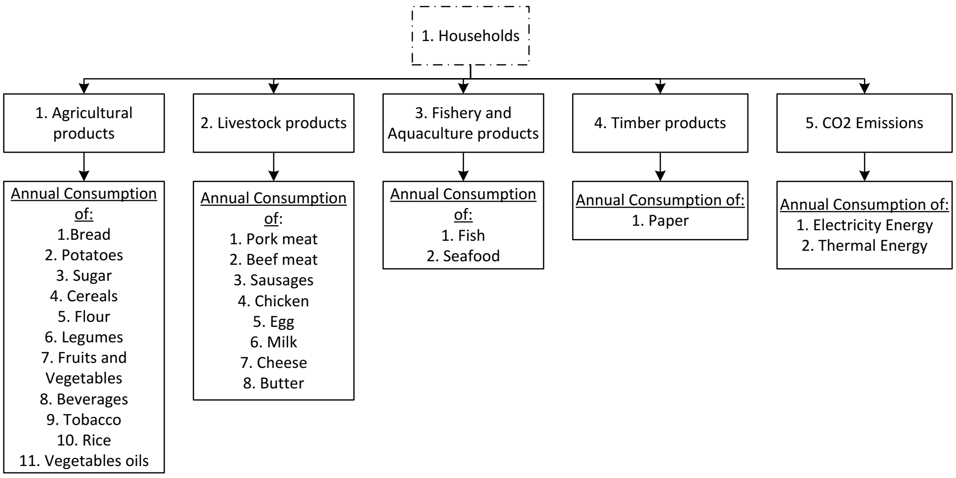


Figure 3-6: The indicators of Ecological Footprint's subcategories in households.

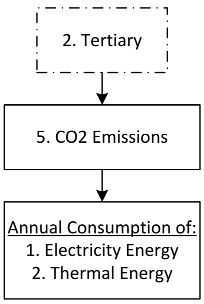


Figure 3-7: The indicators of Ecological Footprint's subcategories in tertiary sector.

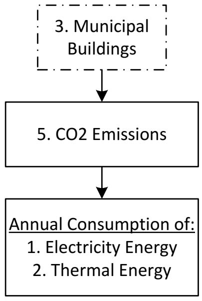


Figure 3-8: The indicators of Ecological Footprint's subcategories in municipality buildings.

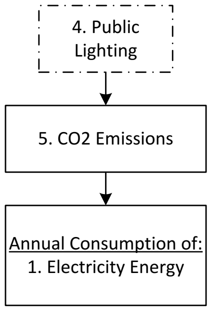


Figure 3-9: The indicators of Ecological Footprint's subcategories in public lighting.

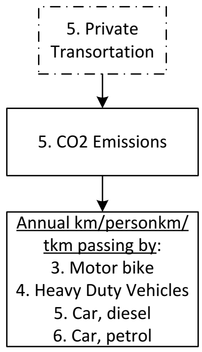


Figure 3-10: The indicators of Ecological Footprint's subcategories in private transportation.

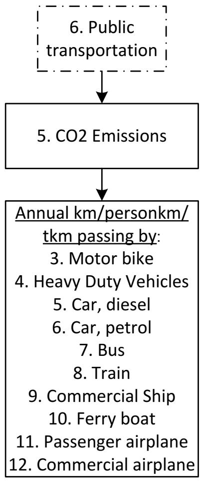


Figure 3-11: The indicators of Ecological Footprint's subcategories in public transportation.

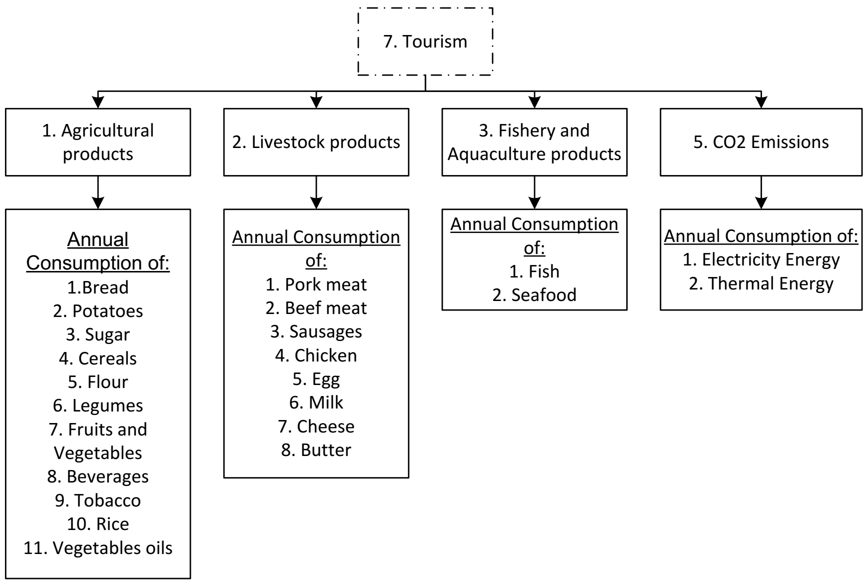


Figure 3-12: The indicators of Ecological Footprint's subcategories in tourism.

3.1.6 Step 6: Definition of indicators for each subcategory of Biocapacity

This is the last step of Stage 1, where the indicators of the Biocapacity are defined. There are two (2) types of indicators, the head indicators and their sub-indicators. Each head indicator is characterized by its code, belongs in one and only subcategory of Biocapacity and has one or more sub-indicators. More details about the description, the unit, the calculation type, the Biocapacity's subcategory it belongs, and the required assumptions and inputs in order to be evaluated of each indicator is given in Appendix B.

In Table 2, the Biocapacity's head indicators are represented, briefly. A short description, the subcategory it belongs and the sub- indicators it has are given for each head indicator. The Indicator Code has the Indicator BC X.Y.Z. form, where BC stands for Biocapacity, X refers to the Biocapacity's subcategory, Y refers to the numbering of the indicators and Z refers to the numbering of the sub-indicators.

Table 3-2: The Biocapacity's indicators.

Subcategory	Ind. Code	Description	Sub-indicators
1.Cropland	**Ind. BC 1.1**	**Area under cultivation and fallow land**	**Ind. BC 1.1.1** **Ind. BC 1.1.2** **Ind. BC 1.1.3**
	Ind. BC 1.1.1	Arable land	
	Ind. BC 1.1.2	Permanent crops	
	Ind. BC 1.1.3	Heterogeneous agricultural areas	
2.Grazing Land	**Ind. BC 2.1**	**Pastures**	**Ind. BC 2.1.1** **Ind. BC 2.1.2** **Ind. BC 2.1.3**
	Ind. BC 2.1.1	Pastures - transitional wood land / shrumb	
	Ind. BC 2.1.2	Pastures - shrumb and / or herbaceous vegetation associations	
	Ind. BC 2.1.3	Pastures - Open spaces with little or no vegetation	
3.Fishing Ground	**Ind. BC 3.1**	**Area under water**	**Ind. BC 3.1.1** **Ind. BC 3.1.2** **Ind. BC 3.1.3**
	Ind. BC 3.1.1	Inland waters	
	Ind. BC 3.1.2	Inland wetlands	
	Ind. BC 3.1.3	Coastal wetlands	
4.Forest and Energy Land	**Ind. BC 4.1**	**Forests and semi-natural areas**	**Ind. BC 4.1.1** **Ind. BC 4.1.2**

	Ind. BC 4.2	**Area under cultivation and fallow land that produces energy**	
	Ind. 4.1.1	Forests	
	Ind. 4.1.2	Transitional wood land / shrumb	
5.Build- up area	**Ind. BC 5.1**	**Areas occupied by the locality (buildings, roads, etc)**	**Ind. BC 5.1.1** **Ind. BC 5.1.2** **Ind. BC 5.1.3** **Ind. BC 5.1.4** **Ind. BC 5.1.5**
	Ind. BC 5.1.1	Urban fabric	
	Ind. BC 5.1.2	Industrial and commercial units	
	Ind. BC 5.1.3	Transport units	
	Ind. BC 5.1.4	Mine , dump and construction sites	
	Ind. BC 5.1.5	Artificial, non agricultural vegetated areas sport and cultural activity sites	

3.1.7 Step 7: Current situation analysis and quantification of the indicators

This is the first step of Stage 2, where an analytical description of the current situation of the study area is implemented. An inventory including indicative quantitative data (Inputs) that are needed in order to evaluate the individual valuation indicators of Ecological Footprint and Biocapacity, as described in Appendix A and B, is implemented. The data collected in order to evaluate an indicator are related to reference year, as defined in Step 1.

This step is usually time and effort disproportional as the data resources may occasionally be found throughout the study area and the allocation of the data require time-consuming procedures. Also, the allocated data issued at national, regional and municipal level and the researcher has to implement some reductions and assumptions in order to evaluate the individual valuation indicators of Ecological Footprint and Biocapacity of the study area.

The Step 7 has to lead to the calculation of each indicator taking into account the relative Inputs and Assumptions that are highlighted for each sector in Appendix A and B.

3.1.8 Step 8: Calculation of Ecological Footprint per sector and in total

The Ecological Footprint calculation method (Wackernagel et al., 2005) converts the energy and food consumption needs in land requirements. The aforementioned method is integrated with the Life Cycle Analysis (LCA) method leading to a more thorough assessment of human activities and ensures that all required processes and materials are taken into account in the calculations (Cucek et al., 2012). The LCA is conventionally characterized as a “cradle-to-grave” or “closed loop” approach as examines the overall environmental impact of a product, process or system, taking into account every step of its life - from receipt of raw materials to its construction, its sale, usage and the final disposal to the environment. It is an environmental management tool which aims to assess the effects of energy use and processing of materials, including disposal of waste on the environment and assess the possibilities for environmental improvement in conjunction with rational use of raw materials and energy in each stage of the life cycle of a system (Haggar, 2007).

This step is carried out (the condition is the completion of the Step 7), by multiplying the value of each indicator with the corresponding conversion factor. The conversion factors for each head indicator are presented in Table 3.

Table 3-3: Conversion Factors of each head indicator.

EF Subcategory	Indicator Code	Description	Convert Factor (Gha/t (or kWh or km or personkm or tkm)/year
1. Agricultural Products	Ind. EF 1.1	Annual bread consumption in t	0,307600
	Ind. EF 1.2	Annual potatoes consumption in t	0,096000
	Ind. EF 1.3	Annual sugar consumption in t	0,335500
	Ind. EF 1.4	Annual cereals consumption in t	0,667000
	Ind. EF 1.5	Annual flour consumption in t	0,423000
	Ind. EF 1.6	Annual legumes consumption in t	0,681300
	Ind. EF 1.7	Annual fruits and vegetables consumption in t	0,743000
	Ind. EF 1.8	Annual beverages consumption in t	2,110000
	Ind. EF 1.9	Annual tobacco consumption in t	1,140000
	Ind. EF 1.10	Annual rice consumption in t	0,573600
	Ind. EF 1.11	Annual vegetable oils consumption in t	2,592000
2. Livestock Products	Ind. EF 2.1	Annual pork meat consumption in t	1,380000
	Ind. EF 2.2	Annual beef meat consumption in t	14,650000
	Ind. EF 2.3	Annual sausages consumption in t	1,380000
	Ind. EF 2.4	Annual chicken consumption in t	0,690000
	Ind. EF 2.5	Annual egg consumption in t	0,513000
	Ind. EF 2.6	Annual milk consumption in t	0,185500
	Ind. EF 2.7	Annual cheese consumption in t	0,151000

	Ind. EF 2.8	Annual butter consumption in t	0,011700
3. Fishery and Aquaculture products	Ind. EF 3.1	Annual fish consumption in t	1,280000
	Ind. EF 3.2	Annual seafood consumption in t	0,021400
4. Timber products	Ind. EF 4.1	Annual paper consumption in t	0,411000
5. CO_2 emissions	Ind. EF 5.1	Annual electricity consumption in kWh	0,000271
	Ind. EF 5.2	Annual thermal energy consumption in kWh	0,000069
	Ind. EF 5.3	Annual km passing by motorbike	0,000026
	Ind. EF 5.4	Annual km passing by heavy duty vehicle	0,000268
	Ind. EF 5.5	Annual km passing by car fueled by diesel	0,000057
	Ind. EF 5.6	Annual km passing by car fueled by petrol	0,000063
	Ind. EF 5.7	Annual km passing by bus	0,000349
	Ind. EF 5.8	Annual personkm passing by train	0,000012
	Ind. EF 5.9	Annual tkm passing by commercial ship	0,000009
	Ind. EF 5.10	Annual tkm passing by ferry boat	0,000009
	Ind. EF 5.11	Annual personkm passing by passenger aircraft	0,000044
	Ind. EF 5.12	Annual tkm passing by commercial aircraft	0,000443

The total required area, as Ecological Footprint, per sector is calculated by summing the multiplications' products of the indicators of each sector. The total Ecological Footprint of the study area is calculated by summing the individual Ecological Footprints of all the sectors.

3.1.9 Step 9: Calculation of Biocapacity

The calculation of Biocapacity is implemented based on the Biocapacity's accounting framework proposed by Wackernagel et al., 2005 (Figure 13).

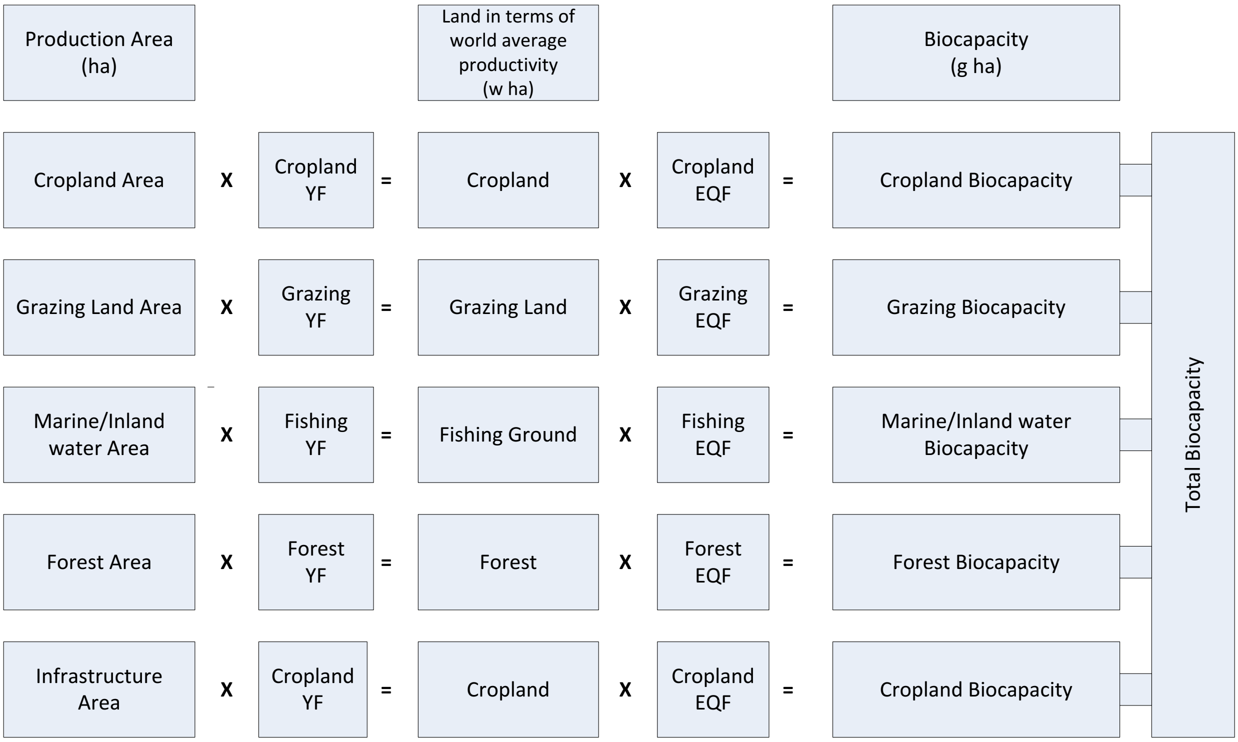


Figure 3-13: Biocapacity's accounting framework.

Each of the indicators described in Appendix B is relative to one and only production areas, as described above. The indicators are estimated in two (2) ways. The first way requires the application of design software which is compatible with the European databases for land uses/covering. The other way requires the exploitation of statistical data relative to land uses/covering available in national, regional and municipal level. Then, the researcher has to implement some reductions and assumptions in order to evaluate the production areas included within the boundaries of the under study protected area.

Then, the production areas are multiplied by the Yield Factors and the Equivalent Factors in order to estimate the Biocapacity of each land use/cover. Finally, the Biocapacities of each production area are summed to the total Biocapacity. Yield Factors (YFs) account for countries' differing levels of productivity for particular land use types. Yield Factors are country-specific and vary by land use type and year. They may reflect natural factors such as differences in precipitation or soil quality, as well as anthropogenic differences such as management practices (Borucke et al., 2013).

Equivalence Factors (EQFs) convert the areas of different land use types, at their respective world average productivities, into their equivalent areas at global average bioproductivity across all land use types. EQFs vary by land use type as well as by year. The rationale behind the Equivalent Factor calculation is to weight different land areas in terms of their inherent capacity to produce human useful biological resources. The weighting criterion is not the actual quantity of biomass produced, but what each hectare would be able to inherently deliver (Borucke et al., 2013). The Yield factors for Greece and Bulgaria and the worldwide Equivalent Factors are presented in Table 4.

Table 3-4: The Yield Factors for Greece and Bulgaria and the Equivalent Factors.

Biocapacity's Subcategory	Yield Factor for Greece*	Yield Factor for Bulgaria*	Equivalent Factor
Cropland Area	1.5	1.5	2.2
Grazing Land Area	2.0	2.0	0.5
Marine/ Inland Water Area	0.8	0.8	0.4
Forest Area	1.3	1.3	1.4
Infrastructure Area	1.5	1.5	2.2

Subject to change – utilization of more representative data if available.

3.1.10 Step 10: Definition of the unit of population per sector

The Ecological Footprint per capita is calculated by dividing the total Ecological Footprint, resulted from the Step 8, with the population whom the needs are met. However, each sector under study does not contribute in the same way to Ecological Footprint, as its population has different characteristics and therefore consumption needs from the others. In Step 10, the units of population for each sector is defined and they can be different from "person", e.g. residents, m^2, km, tkm, personkm, kW etc. Also, a sector can have more than one population's units, as the consumers per sectors can be multiple. In Table 5 are presented the units of population per sector. For each unit of population there is an indicator defined in order to calculate the value of the relative population. The Indicator form is Indicator P X.Y, where P stands for Population, X refers to the population subcategories, and Y refers to the numbering of the indicators- units of population per sector. An analytical description of each indicator mentioned in Table 5, its unit, its calculation type, the sector it belongs, and the required assumptions and inputs in order to be evaluated is given in Appendix C. This step is useful in order to develop scenarios to improve Carrying Capacity in Step 14, Stage 3.

Table 3-5: The units of population per sector.

Sectors	Units of population	Indicator Code
1. Households	Number of residents	Ind. P 1.1
2. Tertiary	squared meters of offices/commercial buildings	Ind. P 2.1
	squared meters of healthcare buildings	Ind. P 2.2
3. Municipal Buildings	Squared meters of educational buildings	Ind. P 3.1
4. Public Lighting	installed power for public lighting in kw	Ind. P 4.1
5. Private transportation	km passing by car	Ind. P 5.1
	km passing by motorbike	Ind. P 5.2
	km passing by heavy duty vehicle	Ind. P 5.3
6. Public transportation	km passing by car	Ind. P 6.1

	km passing by motorbike	Ind. P 6.2
	km passing by heavy duty vehicle	Ind. P 6.3
	km passing by bus	Ind. P 6.4
	personkm per year passing by train	Ind. P 6.5
	tkm per year passing by boat	Ind. P 6.6
	personkm per year passing by passenger aircraft	Ind. P 6.7
	tkm per year passing by commercial aircraft	Ind. P 6.8
7. Tourism	Number of tourists	Ind. P 7.1

3.1.11 Step 11: Calculation of the total population

In the Step 11, the total population of the protected area under study is calculated (the condition is the completion of the Step8). As the units of the populations of each sector are not the same, the populations cannot be summed. For the reasons mentioned above, a new unit is developed, namely **person equivalent**. Each person equivalent needs the average required area to sustain, therefore it contribute with the same way to Ecological Footprint. Firstly, the reference sector is defined and based on its population's unit; the populations of the other sectors will be reduced in order to allow the sum of the different population. For example, if the Carrying Capacity of a protected area, as defined in Step 1, focuses on estimating the maximum number of residents that can be sustained within the boundaries of the protected area under study, then households are selected as the reference sector. In this way, a resident is equal to a person of the population equivalent, and the populations of the other sectors (e.g. tourists) can be traced to population equivalent on the basis of their comparative effects with those of the reference sector. The reference sector can be changed if the Carrying Capacity defined in a different way.

- The total person equivalent is calculated by the Equation 1:

$$P_{eq} = \frac{P_x}{EF_x} \sum_{y=1}^{n} EF_y \quad \textbf{(Equation 1)}$$

Where:

P_{eq} states for the total population equivalent,
P_x refers to the population of the reference sector,
EF_x refers to the Ecological Footprint of the reference sector,
EF_y refers to the Ecological Footprint of the y sector,
x=1, 2,…, n, refers to the reference sector and is state for each study. The numbers are corresponded to the sectors e.g. 1=households, 2= tertiary, 3= municipal buildings, 4=public lighting, 5= private transportation, 6= public transportation, and 7=tourism.

y=1, 2,…, n, refers to the sectors. The numbers are corresponded to the sectors e.g. 1=households, 2= tertiary, 3= municipal buildings, 4=public lighting, 5= private transportation, 6= public transportation, and 7=tourism.

In this study, the sector "Households" is selected as the reference sector, thus x is equal to 1 and state.

3.1.12 Step 12: Calculation of the Ecological Footprint per person equivalent

In Step 12, the calculation of the Ecological Footprint per person equivalent is implemented. The Ecological Footprint per person equivalent is estimated by the division of the result of the Step 8 and the total person equivalent resulting from Step 11. This step is useful in order to compare the protected area under study with other protected areas' or national, European and global Ecological Footprint per capita. The aforementioned comparison is essential for the researcher as it is the first measure of comparison and suggests the measures that should be taken to improve and to what extent.

3.1.13 Step 13: Calculation of Carrying Capacity

This is the last step of Stage 2, where the Carrying capacity is assessed comparing the Ecological Footprint (Step 8) with the Biocapacity (Step 9) or the current person equivalent (Step 11) with the maximum person equivalent.

The maximum person equivalent that an area can sustain is calculated by dividing the Biocopacity to Ecological Footprint per person equivalent (Equation 2).

$$P_{eqmax} = \frac{B}{EF_{P_{eq}}} P_{eq} \text{ (**Equation 2**)}$$

Where:

P_{eqmax} is the maximum person equivalent that an area can sustain,
B is the Biocapacity of the protected area,
EF_{Peq} is the total Ecological Footprint of the protected area,
P_{eq} is the population of person equivalent.

Then, Carrying Capacity's degree of filling is calculated by the Equation 3:

$$CC=\frac{EF_{Peq}}{B} = \frac{P_{eq}}{P_{eqmax}} \text{ (**Equation 3**)}$$

Where:

CC is Carrying Capacity's degree of filling,
$\mathbf{EF_{Peq}}$ is the total Ecological Footprint of the protected area,
B is the Biocapacity of the protected area,
$\mathbf{P_{eq}}$ is the population of person equivalent,
$\mathbf{P_{eqmax}}$ is the maximum population of person equivalent that the protected area under study can sustain.

3.1.14 Step 14: Development of improvement scenarios

In Stage 3, scenarios in order to improve the Carrying Capacity of the protected area under study are developed in assistance to the equations are described above. The equivalence of the population of each sector to person equivalent is calculated by the Equation 4:

$$P_{y\,eq} = \frac{P_{eq}}{\sum_{y=1}^{n} EF_y} EF_y \quad \textbf{(Equation 4)}$$

Where:

$\mathbf{P_{yeq}}$ is the equivalence of the population of y to sector to person equivalent,
$\mathbf{P_{eq}}$ is the population of person equivalent,
$\mathbf{EF_y}$ is the Ecological Footprint of the y sector.
y=1, 2, …., n states for the sectors, e.g. 1=households, 2= tertiary, 3= municipal buildings, 4=public lighting, 5= private transportation, 6= public transportation, and 7=tourism.

The ratio of the populations of the sectors to their person equivalent is calculated by the Equation 5:

$$\alpha_y = \frac{P_y}{P_{yeq}} \quad \textbf{(Equation 5)}$$

Where:

$\boldsymbol{\alpha_y}$ is the ratio of the populations of the sectors to their person equivalent,
$\mathbf{P_y}$ is the population of y sector,
$\mathbf{P_{yeq}}$ is the equivalence of the population of y to sector to person equivalent,
y=1, 2, …., n states for the sectors, e.g. 1=households, 2= tertiary, 3= municipal buildings, 4=public lighting, 5= private transportation, 6= public transportation, and 7=tourism.

The maximum population of each sector is calculated by the Equation 6, considering that the ratio of the person equivalent composition remains stable.

$$P_{ymax} = \frac{P_{yeq}}{P_{eq}} * P_{eqmax} * \alpha_y \quad \textbf{(Equation 6)}$$

Where:

P_{ymax} is the maximum population of each sector that the protected area can sustain,
P_{yeq} is the equivalence of the population of y to sector to person equivalent,
P_{eq} is the population of person equivalent,
P_{eqmax} is the maximum population of person equivalent that the protected area under study can sustain,
α_y is the ratio of the populations of the sectors to their person equivalent,
y=1, 2,…., n states for the sectors, e.g. 1=households, 2= tertiary, 3= municipal buildings, 4=public lighting, 5= private transportation, 6= public transportation, and 7=tourism.

As the limits (maximum populations of each sector) of the protected area under study are known, hypothetical scenarios of the individual populations' fluctuation can lead to the improvement of the Carrying Capacity and at the same time to the development of a strategic planning for the sustainable development of the protected area under study.

3.2 Estimation of Carbon Footprint

For the estimation of the carbon footprint, the quantity of greenhouse gases emitted during a system's lifetime must be estimated and added. The life cycle includes all the stages of a system such as its manufacture, distribution, consumption / use, and ultimately its disposal. Life cycle assessment produces a comprehensive picture of inputs and outputs for the production of air pollutants, water use and wastewater generation, energy consumption, etc. There are standards and guidelines for the calculation of greenhouse gases. The most common of these are (Pandey et al, 2011):

- The World Resource Institute (WRI) GHG / World Business Council on Sustainable Development (WBCSD).
- The Publicly Available Specifications-2050 (PAS 2050) specification of the British Standard Institution (BSI).
- The IPCC guidelines for greenhouse gases.
- ISO 14064 guidelines.
- ISO 14025 guidelines.
- ISO 14067 guidelines

Some countries and organizations have set their own guidelines for its calculation such as the Department of Food and Rural Affairs (DEFRA) in the UK, and the US Environmental Protection Agency (EPA). Although there are several approaches to calculating the carbon footprint, most of them generally follow the following general steps:

1. Selection of the gases to be quantified.
2. Definition of the study boundaries.

3. Definition of indicators for each sector of Carbon Footprint
4. Calculation of the footprint.

3.2.1 Selection of the gases to be quantified

The choice of greenhouse gases to be included in the carbon footprint calculations depends on the instructions to be followed, the necessity of the calculations and the activity / system for which the carbon footprint is calculated. Several studies only include carbon dioxide emissions to determine the carbon footprint, while others include the associated six or less relevant gases. In this study, we calculate the Carbon Footprint from a Life Cycle Assessment perspective, hence all the relevant gases are included as equivalent to Carbon Dioxide.

3.2.2 Definition of the study boundaries

The definition of the boundaries concerns the selection of activities whose emissions will be quantified and taken into account for the calculation of the carbon footprint. Depending on the extent of the boundaries, three relative tiers have been proposed (Figure 3-14):

- Tier 1: Includes all direct emissions
- Tier 2: Includes all indirect emissions from the generation of energy used
- Tier 3: Includes all indirect emissions from activities such as transportation of the goods, travelling, dumping of products etc. (not included in step 1 and 2).

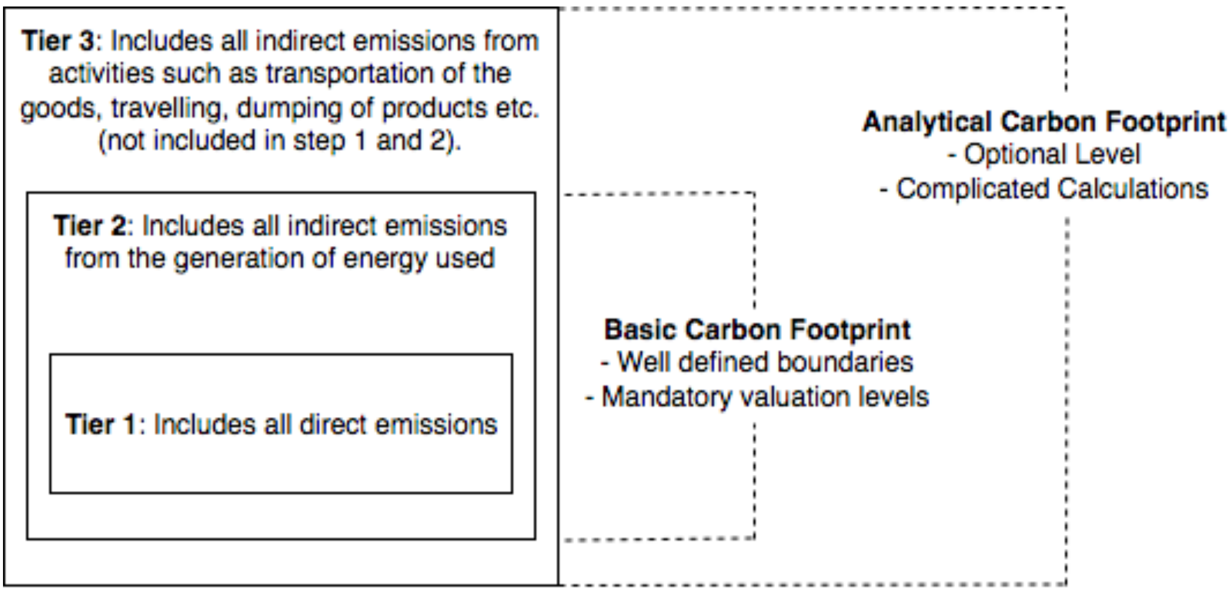


Figure 3-14: Tiers for defining system boundaries for Carbon Footprint Calculation.

As the tier increases, the boundaries of the system to be analyzed and thus the level of carbon footprint analysis are increased as well. Tier 1 and 2 are mandatory and should be included in all published studies according to most calculation guidelines. Instead, step 3 is optional. Most study thresholds are up to Grade 2, as the data required for Grade 3 are scarce and require considerable time and cost.

In this study, carbon footprint is used as a mean to facilitate the calculation of ecological footprint, and ultimately the Carrying Capacity of protected areas. In that manner, the selection of the sector which contribute to Carbon Footprint, as in the case of Ecological Footprint (chapter 3.1.4), is mostly based on the guidelines provided under the Covenant of Mayors Initiative for developing Sustainable Energy Action Pans of Municipalities.

The selected sectors, as shown in Figure 3-15, are households, tertiatry and municipal buldings, public lighting, private and public transportation, and tourism. These sectors are evaluated based on their contribution to Greenhouse Gas emissions, by examining their energy consumption.

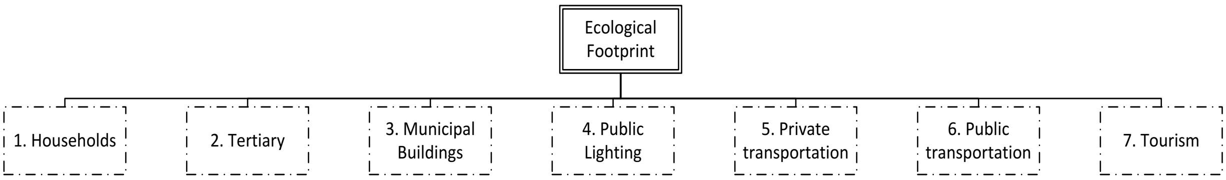


Figure 3-15. Selected sectors for Carbon Footprint estimation

3.2.3. Definition of indicators for each sector of Carbon Footprint

The categorization and definition of indicators for the Carbon Footprint calculation, follow the same pattern as the categorization of the Ecological Footprint's indicators. On Table 3-6 the Carbon Footprint's incdicators are presented, with a brief introductory description.

Table 3-6: Carbon footprint indicators

Sector	Ind. Code	Description
1. Households	CF5.1.1	Electricity Consumption in kWh per year
	CF5.2.1	Thermal Energy Consumption in kWh per year
2. Tertiary	CF5.1.2	Electricity Consumption in kWh per year
	CF5.2.2	Thermal Energy Consumption in kWh per year
3. Municipal Buildings	CF5.1.3	Electricity Consumption in kWh per year
	CF5.2.3	Thermal Energy Consumption in kWh per year
4. Public Lighting	CF5.1.4	Electricity Consumption in kWh per year
5. Private Transportation	CF5.3.5	km per year passing by private scooter
	CF5.4.5	km per year passing by private lorry
	CF5.5.5	km per year passing by private passenger car, diesel
	CF5.6.5	km per year passing by private passenger car, petrol

6. Public Transportation	CF5.3.6	km per year passing by public scooter
	CF5.4.6	km per year passing by public lorry
	CF5.5.6	km per year passing by public passenger car, diesel
	CF5.6.6	km per year passing by public passenger car, petrol
	CF5.7.6	km per year passing by regular bus
	CF5.8.6	personkm per year passing by train
	CF5.9.6	tkm per year passing by barge tanker
	CF5.10.6	tkm per year passing by ferry boat
	CF5.11.6	personkm per year passing by passenger aircraft
	CF5.12.6	tkm per year passing by freight aircraft
7. Tourism	CF5.1.7	Electricity Consumption in kWh per year
	CF5.2.7	Thermal Energy Consumption in kWh per year

3.2.4 Calculation of Carbon Footprint per sector and in total

The calculation of the carbon footprint can be approached methodologically in two basic directions: From bottom-up, based on process analysis, or from top to bottom based on the analysis of environmental inputs - outputs. The collected data is converted to equivalent CO2 tonnes using the AZ conversion factors provided by the IPCC and incorporated in the relevant method adopted (IPCC GWP 100a). These factors take into account the whole life cycle of the energy carrier. Thus, in addition to emissions from combustion, emissions from all stages of the life cycle, such as mining, supply chain, and final disposal-disposal are included.

The carbon footprint unit varies according to the characteristics of the system under consideration. The carbon footprint for individuals and dynamic processes is calculated at regular intervals, usually yearly. Events such as conferences, exhibitions, etc. present their carbon footprint once. On the other hand, there are systems for which a combination of calculations is required. For example, the carbon footprint of a building at its construction stage is calculated only once, and periodic calculations are required during its operational phase. Therefore, the time factor should be explicitly mentioned. For services such as travelling, mail, search engines, etc., emissions refer to an appropriate service unit such as equivalent CO_2 emissions per flight or per hour, etc.

As in Chapter 3.1.8, this step is carried out by multiplying the value of each indicator (Table 3-6), with the corresponding conversion factor. The conversion factors for each indicator are presented in Table 3-7.

Table 3-7. Conversion Fatcors of each indicator for the Calculation of Carbon Footprint

Sector	Ind. Code	Description	Conversion Factor (Kg CO2eq/kwh)
1. Households	CF5.1.1	Electricity Consumption in kWh per year	1,000
	CF5.2.1	Thermal Energy Consumption in kWh per year	0,388
2. Tertiary	CF5.1.2	Electricity Consumption in kWh per year	1,000
	CF5.2.2	Thermal Energy Consumption in kWh per year	0,388
3. Municipal Buildings	CF5.1.3	Electricity Consumption in kWh per year	1,000
	CF5.2.3	Thermal Energy Consumption in kWh per year	0,388
4. Public Lighting	CF5.1.4	Electricity Consumption in kWh per year	1,000
5. Private Transportation	CF5.3.5	km per year passing by private scooter	0,104
	CF5.4.5	km per year passing by private lorry	1,030
	CF5.5.5	km per year passing by private passenger car, diesel	0,214
	CF5.6.5	km per year passing by private passenger car, petrol	0,237
6.Public Transportation	CF5.3.6	km per year passing by public scooter	0,104
	CF5.4.6	km per year passing by public lorry	1,030
	CF5.5.6	km per year passing by public passenger car, diesel	0,214
	CF5.6.6	km per year passing by public passenger car, petrol	0,237
	CF5.7.6	km per year passing by regular bus	1,320
	CF5.8.6	personkm per year passing by train	0,002
	CF5.9.6	tkm per year passing by barge tanker	0,033
	CF5.10.6	tkm per year passing by ferry boat	0,035
	CF5.11.6	personkm per year passing by passenger aircraft	0,166
	CF5.12.6	tkm per year passing by freight aircraft	1,660
7. Tourism	CF5.1.7	Electricity Consumption in kWh per year	1,000
	CF5.2.7	Thermal Energy Consumption in kWh per year	0,388

The total Carbon Footprint, is calculated by the sum of the multiplications of each indicator, as Kg or Tonnes of CO2 equivalent.

3.3 Estimation of Water Footprint

3.3.1 Introduction

The present chapter presents the way of calculating and evaluating the water footprint. The water footprint was calculated according to the methodology of Hoekstra et al. (2011) and Chapagain and Hoekstra (2004) for a geographically defined area. Chapagain and Hoekstra (2004) consider the main sectors of water consumption for a nation's economy, rural, industrial and domestic. The same methodology is followed in this study.

3.3.2 Methodology

The total water footprint will be calculated by summing up the water footprints of the processes that consume and pollute the water in the areas of interest. In particular, water consumption in the agricultural sector, the industrial sector and the household sector will be assessed.

$$WF = AWU + IWU + DWW$$

where AWU is the use of water in the agricultural sector (in m^3/yr), IWU the use of water in the industrial sector (in m^3/yr) and DWW the use of water in the domestic sector (in m^3/yr). The total will be calculated in m^3/yr.

AWU is distinguished on the three components: blue, green and gray Special attention is given to agricultural water use (AWU), since agriculture is one of the most important activities in the study areas.

3.3.3 Water footprint of crops – Agricultural sector

According to Hoekstra et al. (2011)[1], the total water footprint of the cultivation process (plants and trees) is the sum of its green, blue and gray components:

$$WF_{crop} = WF_{crop,green} + WF_{crop,blue} + WF_{crop,grey}$$

and is expressed in units of volume of water to the mass of the quantity produced. The most common unit of water footprint in the agricultural sector is one (1) m3 / ton, which is used after the study.

3.3.3.1 Green water volume calculation

The green component of the water footprint of a crop (WFcrop, green) is calculated as the quotient of the volume of green water used to produce the crop to yield the crop:

$$WF_{crop,green} = \frac{CWU_{green}}{Y}$$

where CWUgreen: the total volume of green water used, in m^3/ acre
Y: crop yield, in tonnes/acre.

The green component of water use (CWUgreen) is calculated by summing the daily evaporation (ET) for the entire growing period of the plant.

$$CWU_{green} = 10 \times \sum_{d=1}^{\lg p} ET_{green}$$

where, ETgreen: the green evaporation of the plant, in mm / day

Multiplication by Factor 10 is performed to convert mm to m^3/ha. The sum is compiled for the period from the first planting day (d = 1) to the day of harvesting (lgp is the growth period of the plant in days). The green component of water use (CWUgreen) represents the rainwater evaporated from the soil during the growing period of the plant.

3.3.3.2 Blue water volume calculation

The blue component of a crop ($WF_{crop, blue}$) is calculated as green to the quotient of the volume of use of blue water for growing the crop to yield the crop:

$$WF_{crop,blue} = \frac{CWU_{blue}}{Y}$$

where, CWU_{blue}: the total volume of blue water used, in m3 / acre
Y: crop yield, in tonnes / acre.

The blue water use component (CWU) is calculated by summing the daily evaporation (ET) for the entire growing period of the plant.

$$CWU_{blue} = 10 \times \sum_{d=1}^{\lg p} ET_{blue}$$

where, ET_{blue}: the blue evaporation of the plant, in mm / day

The blue water use component (CWU_{blue}) represents the irrigation water evaporated from the soil of the field.

3.3.3.3 Grey water volume calculation

The gray component of the water footprint of the cultivation process ($WF_{crop, gray}$) is calculated as the amount of pollutant placed for fertilization per acre on the percentage of pollutant entering the water system divided by the difference in its natural concentration in the aqueous receiver, from the maximum permissible concentration of the pollutant to the yield of the crop1:

$$WF_{crop,grey} = \frac{(a \times AR)/(c_{\max} - c_{nat})}{Y}$$

where: α: the percentage of the pollutant entering the water system, in%
AR: quantity of pollutant placed in the crop for lubrication, in kg / acre,
c_{max}: maximum permissible concentration of the pollutant, in mg / l,
c_{nat}: natural concentration of pollutant in mg / l,
Y: crop yield, in tonnes / acre.

Pollutants (nitrogen, phosphorus, etc.), pesticides and insecticides are considered as pollutants. In the study, the impact of fertilizers on the pollution side was considered to be more critical, so the amounts of nitrogen and phosphorus placed for lubrication in each crop were examined.

3.3.4 Industrual and urban water use

The use of water in the industrial sector is bibliographic according to the data of the relevant management body and various management plans. In the case of study area 1, the Management Plan provides data about industrial use of water for the entire Thrace Water Department.

The use of water for the residential sector is calculated theoretically. For the purposes of this methodological framework, an average daily consumption per inhabitant of 200 lt/day was adopted. While for tourists the consumption was considered 300 liter/night. Also, the results are compared with the data of the River Basin Management Plan of the Thrace Water Department.

3.4 Summary of the Methodological Framework – Steps of Implementation

The methodological framework developed, assesses the environmental status of a protected area through the estimation of four key holistic environmental sustainability indicators: 1) Carrying Capacity (CC), 2) Ecological Footprint (EF), 3) Carbon Footprint (CF) and 4) Water Footprint (WF) (Figure 3-X).

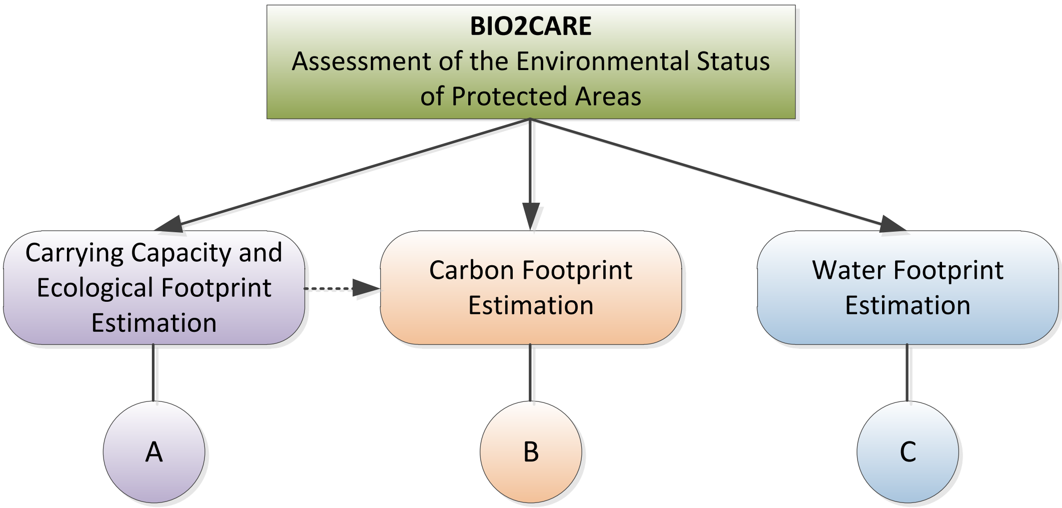


Figure 3-16: BIO2CARE methodological framework for assessing the environmental status of protected areas.

CC and EF are calculated in parallel since the extraction of EF is necessary to convert the energy and food consumption needs in land requirements in order to compare them with the Biocapacity of the examined system (actual production from available lands) and thus find the CC of the area. The estimation of CC and EF can be conducted with the implementation of 14 steps (A).

CF can be considered a sub-indicator of the EF, but it is essential to quantify and assess it on its own, since it provides a much clearer image of Global Warming Potential and Climate Change impacts. The data and information needed to estimate the CC and EF can also be utilized for the assessment of the CF. The estimation of CF can be conducted with the implementation of 4 steps (B). The WF is not directly related to the estimation of the CC of a protected area, however specific steps of implementation will also be extracted (C) in order to increase the utility of our decision support system by integrating water sufficiency related issues in our assessment. A summary of the steps that must be applied to estimate the respective indicators and the relevant chapters where comprehensive information can be found are provided below.

A

Carrying Capacity (CC) and Ecological Footprint (EF)

↓

1st Step: Definition of CC

[Set the objectives and compare EF and BC – see section 3.1.1]

↓

2nd Step: Definition of EF and its subcategories

[6 subcategories are proposed – see section 3.1.2]

↓

3rd Step: Definition of BC and its subcategories

[5 subcategories are proposed – see section 3.1.3]

↓

4th Step: Selection of sector contributing to EF

[7 sectors are proposed – see section 3.1.4]

↓

5th Step: Definition of indicators per subcategory of EF and per sector

[35 indicators are proposed – see section 3.1.5]

↓

6th Step: Definition of indicators per subcategory of BC

[6 head indicators and/or 16 sub-indicators are proposed – see section 3.1.6]

↓

7th Step: Quantification of the indicators and analysis

[Analytical guidelines on Appendix A and B – see section 3.1.7]

↓

8th Step: EF calculation per sector and in total

[Conversion factors per indicator are proposed – see section 3.1.8]

↓

9th Step: BC calculation

[Specific yield factors for GR and BG and EQFs are proposed – see section 3.1.9]

↓

10th Step: Definition of unit of population per sector

[Specific units per sector are proposed – see section 3.1.10]

↓

11th Step: Calculation of the total population

[A new unit – the total person equivalent is introduced – see section 3.1.11]

↓

12th Step: Calculation of the EF per person equivalent

[Divide 8th Step in total results with 11th Step results – see section 3.1.12]

↓

13th Step: Calculation of CC

[Compare 8th Step results with 9th Step results – see section 3.1.13]

↓

14th Step: Development of improvement scenarios

[Find and compare the maximum population of every sector – see section 3.1.14]

B

Carbon Footprint (CF)

↓

1st Step: Definition of the gases to be quantified

[CO_{2eq} including key GHG is proposed – see section 3.2.1]

↓

2nd Step: Definition of the boundaries of the study

[7 sectors are proposed to be included in the analysis – see section 3.2.2]

↓

3rd Step: Definition of indicators per sector

[23 indicators are proposed – see section 3.2.3]

↓

4th Step: Calculation of CF per sector and in total

[Conversion factors per indicator are proposed – see section 3.2.4]

C

Water Footprint (WF)

1st Step: Calculation of green water volume

[– see section 3.3.3.1]

↓

2nd Step: Calculation of blue water volume

[– see section 3.3.3.2]

↓

3rd Step: Calculation of grey water volume

[– see section 3.3.3.3]

↓

3rd Step: Calculation of Industrial and Urban water use

[Bibliographicaly – see section 3.3.4]

Most of the work described in the above mentioned steps has already been undertaken by BIO2CARE and specific suggestions are available for those who wish to assess the environmental status of a protected area. With a view to clarify information that is needed to implement the methodology (and also serve as the basis for developing the relevant e-tool/software in WP4), the following tables summarize all necessary data per examined sector that are needed in order to make a complete assessment.

Examined Sector No 1: Households

Input code	Description
Input 1.1	Number of adults residents
Input 1.2	Number of minors residents
Input 1.3	Surface (m^2) of single dwellings build before 1980
Input 1.4	Surface (m^2) of single dwellings build between 1981-2001
Input 1.5	Surface (m^2) of single dwellings build after 2002
Input 1.6	Surface (m^2) of apartment buildings build before 1980
Input 1.7	Surface (m^2) of apartment buildings build between 1981-2001
Input 1.8	Surface (m^2) of apartment buildings build after 2002

Examined Sector No 2: Tertiary

Input code	Description
Input 2.1	Number of offices/commercial buildings build before 1980
Input 2.2	Number of offices/commercial buildings build between 1981-2001
Input 2.3	Number of offices/commercial buildings build after 2002
Input 2.4	Number of healthcare buildings build before 1980
Input 2.5	Number of healthcare buildings build between 1981-2001
Input 2.6	Number of healthcare buildings build after 2002

Examined Sector No 3: Municipal buildings

Input code	Description
Input 3.1	Number of schools build before 1980
Input 3.2	Number of schools build between 1981-2001
Input 3.3	Number of schools build after 2002

Examined Sector No 4: Public lighting

Input code	Description
Input 4.1	Installed power for public lighting in kW

Examined Sector No 5: Private transportation

Input code	Description
Input 5.1	Number of private passenger cars moving on local roads
Input 5.2	Number of private passenger cars moving on highway
Input 5.3	Number of private scooters moving on local roads

Input 5.4	Number of private lorries moving on local roads
Input 5.5	Number of private lorries moving on highway
Input 5.6	km of highway set within the boundaries of protected area

Examined Sector No 6: Public transportation

Input code	Description
Input 6.1	Number of public passenger cars moving on local roads
Input 6.2	Number of public scooters moving on local roads
Input 6.3	Number of public lorries moving on local roads
Input 6.4	Number of annual passengers moving by train on local railway
Input 6.5	km of local railway set within the boundaries of the protected area
Input 6.6	t loaded or/and unloaded from or/and to barge tanker in each port
Input 6.7	km boarding in each port
Input 6.8	Passengers loaded in ferry boat in each port
Input 6.9	Lorries loaded in ferry boat in each port
Input 6.10	Buses loaded in ferry boat in each port
Input 6.11	Passenger cars loaded in ferry boat in each port
Input 6.12	Scooters loaded in ferry boat in each port
Input 6.13	Number of passengers arrived by airplane in each airport
Input 6.14	Number of passengers left by airplane in each airport
Input 6.15	t loaded to airplane in each airport
Input 6.16	t unloaded from airplane in each airport
Input 6.17	km passing by airplane during landing in each airport
Input 6.18	km passing by airplane during taking off in each airport
Input 6.19	km passing by bus within the boundaries of protected area

Examined Sector No 7: Tourism

Input code	Description
Input 7.1	Number of adults tourists
Input 7.2	Number of minors tourists
Input 7.3	Number of hotels build before 1980
Input 7.4	Number of hotels build between 1981-2001
Input 7.5	Number of hotels build after 2002

To increase the potential applicability of the methodology, a relevant tool/software will be developed in WP4 that will automate all necessary calculation.

Chapter 4 - Conclusions – Towards a holistic decision support system for assessing the environmental sustainability of protected areas

During this study a methodological framework was developed as an effective way to assess the sustainability of an area is through the quantification of the pressures that are placed on its ecosystem and are caused by human activities (e.g. through production and consumption of resources and energy, emission generation etc.) occurring within or affecting the area based on known and documented limits of these pressures. The focus on human activities was given due to the fact that sustainability requires anthropogenic systems to act within certain "ecological" limits to ensure the continuous supply of goods and resources to current and future generations. This methodological framework aims to provide the management bodies with a more holistic point of view regarding the current situation analysis and assists them to structure a strategic planning development in their area of responsibility.

The assessment of the environmental status of protected areas through the implementation of the BIO2CARE methodological framework is happening through the estimation of four key holistic environmental indicators:

- Carrying Capacity (CC)
- Ecological Footprint (EF)
- Carbon Footprint (CF)
- Water Footprint (WF)

CC and EF are calculated in parallel since the extraction of EF is necessary to convert the energy and food consumption needs in land requirements in order to compare them with the Biocapacity of the examined system (actual production from available lands) and thus find the CC of the area. The estimation of CC and EF is conducted with implementation of 14 steps, as showcased in the Chapter 3.4.

In order to assure the successful implementation of the methodological framework a proper definition of the system boundaries is necessary (especially for the calculation of CF). There are three different tiers in order to define a system under study:

- Tier 1: Includes all direct emissions
- Tier 2: Includes all indirect emissions from the generation of energy used
- Tier 3: Includes all indirect emissions from activities such as transportation of the goods, travelling, dumping of products etc. (not included in step 1 and 2).

In the case of BIO2CARE project, as showcased in Deliverable 3.1 "One study collecting information and producing knowledge regarding anthropogenic activities and status of nature (incl. SWOT analysis) of the areas", the two areas under study are:

1. Study Area 1 – National Park of Eastern Macedonia and Thrace (GR)
2. Study Area 2 – Rila National Park and catchment area of the river basin of Blagoevgradska Bistrica (BG).

Both areas under study present a lot of similar characteristics. Both of the study areas are characterized by the rich fauna of flora population, sheltering numerous species, hinting the importance they both have on the natural ecosystem of each country. In case of the methodological framework, the most important similarity of the two areas under study is the anthropogenic activities within each system's boundaries, which ensures more detailed oriented results taking into account not only the natural environment, but also the human factor within each study area.

The BIO2CARE methodological framework for assessing the carrying capacity of protected areas was developed through the implementation of scientific indicators, and the reason behind it is the need not only for a holistic approach but also to ensure the transferability of this holistic approach. By implementing the developed methodological framework to these two, similar yet different, study areas, is a first step towards proof of transferability. Further implementation is encouraged and needed in order to provide feedback and fine tune the methodological framework even further.

Within the concept of this project, the methodological framework was developed in order to assess the carrying capacity of protected areas with anthropogenic activities within their boundaries, and provide a helpful tool for the administrative bodies. The use of the methodological framework though, is not limited and it could be potentially used in a variety of different study areas:

- Cities/municipalities – serving as an administrative tool for municipal bodies in order to determine the carrying capacity within their boundaries and proceed to various actions to reduce carbon emissions, water consumption etc.

- Administrative regions – once again providing a helpful tool for the regional administrative bodies, including many more activities within the region, such as industrial activity.

- Protected areas without anthropogenic activities – fine tuning the methodological framework taking into account only the tourist section.

BIO2CARE project presents only a small amount of the capabilities of this methodological framework, which could be constantly growing in the future, expanding the implementation scenarios, specifying more indicators, serving more needs towards sustainable development.

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Appendix A: Ecological Footprint's Indicators

Indicator code:	Indicator EF 1.1
Description:	Annual bread consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.1= Indicator EF 1.1.1 + Indicator EF 1.1.7

Indicator code:	Indicator EF 1.1.1
Description:	Annual bread consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation type:	**Indicator EF 1.1.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.1.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1=** Average weight of adults residents is 70kg, **Assumption EF G.2.1=** Average weight of minors residents is 40 kg, **Assumption EF G.3.1=** Days of consumption for residents are 365 days per year, **Assumption EF 1.1.1**= Average consumption of bread in g per kg of human mass per day is 3.2g
Inputs:	**Input 1.1=** number of adults residents, **Input 1.2=** number of minors residents
Observations:	Bread: bread and rolls
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.1.7
Description:	Annual bread consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.1.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.1.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7=** Average weight of minors tourists is 40 kg, **Assumption EF G.3.7=** Days of consumption for tourists are 3 days per year, **Assumption EF 1.1.7=** Average consumption of bread in g per kg of human mass per day is 3.2g
Inputs	**Input 7.1=** number of adults tourists, **Input 7.2=** number of minors tourists
Observations:	Bread: bread and rolls
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.2
Description:	Annual potatoes consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.2= Indicator EF 1.2.1 + Indicator EF 1.2.7

Indicator code:	Indicator EF 1.2.1
Description:	Annual potatoes consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.2.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.2.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1=** Average weight of minors residents is 40 kg, **Assumption EF G.3.1=** Days of consumption for residents are 365 days per year, **Assumption EF 1.2.1=** average consumption of potatoes in g per kg of human mass per day is 6.1g.
Inputs:	**Input 1.1=** number of adults residents, **Input 1.2=** number of minors residents
Observations:	Potatoes: potatoes and potatoes products
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.2.7
Description:	Annual potatoes consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.2.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.2.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 1.2.7**= average consumption of potatoes in g per kg of human mass per day is 6.1g.
Inputs	**Input 7.1=** number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Potatoes: potatoes and potatoes products
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.3
Description:	Annual sugar consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.3= Indicator EF 1.3.1 + Indicator EF 1.3.7

Indicator code:	Indicator EF 1.3.1
Description:	Annual sugar consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.3.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.3.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 1.3.1**= average consumption of sugars in g per kg of human mass per day is 0.4g
Inputs:	**Input 1.1=** number of adults residents, **Input 1.2=** number of minors residents
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.3.7
Description:	Annual sugar consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.3.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.3.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 1.3.**7= average consumption of sugars in g per kg of human mass per day is 0.4g
Inputs	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.4
Description:	Annual cereals consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.4= Indicator EF 1.4.1 + Indicator EF 1.4.7

Indicator code:	Indicator EF 1.4.1
Description:	Annual cereals consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.4.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.4.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 1.4.1**= average consumption of cereals in g per kg of human mass per day is 1.6g
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Cereals: breakfast cereals
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.4.7
Description:	Annual cereals consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.4.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.4.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 1.4.7**=average consumption of cereals in g per kg of human mass per day is 1.6g
Inputs	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Cereals: breakfast cereals
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 1.5**
Description:	Annual flour consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.5= Indicator EF 1.5.1 + Indicator EF 1.5.7

Indicator code:	**Indicator EF 1.5.1**
Description:	Annual flour consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.5.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.5.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 1.5.1**= average consumption of flour in g per kg of human mass per day is 0.9g.
Inputs:	**Input 1.1=** number of adults residents, **Input 1.2**= number of minors residents
Observations:	Flour: grain milling products
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 1.5.7**
Description:	Annual flour consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.5.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.5.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 1.5.7**= average consumption of flour in g per kg of human mass per day is 0.9g.
Inputs	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Flour: grain milling products
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.6
Description:	Annual legumes consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.6= Indicator EF 1.6.1 + Indicator EF 1.6.7

Indicator code:	Indicator EF 1.6.1
Description:	Annual legumes consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.6.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.6.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 1.6.1**= average consumption of legumes in g per kg of human mass per day is 5.4g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Legumes: legumes, beans, dried
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.6.7
Description:	Annual legumes consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.6.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.6.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 1.6.7**= average consumption of legumes in g per kg of human mass per day is 5.4g.
Inputs	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Legumes: legumes, beans, dried
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 1.7**
Description:	Annual fruits and vegetables consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.7= Indicator EF 1.7.1 + Indicator EF 1.7.7

Indicator code:	**Indicator EF 1.7.1**
Description:	Annual fruits and vegetables consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.7.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.7.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 1.7.1**= average consumption of fruits and vegetables in g per kg of human mass per day is 53.9 g.
Inputs:	**Input 1.1=** number of adults residents, **Input 1.2**= number of minors residents
Observations:	Fruits and Vegetables: citrus, pome, stone, berries and small fruits, miscellaneous, dried fruits, jam, marmalade and other fruits spreads, other fruits products (excluding beverages) and vegetables and vegetables products (including fungi), root, bulb, fruiting, brassica, leaf, legume and stem vegetables
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 1.7.7**
Description:	Annual fruits and vegetables consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.7.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.7.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 1.7.7**= average consumption of fruits and vegetables in g per kg of human mass per day is 53.9 g.
Inputs	**Input 7.1**= number of adults tourists, I**nput 7.2=** number of minors

	tourists
Observations:	Fruits and Vegetables: citrus, pome, stone, berries and small fruits, miscellaneous, dried fruits, jam, marmalade and other fruits spreads, other fruits products (excluding beverages) and vegetables and vegetables products (including fungi), root, bulb, fruiting, brassica, leaf, legume and stem vegetables
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 1.8**
Description:	Annual beverage consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.8= Indicator EF 1.8.1 + Indicator EF 1.8.7

Indicator code:	**Indicator EF 1.8.1**
Description:	Annual beverage consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.8.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.8.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 1.8.1**=average consumption of beverage in g per kg of human mass per day is 17.9 g
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Beverage: beer and beer-like, wine, spirits, soft drinks
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 1.8.7**
Description:	Annual beverage consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.8.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.8.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg,

	Assumption EF G.3.7= Days of consumption for tourists are 3 days per year, **Assumption EF 1.8.7**= average consumption of beverage in g per kg of human mass per day is 57.2g
Inputs	**Input 7.1**: number of adults tourists, **Input 7.2**: number of minors tourists
Observations:	Beverage: beer and beer-like, wine, spirits, soft drinks
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 1.9**
Description:	Annual tobacco consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.9= Indicator EF 1.9.1 + Indicator EF 1.9.7

Indicator code:	**Indicator EF 1.9.1**
Description:	Annual tobacco consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.9.1**= Assumption EF 1.9.1b * Input 1.1 * Assumption EF 1.9.1a * Assumption EF G.3.1
Assumptions:	**Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 1.9.1a**= Greeks consume on average 20g tobacco per day, **Assumption EF 1.9.1b**= 40% of Greeks are smokers
Inputs:	**Input 1.1:** number of adults residents
Sources:	Special Eurobarometer 332, European Commission, May 2010

Indicator code:	**Indicator EF 1.9.7**
Description:	Annual tobacco consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.9.7**= Assumption EF 1.9.7b* Input 7.1* Assumption EF 1.9.7a * Assumption EF G.3.7
Assumptions:	**Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 1.9.7a**= Europeans consume on average 10g tobacco per day, **Assumption EF 1.9.7b**= 29% of Europeans are smokers
Inputs	**Input 7.1:** number of adults tourists
Sources:	Special Eurobarometer 332, European Commission, May 2010

Indicator code:	**Indicator EF 1.10**
Description:	Annual rice consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.10= Indicator EF 1.10.1 + Indicator EF 1.10.7

Indicator code:	**Indicator EF 1.10.1**
Description:	Annual rice consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.10.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.10.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 1.10.1**= average consumption of rice in g per kg of human mass per day is 10g.
Inputs:	**Input 1.1=** number of adults residents, **Input 1.2=** number of minors residents
Observations:	Rice: rice-based meals
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 1.10.7**
Description:	Annual rice consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.10.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.10.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 1.10.7**= average consumption of rice in g per kg of human mass per day is 10g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Rice: rice-based meals
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.11
Description:	Annual vegetables oil consumption
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 1.11= Indicator EF 1.11.1 + Indicator EF 1.11.7

Indicator code:	Indicator EF 1.11.1
Description:	Annual vegetables oil consumption in households
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	1.Households
Calculation Type:	**Indicator EF 1.11.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 1.11.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 1.11.1**= average consumption of vegetables oil in g per kg of human mass per day is 1.3g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Vegetables oil: vegetables fats and oils
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 1.11.7
Description:	Annual vegetables oil consumption in tourism
Unit:	In tones per year
EF Subcategory:	1.Agricultural products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 1.11.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 1.11.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 1.11.7**= average consumption of vegetables oil in g per kg of human mass per day is 1.3g.
Inputs:	Input 7.1: number of adults tourists, Input 7.2: number of minors tourists
Observations:	Vegetables oil: vegetables fats and oils
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.1
Description:	Annual pork meat consumption
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 2.1= Indicator EF 2.1.1 + Indicator EF 2.1.7

Indicator code:	Indicator EF 2.1.1
Description:	Annual pork meat consumption in households
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households
Calculation Type:	**Indicator EF 2.1.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 2.1.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 2.1.1**= average consumption of pork meat in g per kg of human mass per day is 4.4g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Pork meat: livestock meat
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.1.7
Description:	Annual pork meat consumption in tourism
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 2.1.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 2.1.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 2.1.7**= average consumption of pork meat in g per kg of human mass per day is 4.4g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Pork meat: livestock meat
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 2.2**
Description:	Annual beef meat consumption
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 2.2= Indicator EF 2.2.1 + Indicator EF 2.2.7

Indicator code:	**Indicator EF 2.2.1**
Description:	Annual beef meat consumption in households
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households
Calculation Type:	**Indicator EF 2.2.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 2.2.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 2.2.1**= average consumption of beef meat in g per kg of human mass per day is 4.1g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Beef meat: edible offal, farmed animals
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 2.2.7**
Description:	Annual beef meat consumption in tourism
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 2.2.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 2.2.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 2.2.7**= average consumption of beef meat in g per kg of human mass per day is 4.1g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2=** number of minors tourists
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 2.3**
Description:	Annual sausages consumption
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 2.3= Indicator EF 2.3.1 + Indicator EF 2.3.7

Indicator code:	**Indicator EF 2.3.1**
Description:	Annual sausages consumption in households
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households
Calculation Type:	**Indicator EF 2.3.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 2.3.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 2.3.1**= average consumption of sausages in g per kg of human mass per day is 2g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 2.3.7**
Description:	Annual sausages consumption in tourism
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 2.3.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 2.3.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 2.3.7**= average consumption of sausages in g per kg of human mass per day is 2g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 2.4**
Description:	Annual chicken consumption
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 2.4= Indicator EF 2.4.1 + Indicator EF 2.4.7

Indicator code:	**Indicator EF 2.4.1**
Description:	Annual chicken consumption in households
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households
Calculation Type:	**Indicator EF 2.4.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 2.4.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 2.4.1**= average consumption of chicken in g per kg of human mass per day 3.2g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Chicken: poultry
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 2.4.7**
Description:	Annual chicken consumption in tourism
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 2.4.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 2.4.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 2.4.7**= average consumption of chicken in g per kg of human mass per day 3.2g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Chicken: poultry
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.5
Description:	Annual eggs consumption
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 2.5= Indicator EF 2.5.1 + Indicator EF 2.5.7

Indicator code:	Indicator EF 2.5.1
Description:	Annual eggs consumption in households
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households
Calculation Type:	**Indicator EF 2.5.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 2.5.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 2.5.1**= average consumption of eggs in g per kg of human mass per day is 2.6g.
Inputs:	Input 1.1: number of adults residents, Input 1.2: number of minors residents
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.5.7
Description:	Annual eggs consumption in tourism
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 2.5.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 2.5.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 2.5.7**= average consumption of eggs in g per kg of human mass per day is 2.6g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.6
Description:	Annual milk consumption
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 2.6= Indicator EF 2.6.1 + Indicator EF 2.6.7

Indicator code:	Indicator EF 2.6.1
Description:	Annual milk consumption in households
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households
Calculation Type:	**Indicator EF 2.6.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 2.6.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 2.6.1**= average consumption of milk in g per kg of human mass per day is 32.5g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Milk: liquid and concentrated milk and milk based beverages
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.6.7
Description:	Annual milk consumption in tourism
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 2.6.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 2.6.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 2.6.7**= average consumption of milk in g per kg of human mass per day is 32.5g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Milk: liquid and concentrated milk and milk based beverages
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.7
Description:	Annual cheese consumption
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 2.7= Indicator EF 2.7.1 + Indicator EF 2.7.7

Indicator code:	Indicator EF 2.7.1
Description:	Annual cheese consumption in households
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households
Calculation Type:	**Indicator EF 2.7.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 2.7.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 2.7.1**= average consumption of cheese in g per kg of human mass per day is 2g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.7.7
Description:	Annual cheese consumption in tourism
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 2.7.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 2.7.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7=**Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 2.7.7**= average consumption of cheese in g per kg of human mass per day is 2g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.8
Description:	Annual butter consumption
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 2.8= Indicator EF 2.8.1 + Indicator EF 2.8.7

Indicator code:	Indicator EF 2.8.1
Description:	Annual butter consumption in households
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	1.Households
Calculation Type:	**Indicator EF 2.8.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 2.8.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 2.8.1**= average consumption of butterin g per kg of human mass per day is 0.7g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Butter: animals fat, margarine and similar products
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 2.8.7
Description:	Annual butter consumption in tourism
Unit:	In tones per year
EF Subcategory:	2.Livestock products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 2.8.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 2.8.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 2.8.7**= average consumption of butter in g per kg of human mass per day is 0.7g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Butter: animals fat, margarine and similar products
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 3.1**
Description:	Annual fish consumption
Unit:	In tones per year
EF Subcategory:	3. Fishery and Aquaculture products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 3.1= Indicator EF 3.1.1 + Indicator EF 3.1.7

Indicator code:	**Indicator EF 3.1.1**
Description:	Annual fish meat consumption in households
Unit:	In tones per year
EF Subcategory:	3. Fishery and Aquaculture products
Sectors:	1.Households
Calculation Type:	**Indicator EF 3.1.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 3.1.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 3.1.1**= average consumption of fish meat in g per kg of human mass per day is 4.5g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 3.1.7**
Description:	Annual fish consumption in tourism
Unit:	In tones per year
EF Subcategory:	3. Fishery and Aquaculture products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 3.1.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 3.1.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 3.1.7**= average consumption of fish meat in g per kg of human mass per day is 4.5g.
Inputs:	**Input 7.1**: number of adults tourists, **Input 7.2**: number of minors tourists
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 3.2
Description:	Annual seafood consumption
Unit:	In tones per year
EF Subcategory:	3. Fishery and Aquaculture products
Sectors:	1.Households and 7.Tourism
Calculation Type:	Indicator EF 3.2= Indicator EF 3.2.1 + Indicator EF 3.2.7

Indicator code:	Indicator EF 3.2.1
Description:	Annual seafood consumption in households
Unit:	In tones per year
EF Subcategory:	3. Fishery and Aquaculture products
Sectors:	1.Households
Calculation Type:	**Indicator EF 3.2.1**= [(Assumption EF G1.1 * Input 1.1) + (Assumption EF G.2.1 * Input 1.2)]* Assumption EF 3.2.1* Assumption EF G.3.1
Assumptions:	**Assumption EF G.1.1**=Average weight of adults residents is 70kg, **Assumption EF G.2.1**= Average weight of minors residents is 40 kg, **Assumption EF G.3.1**= Days of consumption for residents are 365 days per year, **Assumption EF 3.2.1**=average consumption of seafood in g per kg of human mass per day is 7.3g.
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Seafood: crustaceans, water mollusks, amphibians, reptiles, snails and insects
Sources:	European Food Safety Authority

Indicator code:	Indicator EF 3.2.7
Description:	Annual seafood consumption in tourism
Unit:	In tones per year
EF Subcategory:	3. Fishery and Aquaculture products
Sectors:	7.Tourism
Calculation Type:	**Indicator EF 3.2.7**= [(Assumption EF G.1.7* Input 7.1)+(Assumption EF G.2.7 * Input 7.2)] * Assumption EF 3.2.7 * Assumption EF G.3.7
Assumptions:	**Assumption EF G.1.7**=Average weight of adults tourists is 70kg, **Assumption EF G.2.7**= Average weight of minors tourists is 40 kg, **Assumption EF G.3.7**= Days of consumption for tourists are 3 days per year, **Assumption EF 3.2.7**= average consumption of seafood in g per kg of human mass per day is 7.3g.
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors tourists
Observations:	Seafood: crustaceans, water mollusks, amphibians, reptiles, snails and insects

Sources:	European Food Safety Authority

Indicator code:	**Indicator EF 4.1**
Description:	Annual paper consumption
Unit:	In tones per year
EF Subcategory:	4. Timber products
Sectors:	1.Households
Calculation Type:	Indicator EF 4.1= Indicator EF 4.1.1
	Indicator EF 4.1.1= (Input 1.1 + Input 1.2) * Assumption EF 4.1.1
Assumptions:	**Assumption EF 4.1.1**= Average consumption of paper per capita per year in Greece is 79 kg
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents
Observations:	Paper: paper and board
Sources:	European Recycling Industries’ Confederation. EU-28 Recovered paper statistics (reference year 2014).

Indicator code:	**Indicator EF 5.1**
Description:	Annual electricity consumption
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	1.Households, 2.Tertiary, 3. Municipal Buildings, 4. Public Lighting and 7.Tourism
Calculation Type:	Indicator EF 5.1= Indicator EF 5.1.1+Indicator EF 5.1.2+ Indicator EF 5.1.3+Indicator EF 5.1.4+Indicator EF 5.1.7

Indicator code:	**Indicator EF 5.1.1**
Description:	Annual electricity consumption in households
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	1. Households
Calculation Type:	**Indicator EF 5.1.1**= (Input 1.3* Assumption EF5.1.1a) + (Input 1.4* Assumption EF 5.1.1b)+ (Input 1.5* Assumption EF 5.1.1c) + (Input 1.6* Assumption EF 5.1.1d) + (Input 1.7*Assumption EF 5.1.1e) + (Input 1.8* Assumption EF 5.1.1f)
Assumptions:	**Assumption EF5.1.1a**= average electrical energy consumption per m^2 for single dwellings 1980 is 24.08 kWh/m^2, **Assumption EF 5.1.1b**= average electrical energy consumption per m^2 for single dwellings 2001 is 34.99 kWh/m^2, **Assumption EF 5.1.1c**= average electrical energy consumption per m^2 for single dwellings 2010 is 33.74 kWh/m^2, **Assumption EF**

	5.1.1d= average electrical energy consumption per m^2 for apartment buildings 1980 is 25.77 kWh/m^2, **Assumption EF 5.1.1e**= average electrical energy consumption per m^2 for apartment buildings 2001 is 36.99 kWh/m^2, **Assumption EF 5.1.1f**= average electrical energy consumption per m^2 for apartment buildings 2010 is 35.45 kWh/m^2
Inputs:	**Input 1.3=** surface (in m^2) of single dwellings build before 1980, **Input 1.4=** surface (in m^2) of single dwellings build between 1981-2001, **Input 1.5=** surface (in m^2) of single dwellings build after 2002, **Input 1.6=** surface (in m^2) of apartment buildings build before 1980, **Input 1.7=** surface (in m^2) of apartment buildings build between 1981-2001, **Input 1.8=** surface (in m^2) of apartment buildings build after 2002
Sources:	Garlia et al., 2007

Indicator code:	**Indicator EF 5.1.2**
Description:	Annual electricity consumption in tertiary sector
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	2. Tertiary Sector
Calculation Type:	**Indicator EF 5.1.2**= (Input 2.1* Assumption EF G.1.2* Assumption EF 5.1.2a)+ (Input 2.2* Assumption EF G.2.2* Assumption EF 5.1.2b)+ (Input 2.3* Assumption EF G.3.2* Assumption EF 5.1.2c)+ (Input 2.4* Assumption EF G.4.2* Assumption EF 5.1.2d)+ (Input 2.5* Assumption EF G.5.2* Assumption EF 5.1.2e)+ (Input 2.6* Assumption EF G.6.2* Assumption EF 5.1.2f)
Assumptions:	**Assumption EF 5.1.2a**= average electrical energy consumption per m^2 for offices/commercial buildings 1980 is 39 kWh/m^2, **Assumption EF 5.1.2b**= average electrical energy consumption per m^2 for offices/commercial buildings 2001 is 51 kWh/m^2, **Assumption EF 5.1.2c**= average electrical energy consumption per m^2 for offices/commercial buildings 2010 is 64 kWh/m^2, **Assumption EF 5.1.2d**= average electrical energy consumption per m^2 for healthcare buildings 1980 is 82 kWh/m^2, **Assumption EF 5.1.2e**= average electrical energy consumption per m^2 for healthcare buildings 2001, 94 kWh/m^2, **Assumption EF 5.1.2f**= average electrical energy consumption per m^2 for healthcare buildings 2010 is 104 kWh/m^2, **Assumption EF G.1.2**= average surface (m^2) of offices/commercial buildings build before 1980 is 450 m^2, **Assumption EF G.2.2=** average surface (m^2) of offices/commercial buildings build between 1981- 2001 is 900 m^2, **Assumption EF G.3.2**= average surface (m^2) of offices/commercial buildings build after 2001 is 1200 m^2, and **Assumption EF G.4.2**= average surface (m^2) of healthcare buildings build before 1980 is 1666 m^2, **Assumption EF G.5.2=** average surface (m^2) of healthcare buildings build between 1981-2001 is 8922 m^2, **Assumption**

	EF G.6.2= average surface (m^2) of healthcare buildings build after 2001 is 10305 m^2
Inputs:	**Input 2.1**= number of offices/commercial buildings build before 1980, **Input 2.2=** number of offices/commercial buildings build between 1981-2001, **Input 2.3**= number of offices/commercial buildings build after 2001, **Input 2.4**= number of healthcare buildings build before 1980, **Input 2.5=** number of healthcare buildings build between 1981-2001, **Input 2.6=** number of healthcare buildings build after 2001
Sources:	Balaras et al., 2007

Indicator code:	**Indicator EF 5.1.3**
Description:	Annual electricity consumption in municipal buildings
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	3. Municipal Buildings
Calculation Type:	**Indicator EF 5.1.3**= (Input 3.1* Assumption EF G.1.3 * Assumption EF 5.1.3a) + (Input 3.2* Assumption EF G.2.3 *Assumption EF 5.1.3b)+ (Input 3.3* Assumption EF G.3.3 *Assumption EF 5.1.3c)
Assumptions:	**Assumption EF 5.1.3a=** average electrical energy consumption per m^2 for schools 1980 is 18 kWh/m^2, **Assumption EF 5.1.3b=** average electrical energy consumption per m^2 for schools 2001 is 19 kWh/m^2, **Assumption EF 5.1.3c=** average electrical energy consumption per m^2 for schools 2010, 20 kWh/m^2, **Assumption EF G.1.3**= average surface (m^2) of schools build before 1980 is 1500 m^2, **Assumption EF G.2.3**= average surface (m^2) of schools build between 1981-2001 is 1702 m^2, **Assumption EF G.3.3**= average surface (m^2) of schools build after 2001 is 1801 m^2
Inputs:	**Input 3.1**= number of schools build before 1980, **Input 3.2=** number of schools build between 1981-2001, **Input 3.3=** number of schools build after 2001
Sources:	Balaras et al., 2007

Indicator code:	**Indicator EF 5.1.4**
Description:	Annual electricity consumption in public lighting
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	4. Public Lighting
Calculation Type:	**Indicator EF 5.1.4**= Input 4.1* Assumption EF 5.1.4
Assumptions:	**Assumption EF 5.1.4**= The average time of lights' operation per year is 4,065 hours
Inputs:	**Input 4.1**= Installed power for public lighting in kW.
Sources:	SEAP Guidelines (Covenant of Mayors)

Indicator code:	Indicator EF 5.1.7
Description:	Annual electricity consumption in tourism
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	7. Tourism
Calculation Type:	**Indicator EF 5.1.7**= (**Input 7.3*** **Assumption EF G.4.7*** **Assumption EF 5.1.7a**) + (**Input 7.4*** **Assumption EF G.5.7** * **Assumption EF 5.1.7b**) + (**Input 7.5*** **Assumption EF G.6.7*** **Assumption EF 5.1.7c**)
Assumptions:	**Assumption EF 5.1.7a=** average electrical energy consumption per m^2 for hotels 1980 is 54 kWh/m^2, **Assumption EF 5.1.7b=** average electrical energy consumption per m^2 for hotels 2001 is 86 kWh/m^2, **Assumption EF 5.1.7c=** average electrical energy consumption per m^2 for hotels 2010 is 102 kWh/m^2, **Assumption EF G.4.7**= average surface (m^2) for hotels build before 1980 is 1632 m^2, **Assumption EF G.5.7**= average surface (m^2) for hotels build between 1981-2001 is 2798 m^2, **Assumption EF G.6.7**= average surface (m^2) for hotels build after 2001 is 3496 m^2
Inputs:	**Input 7.3**= number of hotels build before 1980, **Input 7.4**= number of hotels build between 1981-2001, **Input 7.5**= number of hotels build after 2002
Sources:	Balaras et al., 2007

Indicator code:	Indicator EF 5.2
Description:	Annual thermal energy consumption
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	1.Households, 2.Tertiary, 3. Municipal Buildings and 7.Tourism
Calculation Type:	Indicator EF 5.2= Indicator EF 5.2.1+Indicator EF 5.2.2+ Indicator EF 5.2.3+Indicator EF 5.2.7

Indicator code:	Indicator EF 5.2.1
Description:	Annual thermal energy consumption in households
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	1.Households
Calculation Type:	**Indicator EF 5.2.1**= [(Input 1.3* Assumption EF 5.2.1a)+ (Input 1.4* Assumption EF 5.2.1b)+ (Input 1.5* Assumption EF 5.2.1c)+ (Input 1.6* Assumption EF 5.2.1d)+ (Input 1.7* Assumption EF 5.2.1e)+ (Input 1.8* Assumption EF 5.2.1f)]*(1- Assumption EF G.4.1)
Assumptions:	**Assumption EF 5.2.1a**= average thermal energy consumption per m^2 for single dwellings 1980 is 159.4 kWh/m^2, **Assumption EF 5.2.1b**= average thermal energy consumption per m^2 for single dwellings 2001 is 145.1

	kWh/m^2, **Assumption EF 5.2.1c**= average thermal energy consumption per m^2 for single dwellings 2010 is 107.7 kWh/m^2, and **Assumption EF 5.2.1d**= average thermal energy consumption per m^2 for apartment buildings 1980 is 110.8 kWh/m^2, **Assumption EF 5.2.1e**= average thermal energy consumption per m^2 for apartment buildings 2001 is 109 kWh/m^2, **Assumption EF 5.2.1f**= average thermal energy consumption per m^2 for apartment buildings 2010 is 90.4 kWh/m^2, **Assumption EF G.4.1=** % reduction on fuel combustion for heating due to poverty is 30%
Inputs:	**Input 1.3**= surface (in m^2) of single dwellings build before 1980, **Input 1.4**= surface (in m^2) of single dwellings build between 1981-2001, **Input 1.5**= surface (in m^2) of single dwellings build after 2002, **Input 1.6**= surface (in m^2) of apartment buildings build before 1980, **Input 1.7**= surface (in m^2) of apartment buildings build between 1981-2001, **Input 1.8**= surface (in m^2) of apartment buildings build after 2002
Sources:	Garlia et al., 2007

Indicator code:	**Indicator EF 5.2.2**
Description:	Annual thermal energy consumption in tertiary sector
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	2.Tertiary Sector
Calculation Type:	**Indicator EF 5.2.2**= [(Input 2.1* Assumption EF G.1.2* Assumption EF 5.2.2a)**+** (Input 2.2* Assumption EF G.2.2* Assumption EF 5.2.2b)+ (Input 2.3* Assumption EF G.3.2* Assumption EF 5.2.2c)+ (Input 2.4* Assumption EF G.4.2* Assumption EF 5.2.2d) **+** (Input 2.5* Assumption EF G.5.2* Assumption EF 5.2.2e)**+** (Input 2.6* Assumption EF G.6.2* Assumption EF 5.2.2f)]*(1- Assumption EF G.7.2)
Assumptions:	**Assumption EF 5.2.2a**= average thermal energy consumption per m^2 for offices/commercial buildings 1980 is 107 kWh/m^2, **Assumption EF 5.2.2b**= average thermal energy consumption per m^2 for offices/commercial buildings 2001 is 89 kWh/m^2, **Assumption EF 5.2.2c**= average thermal energy consumption per m^2 for offices/commercial buildings 2010 is 83 kWh/m^2, and **Assumption EF 5.2.2d**= average thermal energy consumption per m^2 for healthcare buildings 1980 is 188 kWh/m^2, **Assumption EF 5.2.2e**= average thermal energy consumption per m^2 for healthcare buildings 2001 is 168 kWh/m^2, **Assumption EF 5.2.2f**= average thermal energy consumption per m^2 for healthcare buildings 2010 is 160 kWh/m^2, **Assumption EF G.1.2=** average surface (m^2) of offices/commercial buildings build before 1980 is 450 m^2, **Assumption EF G.2.2=** average surface (m^2) of offices/commercial buildings build between 1981- 2001 is 900 m^2, **Assumption EF G.3.2=** average surface (m^2) of offices/commercial buildings build after 2001 is

	1200 m^2, and **Assumption EF G.4.2=** average surface (m^2) of healthcare buildings build before 1980 is 1666 m^2, **Assumption EF G.5.2=** average surface (m^2) of healthcare buildings build between 1981-2001 is 8922 m^2, **Assumption EF G.6.2=** average surface (m^2) of healthcare buildings build after 2001 is 10305 m^2 , **Assumption EF G.7.2=** % reduction on fuel combustion for heating due to poverty is 30%
Inputs:	**Input 2.1**= number of offices/commercial buildings build before 1980, **Input 2.2**= number of offices/commercial buildings build between 1981-2001, **Input 2.3**= number of offices/commercial buildings build after 2002, **Input 2.4**= number of healthcare buildings build before 1980, **Input 2.5**= number of healthcare buildings build between 1981-2001, **Input 2.6**= number of healthcare buildings build after 2001
Sources:	Balaras et al., 2007

Indicator code:	**Indicator EF 5.2.3**
Description:	Annual thermal consumption in municipal buildings
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	3.Municipal Buildings
Calculation Type:	**Indicator EF 5.2.3**= (Input 3.1* Assumption EF G.1.3* Assumption EF 5.2.3a) **+** (Input 3.2* Assumption EF G.2.3* Assumption EF 5.2.3b)**+** (Input 3.3* Assumption EF G.3.3* Assumption EF 5.2.3c)
Assumptions:	**Assumption EF 5.2.3a=** average thermal energy consumption per m^2 for schools 1980 is 37 kWh/m^2, **Assumption EF 5.2.3b=** average thermal energy consumption per m^2 for schools 2001 is 36 kWh/m^2, **Assumption EF 5.2.3c=** average thermal energy consumption per m^2 for schools 2010 is 36 kWh/m^2, **Assumption EF G.1.3**= average surface (m^2) of schools build before 1980 is 1500 m^2, **Assumption EF G.2.3**= average surface (m^2) of schools build between 1981-2001 is 1702 m^2, **Assumption EF G.3.3**= average surface (m^2) of schools build after 2001 is 1801 m^2
Inputs:	**Input 3.1**= number of schools build before 1980, **Input 3.2**= number of schools build between 1981-2001, **Input 3.3**= number of schools build after 2001
Sources:	Balaras et al., 2007

Indicator code:	**Indicator EF 5.2.7**
Description:	Annual thermal consumption in tourism
Unit:	In kWh per year
EF Subcategory:	5. CO2 emissions
Sectors:	7. Tourism
Calculation Type:	**Indicator EF 5.2.7**= (Input 7.3* Assumption EF G.4.7 * Assumption EF 5.2.7a)+ (Input 7.4* Assumption EF G.5.7* Assumption EF 5.2.7b)+ (Input

	7.5* Assumption EF G.6.7* Assumption EF 5.2.7c)
Assumptions:	**Assumption EF 5.2.7a=** average thermal energy consumption per m^2 for hotels 1980 is 113kWh/m^2, **Assumption EF 5.2.7b=** average thermal energy consumption per m^2 for hotels 2001 is 99 kWh/m^2, **Assumption EF 5.2.7c=** average thermal energy consumption per m^2 for hotels 2010 is 92 kWh/m^2, **Assumption EF G.4.7**= average surface (m^2) for hotels build before 1980 is 1632 m^2, **Assumption EF G.5.7**= average surface (m^2) for hotels build between 1981-2001 is 2798 m^2, **Assumption EF G.6.7**= average surface (m^2) for hotels build after 2001 is 3496 m^2
Inputs:	**Input 7.3**= number of hotels build before 1980, **Input 7.4**= number of hotels build between 1981-2001, **Input 7.5**= number of hotels build after 2001
Sources:	Balaras et al., 2007

Indicator code:	**Indicator EF 5.3**
Description:	Annual km passing by motorbike
Unit:	In km per year
EF Subcategory:	5. CO2 emissions
Sectors:	5. Private transportation, 6. Public transportation
Calculation Type:	Indicator EF 5.3= Indicator EF 5.3.5+Indicator EF 5.3.6

Indicator code:	**Indicator EF 5.3.5**
Description:	Annual km passing by private motorbike
Unit:	In km per year
EF Subcategory:	5. CO2 emissions
Sectors:	5.Private transportation
Calculation Type:	**Indicator EF 5.3.5**= Input 5.3* Assumption EF G.1.5
Assumptions:	**Assumption EF G.1.5=** average km passing by vehicle on local roads per year are 7500 km/year.
Inputs:	**Input 5.3**= number of private motorbikes moving on local roads
Sources:	SEAP Guidelines (Covenant of Mayors)

Indicator code:	**Indicator EF 5.3.6**
Description:	Annual km passing by public motorbike
Unit:	In km per year
EF Subcategory:	5. CO2 emissions
Sectors:	6.Public transportation
Calculation Type:	**Indicator EF 5.3.6**= Input 6.2* Assumption EF G.1.6
Assumptions:	**Assumption EF G.1.6=** average km passing by vehicle on local roads per year are 7500 km/year.
Inputs:	**Input 6.2**= number of public motorbikes moving on local roads

Sources:	SEAP Guidelines (Covenant of Mayors)

Indicator code:	**Indicator EF 5.4**
Description:	Annual km passing by heavy duty vehicle
Unit:	In km per year
EF Subcategory:	5. CO2 emissions
Sectors:	5.Private transportation, 6. Public transportation
Calculation Type:	Indicator EF 5.4= Indicator EF 5.4.5+Indicator EF 5.4.6

Indicator code:	**Indicator EF 5.4.5**
Description:	Annual km passing by private heavy duty vehicle
Unit:	In km per year
EF Subcategory:	5. CO2 emissions
Sectors:	5.Private transportation
Calculation Type:	**Indicator EF 5.4.5= (Input 5.4* Assumption EF G.1.5)+[$\sum_{x=1}^{x=n}$(Input 5.5x* Input 5.6x)]**
Assumptions:	**Assumption EF G.1.5=** average km passing by vehicle on local roads per year are 7500 km/year.
Inputs:	**Input 5.4**= number of private heavy duty vehicles moving on local roads, **Input 5.5**= number of private heavy duty vehicles moving on each part of highway set within the boundaries of the protected area, **Input 5.6**= km of each part of highway set within the boundaries of the protected area
Observations:	x are the number of parts of the highway set within the boundaries of the protected area
Sources:	SEAP Guidelines (Covenant of Mayors)

Indicator code:	**Indicator EF 5.4.6**
Description:	Annual km passing by public heavy duty vehicle
Unit:	In km per year
EF Subcategory:	5. CO2 emissions
Sectors:	6.Public transportation
Calculation Type:	**Indicator EF 5.4.6**= Input 6.3* Assumption EF G.1.6
Assumptions:	**Assumption EF G.1.6=** average km passing by vehicle on local roads per year are 7500 km/year.
Inputs:	**Input 6.3**= number of public heavy duty vehicle moving on local roads
Sources:	SEAP Guidelines (Covenant of Mayors)

Indicator code:	**Indicator EF 5.5**
Description:	Annual km passing by car fueled by diesel
Unit:	In km per year
EF Subcategory:	5. CO2 emissions

Sectors:	5.Private transportation, 6. Public transportation
Calculation Type:	Indicator EF 5.5= Indicator EF 5.5.5+Indicator EF 5.5.6

Indicator code:	**Indicator EF 5.5.5**
Description:	Annual km passing by private car fueled by diesel
Unit:	In km per year
EF Subcategory:	5. CO_2 emissions
Sectors:	5.Private transportation
Calculation Type:	**Indicator EF 5.5.5**= Assumption EF 5.5.5 *[(Input 5.1* Assumption EF G.1.5) +$\sum_{x=1}^{x=n}$(Input 5.2x* Input 5.6x)]
Assumptions:	**Assumption EF G.1.5=** average km passing by vehicle on local roads per year are 7500 km/year, **Assumption EF 5.5.5**= The national percentage of car fueled by diesel is 17%.
Inputs:	**Input 5.1**= number of private car moving on local roads, **Input 5.2**= number of private car moving on the each part of the highway set within the boundaries of the protected area, **Input 5.6**= km of the each part of the highway set within the boundaries of protected area
Observations:	x is the number of the parts of the highway set within the boundaries of the protected area
Sources:	SEAP Guidelines (Covenant of Mayors)

Indicator code:	**Indicator EF 5.5.6**
Description:	Annual km passing by public car fueled by diesel
Unit:	In km per year
EF Subcategory:	5. CO_2 emissions
Sectors:	6.Public transportation
Calculation Type:	**Indicator EF 5.5.6**= Input 6.1* Assumption EF 5.5.6* Assumption EF G.1.6
Assumptions:	**Assumption EF G.1.6=** average km passing by vehicle on local roads per year are 7500 km/year, **Assumption EF 5.5.6**= The national percentage of car fueled by diesel is 17%.
Inputs:	**Input 6.1**= number of public car moving on local roads.
Sources:	SEAP Guidelines (Covenant of Mayors)

Indicator code:	**Indicator EF 5.6**
Description:	Annual km passing by car fueled by petrol
Unit:	In km per year
EF Subcategory:	5. CO_2 emissions
Sectors:	5.Private transportation, 6. Public transportation
Calculation Type:	Indicator EF 5.6= Indicator EF 5.6.5+Indicator EF 5.6.6

Indicator code:	Indicator EF 5.6.5
Description:	Annual km passing by private car fueled by petrol
Unit:	In km per year
EF Subcategory:	5. CO2 emissions
Sectors:	5.Private transportation
Calculation Type:	Indicator EF 5.6.5= Assumption EF 5.6.5 *[(Input 5.1* Assumption EF G.1.5)+$\sum_{x=1}^{x=n}$(Input 5.2x* Input 5.6x)]
Assumptions:	**Assumption EF G.1.5**= the average km passing by vehicle on local roads per year are 7500 km/year, **Assumption EF 5.6.5**= the national percentage of car fueled by petrol is 83%.
Inputs:	**Input 5.1=** number of private car moving on local roads, **Input 5.2**= number of private car moving on each part of the highway set within the boundaries of the protected area, **Input 5.6**= km of each part of the highway set within the boundaries of the protected area
Observations:	n is the number of the parts of the highway set within the boundaries of the protected area
Sources:	SEAP Guidelines (Covenant of Mayors)

Indicator code:	Indicator EF 5.6.6
Description:	Annual km passing by public car fueled by petrol
Unit:	In km per year
EF Subcategory:	5. CO2 emissions
Sectors:	6.Public transportation
Calculation Type:	**Indicator EF 5.6.6**= Input 6.1* Assumption EF 5.6.6* Assumption EF G.1.6
Assumptions:	**Assumption EF G.1.6**= the average km passing by vehicle on local roads per year is 7500 km/year, **Assumption EF 5.6.6=** The national percentage of car fueled by petrol is 83%.
Inputs:	**Input 6.1**= number of public car moving on local roads.
Sources:	SEAP Guidelines (Covenant of Mayors)

Indicator code:	Indicator EF 5.7
Description:	Annual km passing by bus
Unit:	In km per year
EF Subcategory:	5. CO2 emissions
Sectors:	6. Public transportation
Calculation Type:	Indicator EF 5.7= Indicator EF 5.7.6= Input 6.19
Inputs:	**Input 6.19**= km passing by bus within the boundaries of the protected area

Indicator code:	Indicator EF 5.8
Description:	Annual personkm passing by train

Unit:	In personkm per year
EF Subcategory:	5. CO2 emissions
Sectors:	6. Public transportation
Calculation Type:	Indicator EF 5.8= Indicator EF 5.8.6
	Indicator EF 5.8.6= Input 6.4* Input 6.5
Inputs:	**Input 6.4**= number of annual passenger moving by train on local railway, **Input 6.5**= km of local railway set within the boundaries of protected area.

Indicator code:	**Indicator EF 5.9**
Description:	Annual tkm passing by commercial ship
Unit:	In tkm per year
EF Subcategory:	5. CO2 emissions
Sectors:	6. Public transportation
Calculation Type:	Indicator EF 5.9= Indicator EF 5.9.6
	Indicator EF 5.9.6= $\sum_{y=1}^{y=n}$ (Input 6.6y* Input 6.7y)
Inputs:	**Input 6.6=**t loaded or/and unloaded from/to commercial ship in each port, **Input 6.7**= km boarding in each port
Observations:	y is the number of ports set within the boundaries of the protected area

Indicator code:	**Indicator EF 5.10**
Description:	Annual tkm passing by ferry boat
Unit:	In tkm per year
EF Subcategory:	5. CO2 emissions
Sectors:	6. Public transportation
Calculation Type:	Indicator EF 5.10= Indicator EF 5.10.6
	Indicator EF 5.10.6=$\sum_{y=1}^{y=n}${ Input 6.7y*[(Input 6.8y* Assumption EF 5.10.6a)+ (Input 6.9y* Assumption EF 5.10.6b) + (Input 6.10y* Assumption EF 5.10.6c)+ (Input 6.11y* Assumption EF 5.10.6d) + (Input 6.12y* Assumption EF 5.10.6e)]}
Assumptions:	**Assumption EF 5.10.6a**= The average weight of a passenger is 0.0708 t, **Assumption EF 5.10.6b**= The average weight of a heavy duty vehicle is 5 t, **Assumption EF 5.10.6c**= The average weight of a bus is 5 t, **Assumption EF 5.10.6d**= The average weight of a car is 1.5 t, **Assumption EF 5.10.6e**= The average weight of a motorbike is 0.2 t.
Inputs:	**Input 6.7**= km boarding at each port, **Input 6.8**= number of passengers loaded to ferry boat at each port, **Input 6.9**= number of heavy duty vehicles loaded to ferry boat at each port, **Input 6.10**= number of buses loaded to ferry boat at each port, **Input 6.11**= number of car loaded to ferry boat at each port, **Input 6.12**= number of motorbike loaded to ferry boat at each port.

Observations:	y is the number of the ports set within the boundaries of the protected area

Indicator code:	**Indicator EF 5.11**
Description:	Annual personkm passing by passenger aircraft
Unit:	In personkm per year
EF Subcategory:	5. CO2 emissions
Sectors:	6. Public transportation
Calculation Type:	Indicator EF 5.11= Indicator EF 5.11.6
	Indicator EF 5.11.6=$\sum_{z=1}^{z=n}${(Input 6.13z* Input 6.17z)+(Input 6.14z* Input 6.18z)}
Inputs:	**Input 6.13**= number of passengers arrived by airplane in each airport, **Input 6.14**= number of passengers taking off by airplane from each airport, **Input 6.17**= km passing by airplane during landing at each airport, **Input 6.18**= km passing by airplane during taking off at each airport
Observations:	z is the number of the airports set within the boundaries of the protected area

Indicator code:	**Indicator EF 5.12**
Description:	Annual tkm passing by commercial aircraft
Unit:	In tkm per year
EF Subcategory:	5. CO2 emissions
Sectors:	6. Public transportation
Calculation Type:	Indicator EF 5.12= Indicator EF 5.12.6
	Indicator EF 5.12.6=$\sum_{z=1}^{z=n}${(Input 6.16z* Indicator 6.17z)+(Input 6.15z* Input 6.18z)}
Inputs:	**Input 6.15**= t loaded to airplane at each airport, **Indicator 6.16**= t unloaded from airplane at each airport, **Indicator 6.17**= km passing by airplane during landing at each airport, **Input 6.18**= km passing by airplane during taking off at each airport
Observations:	z is the number of the airports set within the boundaries of the protected area

Indicator code:	**Indicator EF 6.1**
Description:	Build-up area within the boundaries of the protected area
Unit:	gha
EF Subcategory:	6. Build-up surfaces
Sectors:	In total
Calculation Type:	Indicator EF 6.1= Indicator BC 5.1*Cropland Global Equivalent Factor
Observations:	Cropland Global Equivalent Factor is 2.2

	Indicator BC 5.1=Areas occupied by the locality (buildings, roads, etc) analyzed in Appendix B.

Appendix B: Biocapacity's Indicators

Indicator code:	Indicator BC 1.1
Description:	Area under cultivation and fallow lands
Unit:	In ha
BC Subcategory:	1. Cropland
Calculation Type:	Indicator BC 1.1= Indicator BC1.1.1+ Indicator BC1.1.2+ Indicator BC1.1.3
Observations:	The value of the indicator can both be found in total (as cultivated and fallow land) or be calculated by the sum of its three (3) sub-indicators, removing the area that produces energy (Indicator BC 4.2)

Indicator code:	Indicator BC 1.1.1
Description:	Area of arable lands
Unit:	In ha
BC Subcategory:	1. Cropland

Indicator code:	Indicator BC 1.1.2
Description:	Area of permanent crops
Unit:	In ha
BC Subcategory:	1. Cropland

Indicator code:	Indicator BC 1.1.3
Description:	Heterogeneous agricultural area
Unit:	In ha
BC Subcategory:	1. Cropland

Indicator code:	Indicator BC 2.1
Description:	Pastures area
Unit:	In ha
BC Subcategory:	2. Grazing Land
Calculation Type:	Indicator BC 2.1= Indicator BC2.1.1+ Indicator BC2.1.2+ Indicator BC2.1.3
Observations:	The value of the indicator can both be found in total (as Pastures) or can be calculated by the sum of its three (3) sub-indicators.

Indicator code:	Indicator BC 2.1.1
Description:	Pastures- transitional wood land/ shrumb
Unit:	In ha
BC Subcategory:	2. Grazing Land

Indicator code:	Indicator BC 2.1.2
Description:	Pastures- shrumb and/ or herbaceous vegetation associations
Unit:	In ha
BC Subcategory:	2. Grazing Land

Indicator code:	Indicator BC 2.1.3
Description:	Pastures- Open spaces with little or no vegetation
Unit:	In ha
BC Subcategory:	2. Grazing Land

Indicator code:	Indicator BC 3.1
Description:	Area under water
Unit:	In ha
BC Subcategory:	3. Fishing Ground
Calculation Type:	Indicator BC 3.1= Indicator BC3.1.1+ Indicator BC3.1.2+ Indicator BC3.1.3
Observations:	The value of the indicator can both be found in total (as Area under water) or can be calculated by the sum of its three (3) sub-indicators.

Indicator code:	Indicator BC 3.1.1
Description:	Area under inland waters
Unit:	In ha
BC Subcategory:	3. Fishing Ground

Indicator code:	Indicator BC 3.1.2
Description:	Area under inland wetlands
Unit:	In ha
BC Subcategory:	3. Fishing Ground

Indicator code:	Indicator BC 3.1.3
Description:	Area under coastal wetlands
Unit:	In ha
BC Subcategory:	3. Fishing Ground

Indicator code:	Indicator BC 4.1
Description:	Forests and semi-natural areas
Unit:	In ha

BC Subcategory:	4. Forest and Energy Land
Calculation Type:	Indicator BC 4.1= Indicator BC4.1.1+ Indicator BC4.1.2
Observations:	The value of the indicator can both be found in total (as forests and semi-natural areas) or can be calculated by the sum of its two (2) sub-indicators.

Indicator code:	**Indicator BC 4.1.1**
Description:	Forests area
Unit:	In ha
BC Subcategory:	4.Forest and Energy Land

Indicator code:	**Indicator BC 4.1.2**
Description:	Area of transitional wood land/ shrumb
Unit:	In ha
BC Subcategory:	4.Forest and Energy Land

Indicator code:	**Indicator BC 4.2**
Description:	Area under cultivation and fallow land that produces energy
Unit:	In ha
BC Subcategory:	4.Forest and Energy Land
Observations:	The value of the indicator must be removed from the value of Indicator BC 1.1

Indicator code:	**Indicator BC 5.1**
Description:	Areas occupied by the locality (buildings, roads, etc)
Unit:	In ha
BC Subcategory:	5. Build-up Area
Calculation Type:	Indicator BC 5.1= Indicator BC5.1.1+ Indicator BC5.1.2+ Indicator BC5.1.3+ Indicator BC5.1.4+ Indicator BC5.1.5
Observations:	The value of the indicator can both be found in total (as areas occupied by locality) or can be calculated by the sum of its five (5) sub-indicators.

Indicator code:	**Indicator BC 5.1.1**
Description:	Urban Fabric Area
Unit:	In ha
BC Subcategory:	5.Build-up Area

Indicator code:	**Indicator BC 5.1.2**
Description:	Area of industrial and commercial units
Unit:	In ha
BC Subcategory:	5.Build-up Area

Indicator code:	**Indicator BC 5.1.3**
Description:	Area of transport units
Unit:	In ha
BC Subcategory:	5.Build-up Area

Indicator code:	**Indicator BC 5.1.4**
Description:	Area of mine, dump and construction sites
Unit:	In ha
BC Subcategory:	5.Build-up Area

Indicator code:	**Indicator BC 5.1.5**
Description:	Artificial, non-agricultural vegetated areas, sport and cultural activity sites
Unit:	In ha
BC Subcategory:	5.Build-up Area

Appendix C: Population's Indicators

Indicator code:	Indicator P 1.1
Description:	Number of residents (adults and minors included)
Unit:	person
Sectors:	1. Households
Calculation Type:	Indicator P 1.1= Input 1.1+ Input 1.2
Inputs:	**Input 1.1**= number of adults residents, **Input 1.2**= number of minors residents

Indicator code:	Indicator P 2.1
Description:	squared meters of offices/commercial buildings
Unit:	m^2
Sectors:	2. Tertiary Buildings
Calculation Type:	Indicator P 2.1= Input 2.1* Assumption EF G.1.2+ Input 2.2* Assumption EF G.2.2+ Input 2.3*Assumption EF G.3.2
Inputs:	**Input 2.1**= number of offices/commercial buildings build before 1980, **Input 2.2=** number of offices/commercial buildings build between 1981-2001, **Input 2.3**= number of offices/commercial buildings build after 2001
Assumptions:	**Assumption EF G.1.2**= average surface (m^2) of offices/commercial buildings build before 1980 is 450 m^2, **Assumption EF G.2.2=** average surface (m^2) of offices/commercial buildings build between 1981- 2001 is 900 m^2, **Assumption EF G.3.2**= average surface (m^2) of offices/commercial buildings build after 2001 is 1200 m^2
Sources:	Balaras et al., 2007

Indicator code:	Indicator P 2.2
Description:	squared meters of healthcare buildings
Unit:	m^2
Sectors:	2. Tertiary Buildings
Calculation Type:	Indicator P 2.2= Input 2.4* Assumption EF G.4.2+ Input 2.5* Assumption EF G.5.2+ Input 2.6*Assumption EF G.6.2
Inputs:	**Input 2.4**= number of healthcare buildings build before 1980, **Input 2.5**= number of healthcare buildings build between 1981-2001, **Input 2.6**= number of healthcare buildings build after 2001
Assumptions:	**Assumption EF G.4.2=** average surface (m^2) of healthcare buildings build before 1980 is 1666 m^2, **Assumption EF G.5.2=** average surface (m^2) of healthcare buildings build between 1981-2001 is 8922 m^2, **Assumption EF G.6.2=** average surface (m^2) of healthcare buildings build after 2001 is 10305 m^2
Sources:	Balaras et al., 2007

Indicator code:	**Indicator P 3.1**
Description:	squared meters of educational buildings
Unit:	m^2
Sectors:	3. Municipal Buildings
Calculation Type:	Indicator P 3.1= Input 3.1* Assumption EF G.1.3+ Input 3.2* Assumption EF G.2.3+ Input 3.3*Assumption EF G.3.3
Inputs:	**Input 3.1**= number of schools build before 1980, **Input 3.2**= number of schools build between 1981-2001, **Input 3.3**= number of schools build after 2001
Assumptions:	**Assumption EF G.1.3**= average surface (m^2) of schools build before 1980 is 1500 m^2, **Assumption EF G.2.3**= average surface (m^2) of schools build between 1981-2001 is 1702 m^2, **Assumption EF G.3.3**= average surface (m^2) of schools build after 2001 is 1801 m^2
Sources:	Balaras et al., 2007

Indicator code:	**Indicator P 4.1**
Description:	installed power for public lighting
Unit:	kW
Sectors:	4. Public Lighting
Calculation Type:	Indicator P 4.1= Input 4.1
Inputs:	**Input 4.1**= Installed power for public lighting in kW

Indicator code:	**Indicator P 5.1**
Description:	km passing by private passenger cars
Unit:	km
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 5.1= (Input 5.1*Assumption EF G.1.5* Assumption EF 5.5.5)+ (Assumption EF 5.5.5* [$\sum_{x=1}^{x=n}(Input\ 5.2x * Input\ 5.6x\ )$])+ (Input 5.1*Assumption EF G.1.5* Assumption EF 5.6.5)+ (Assumption EF 5.6.5* [$\sum_{x=1}^{x=n}(Input\ 5.2x * Input\ 5.6x)$])
Inputs:	**Input 5.1=** number of private car moving on local roads, **Input 5.2**= number of private car moving on each part of the highway set within the boundaries of the protected area, **Input 5.6**= km of each part of the highway set within the boundaries of the protected area
Assumptions:	**Assumption EF G.1.5**= the average km passing by vehicle on local roads per year are 7500 km/year, **Assumption EF 5.5.5**= the national percentage of car fueled by diesel is 17%, **Assumption EF 5.6.5**= the national percentage of car fueled by petrol is 83%.
Observations:	X stands the number of parts of highway within the boundaries of the protected area

Indicator code:	Indicator P 5.2
Description:	km passing by motorbike
Unit:	km
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 5.2= Input 5.3*Assumption EF G.1.5
Inputs:	**Input 5.3**= number of private motorbikes moving on local roads
Assumptions:	**Assumption EF G.1.5**= the average km passing by vehicle on local roads per year are 7500 km/year

Indicator code:	Indicator P 5.3
Description:	km passing by heavy duty vehicles
Unit:	km
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 5.3= (Input 5.4*Assumption EF G.1.5)+ $\sum_{x=1}^{x=n}(Input\ 5.5x * Input\ 5.6x)$])
Inputs:	**Input 5.5=** number of heavy duty vehicles moving on highway**, Input 5.6**= km of each part of the highway set within the boundaries of the protected area
Assumptions:	**Assumption EF G.1.5**= the average km passing by vehicle on local roads per year are 7500 km/year
Observations:	X stands the number of parts of highway within the boundaries of the protected area

Indicator code:	Indicator P 6.1
Description:	km passing by public passenger cars
Unit:	km
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 6.1= Input 6.1*Assumption EF G.1.6* (Assumption EF 5.5.6+ Assumption EF 5.6.6)
Inputs:	**Input 6.1**= number of public passenger cars moving on local roads
Assumptions:	**Assumption EF G.1.6**= the average km passing by vehicle on local roads per year are 7500 km/year, **Assumption EF 5.5.6**= the national percentage of car fueled by diesel is 17%, **Assumption EF 5.6.6**= the national percentage of car fueled by petrol is 83%.

Indicator code:	Indicator P 6.2
Description:	km passing by public motorbike
Unit:	km
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 6.2= Input 6.2*Assumption EF G.1.6
Inputs:	**Input 6.2**= number of public motorbikes moving on local roads

Assumptions:	**Assumption EF G.1.6**= the average km passing by vehicle on local roads per year are 7500 km/year

Indicator code:	**Indicator P 6.3**
Description:	km passing by public heavy duty vehicles
Unit:	km
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 6.3= Input 6.3*Assumption EF G.1.6
Inputs:	**Input 6.3**= number of public heavy duty vehicles moving on local roads
Assumptions:	**Assumption EF G.1.6**= the average km passing by vehicle on local roads per year are 7500 km/year

Indicator code:	**Indicator P 6.4**
Description:	km passing by bus
Unit:	km
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 6.4= Input 6.19
Inputs:	**Input 6.19=** km passing by bus within the boundaries of protected area

Indicator code:	**Indicator P 6.5**
Description:	personkm per year passing by train
Unit:	personkm
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 6.5= Input 6.4* Input 6.5
Inputs:	**Input 6.4=** number of annual passengers moving by train on local railway**, Input 6.5**= km of the railway set within the boundaries of the protected area

Indicator code:	**Indicator P 6.6**
Description:	tkm per year passing by boat
Unit:	tkm
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 6.6= $\sum_{x=1}^{x=n}$(Input 6.7*[Input 6.6+ (Input 6.8*Assumption EF 5.10.6a)+(Input 6.9* Assumption EF 5.106b)+(Input 6.10*Assumption EF 5.10.6c)+(Input 6.11* Assumption EF 5.10.6d)+(Input 6.12*Assumption EF 5.10.6e)])
Inputs:	**Input 6.6=** t loaded or/and unloaded from or/and to commercial ship in each port**, Input 6.7**= km boarding at each port, **Input 6.8**= number of passengers loaded to ferry boat at each port, **Input 6.9**= number of heavy duty vehicles loaded to ferry boat at each port, **Input 6.10**= number of buses loaded to ferry boat at each port, **Input 6.11**= number

	of car loaded to ferry boat at each port, **Input 6.12**= number of motorbike loaded to ferry boat at each port.
Assumptions:	**Assumption EF 5.10.6a**= The average weight of a passenger is 0.0708 t, **Assumption EF 5.10.6b**= The average weight of a heavy duty vehicle is 5 t, **Assumption EF 5.10.6c**= The average weight of a bus is 5 t, **Assumption EF 5.10.6d**= The average weight of a car is 1.5 t, **Assumption EF 5.10.6e**= The average weight of a motorbike is 0.2 t.
Observations:	X stands the number of ports within the boundaries of the protected area

Indicator code:	**Indicator P 6.7**
Description:	personkm per year passing by passenger aircraft
Unit:	personkm
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 6.7= $\sum_{x=1}^{x=n}$((Input 6.13*Input 6.17)+ (Input 6.14*Input 6.18))
Inputs:	**Input 6.13**= number of passengers arrived by airplane in each airport, **Input 6.14**= number of passengers taking off by airplane from each airport, **Input 6.17**= km passing by airplane during landing at each airport, **Input 6.18**= km passing by airplane during taking off at each airport
Observations:	X stands the number of airports within the boundaries of the protected area

Indicator code:	**Indicator P 6.8**
Description:	tkm per year passing by commercial aircraft
Unit:	tkm
Sectors:	5. CO2 Emissions
Calculation Type:	Indicator P 6.8= $\sum_{x=1}^{x=n}$((Input 6.16*Input 6.17)+ (Input 6.15*Input 6.18))
Inputs:	**Input 6.15**= t loaded to airplane at each airport, **Indicator 6.16**= t unloaded from airplane at each airport, **Input 6.17**= km passing by airplane during landing at each airport, **Input 6.18**= km passing by airplane during taking off at each airport
Observations:	X stands the number of airports within the boundaries of the protected area

Indicator code:	**Indicator P 7.1**
Description:	Number of tourists (adults and minors included)
Unit:	person
Sectors:	7. Tourism
Calculation Type:	Indicator P 7.1= Input 7.1+ Input 7.2
Inputs:	**Input 7.1**= number of adults tourists, **Input 7.2**= number of minors

	tourists