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Reinforcing Protected Areas Capacity through an Innovative Methodology for Sustainability
– BIO2CARE –
(Reg. No: 1890)

WP3
Deliverable 3.3
One (1) report including results from the implementation of the methodological framework in two intervention areas

Contributing Partners

LB - Democritus University of Thrace - Laboratory of Environmental Management and Industrial Ecology
PB4 - Greek Biotope/Wetland Centre
PB6 - Regional Inspectorate of Environment and Waters - Blagoevgrad
PB8 - South-West University "Neofit Rilsky"
PB9 - Pirin Tourism Forum

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Chapter 1 - Introduction

The methodological framework that was developed in Del 3.2 of WP3 of the Project BIO2CARE, includes all necessary steps-actions and guidance to estimate and assess the Carrying Capacity and other holistic environmental indicators-footprints in protected areas. During this process already available methodologies were adapted according to protected areas' needs and procedures were simplified so that in the future decision makers and relevant agents can utilize BIO2CARE framework by importing predefined data. 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.

The aim of this report is to implement in practice the methodological framework that was developed in WP3 Del3.2 in the two Study Areas of the Project: 1) National Park of Eastern Macedonia and Thrace in Greece (NP-EMATH) (Study Area 1) and 2) Rila National Park of Bulgaria (RNPD) including the catchment area of the river basin of Blagoevgradska Bistrica (Study Area 2). In Chapters 2 and 3 the data needed for the implementation, respective calculations and comprehensive results per indicators are presented. Building upon the results, and international literature specific actions of improvement are proposed in Chapter 4 that can help improve the Carrying Capacity, Ecological Footprint, Carbon Footprint and Water Footprint of an area. A sensitivity analysis is also performed to evaluate different scenarios and assess the impact of alternative anthropogenic activities to the environmental status of the examined areas. In Chapter 5 an attempt is made to compare the results of the methodological framework with similar studies to check its validity. The key conclusions are summarized in Chapter 6.

Chapter 2 - Implementation of framework in Study Area 1

2.1 Data inventory and calculations

The implementation of the BIO2CARE framework in Study Area 1 (National Park of Eastern Macedonia and Thrace – NP-EMATH) was performed by following the detailed guidelines provided in D3.2 of WP3. In Section 3.4 of D3.2, specific steps and inputs that are needed for the evaluation of the environmental status of the protected areas in a holistic way are comprehensively described. Implementation of BIO2CARE framework requires the quantification of specific inputs per examined sector to develop a data inventory that is utilized to feed CC, EF and CF indicators (see Appendices of D3.2). For NP-EMATH, the specific inputs (Table 2-1 to 2-7) have been estimated by utilizing data from D3.1 where extended information and knowledge regarding the anthropogenic activities and status of nature of the protected areas has been collected. In case relevant information is not included in D3.1, online statistical sources (i.e. Hellenic Statistical Authority), and technical documents available by NP-EMATH and expert's estimations have been utilized for a limited number of inputs.

Table 2-1: Data inventory for examined Sector No 1: Households.

Input code	Description	Value for Study Area 1 (GR)
Input 1.1	Number of adults residents	23,249
Input 1.2	Number of minors residents	6,027
Input 1.3	Surface (m^2) of single dwellings build before 1980	744,404
Input 1.4	Surface (m^2) of single dwellings build between 1981-2001	297,578
Input 1.5	Surface (m^2) of single dwellings build after 2002	229,195
Input 1.6	Surface (m^2) of apartment buildings build before 1980	22,474
Input 1.7	Surface (m^2) of apartment buildings build between 1981-2001	35,378
Input 1.8	Surface (m^2) of apartment buildings build after 2002	91,090

Table 2-2: Data inventory for examined Sector No 2: Tertiary.

Input code	Description	Value for Study Area 1 (GR)
Input 2.1	Number of offices/commercial buildings build before 1980	573
Input 2.2	Number of offices/commercial buildings build between 1981-2001	168
Input 2.3	Number of offices/commercial buildings build after 2002	81
Input 2.4	Number of healthcare buildings build before 1980	4
Input 2.5	Number of healthcare buildings build between 1981-2001	4

Input 2.6	Number of healthcare buildings build after 2002	0

Table 2-3: Data inventory for examined Sector No 3: Municipal buildings.

Input code	Description	Value for Study Area 1 (GR)
Input 3.1	Number of schools build before 1980	79
Input 3.2	Number of schools build between 1981-2001	16
Input 3.3	Number of schools build after 2002	7

Table 2-4: Data inventory for examined Sector No 4: Public lighting.

Input code	Description	Value for Study Area 1 (GR)
Input 4.1	Installed power for public lighting in kW	705

Table 2-5: Data inventory for examined Sector No 5: Private transportation.

Input code	Description	Value for Study Area 1 (GR)
Input 5.1	Number of private passenger cars moving on local roads	11,117
Input 5.2	Number of private passenger cars moving on highway	2,030,612
Input 5.3	Number of private scooters moving on local roads	4,198
Input 5.4	Number of private lorries moving on local roads	3,991
Input 5.5	Number of private lorries moving on highway	386,783
Input 5.6	km of highway set within the boundaries of protected area	1.8

Table 2-6: Data inventory for examined Sector No 6: Public transportation.

Input code	Description	Value for Study Area 1 (GR)
Input 6.1	Number of public passenger cars moving on local roads	72
Input 6.2	Number of public scooters moving on local roads	7
Input 6.3	Number of public lorries moving on local roads	125
Input 6.4	Number of annual passengers moving by train on local railway	146,000
Input 6.5	km of local railway within the boundaries of the protected area	10.5
Input 6.6	t loaded/ unloaded from or/and to barge tanker in each port	132,502
Input 6.7	km boarding in each port	1.852
Input 6.8	Passengers loaded in ferry boat in each port	1,402,331
Input 6.9	Lorries loaded in ferry boat in each port	111,077
Input 6.10	Buses loaded in ferry boat in each port	5,989
Input 6.11	Passenger cars loaded in ferry boat in each port	316,924
Input 6.12	Scooters loaded in ferry boat in each port	11,746

Input 6.13	Number of passengers arrived by airplane in each airport	104,054
Input 6.14	Number of passengers left by airplane in each airport	105,346
Input 6.15	t loaded to airplane in each airport	280
Input 6.16	t unloaded from airplane in each airport	0
Input 6.17	km passing by airplane during landing in each airport	20.372
Input 6.18	km passing by airplane during taking off in each airport	25.928
Input 6.19	km passing by bus within the boundaries of protected area	924,662.4

Table 2-7: Data inventory for examined Sector No 7: Tourism.

Input code	Description	Value for Study Area 1 (GR)
Input 7.1	Number of adults tourists	18,947
Input 7.2	Number of minors tourists	6,316
Input 7.3	Number of hotels build before 1980	12
Input 7.4	Number of hotels build between 1981-2001	16
Input 7.5	Number of hotels build after 2002	3

With a view to facilitate implementation and reduce the amount of data that are needed to extract the vast number of CC, EF, CF and WF indicators (>100) only to those presented in Tables 2-1 to 2-7, a number of assumptions have been developed that facilitate the evaluation procedure. Taking into account the information provided in the Appendixes of D3.2, the following assumptions (Table 2-8) have been adopted for NP-EMATH in order to proceed to the respective footprints' calculations.

Table 2-8: Assumptions applied to estimate the EF and CF indicators of BIO2CARE methodology for NP-EMATH (Study Area 1).

1. Households			
	Description	**Value**	**Units**
General	Average weight of adults residents	70	kg
	Average weight of minors residents	40	kg
	Days of consumption for the residents	365	days/year
	% fuel combustion for heating due to poverty	70%	%
	Description	**Value**	**Units**
1. Agricultural products	average consumption of bread and rolls in g per kg of human mass per day	3,2	g/kg/d
	average consumption of potatoes and potatoes products in g per kg of human mass per day	6,1	g/kg/d
	average consumption of sugars per kg of human mass per day	0,4	g/kg/d

	Description	Value	Units
	average consumption of breakfast cereals per kg of human mass per day	1,6	g/kg/d
	average consumption of grain milling products in g per kg of human mass per day	0,9	g/kg/d
	average consumption of legumes, beans, dried per kg of human mass per day	5,4	g/kg/d
	average consumption of fruits (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) in g per kg of human mass per day	53,9	g/kg/d
	average consumption of beer and beer-like, wine, spirits, soft drinks per kg of human mass per day	17,9	g/kg/d
	average consumption of tobacco per day in Greece	20	g/d
	% smokers in Greece	40%	%
	average consumption of rice-based meals per kg of human mass per day	10	g/kg/d
	average consumption of vegetables fats and oils per kg of human mass per day	1,3	g/kg/d
	Description	**Value**	**Units**
2. Livestock products	average consumption of livestock meat (mostly pork) per kg of human mass per day	4,4	g/kg/d
	average consumption of farmed animals (mostly beef) per kg of human mass per day	4,1	g/kg/d
	average consumption of sausages per kg of human mass per day	2	g/kg/d
	average consumption of poultry in g per kg of human mass per day	3,2	g/kg/d
	average consumption of eggs per kg of human mass per day	2,6	g/kg/d
	average consumption of liquid and concentrated milk and milk based beverages per kg of human mass per day	32,5	g/kg/d
	average consumption of cheese per kg of human mass per day	2	g/kg/d
	average consumption of animals fat, margarine and similar products per kg of human mass per day	0,7	g/kg/d
	Description	**Value**	**Units**
3. Fishery & Aquaculture products	average consumption of fish meat per kg of human mass per day	4,5	g/kg/d

	average consumption of crustaceans, water mollusks, amphibians, reptiles, snails and insects per kg of human mass per day	7,3	g/kg/d
	Description	**Value**	**Units**
4. Timber products	average consumption of paper and board per capita in Greece per year	79	kg/cap
	Description	**Value**	**Units**
5. CO2 emissions	average electrical energy consumption per m^2 for single dwellings 1980	24,08	kWh/m^2
	average electrical energy consumption per m^2 for single dwellings 2001	34,99	kWh/m^2
	average electrical energy consumption per m^2 for single dwellings 2010	33,74	kWh/m^2
	average electrical energy consumption per m^2 for apartment buildings 1980	25,77	kWh/m^2
	average electrical energy consumption per m^2 for apartment buildings 2001	36,99	kWh/m^2
	average electrical energy consumption per m^2 for apartment buildings 2010	35,45	kWh/m^2
	average thermal energy consumption per m^2 for single dwellings 1980	159,4	kWh/m^2
	average thermal energy consumption per m^2 for single dwellings 2001	145,1	kWh/m^2
	average thermal energy consumption per m^2 for single dwellings 2010	107,7	kWh/m^2
	average thermal energy consumption per m^2 for apartment buildings 1980	110,8	kWh/m^2
	average thermal energy consumption per m^2 for apartment buildings 2001	109	kWh/m^2
	average thermal energy consumption per m^2 for apartment buildings 2010	90,4	kWh/m^2
	% of thermal energy resulting from oil burning	64%	%
	% of thermal energy resulting from logs burning	14%	%
	% of thermal energy resulting from natural gas burning	9%	%
	% of thermal energy resulting from electricity use	13%	%
2. Tertiary			
	Description	**Value**	**Units**

General	average surface of offices/commercial buildings build before 1980	450	m^2
	average surface of offices/commercial buildings build between 1981-2001	900	m^2
	average surface of offices/commercial buildings build after 2001	1200	m^2
	average surface of healthcare buildings build before 1980	1666	m^2
	average surface of healthcare buildings build between 1981-2001	8922	m^2
	average surface of healthcare buildings build after 2001	10305	m^2
	% reduction of fuel combustion for heating due to poverty	70%	%
	Description	**Value**	**Units**
5. CO2 emissions	average electrical energy consumption per m^2 for offices/commercial buildings 1980	39	kWh/m^2
	average electrical energy consumption per m^2 for offices/commercial buildings 2001	51	kWh/m^2
	average electrical energy consumption per m^2 for offices/commercial buildings 2010	64	kWh/m^2
	average electrical energy consumption per m^2 for healthcare buildings 1980	82	kWh/m^2
	average electrical energy consumption per m^2 for healthcare buildings 2001	94	kWh/m^2
	average electrical energy consumption per m^2 for healthcare buildings 2010	104	kWh/m^2
	average thermal energy consumption per m^2 for offices/commercial buildings 1980	107	kWh/m^2
	average thermal energy consumption per m^2 for offices/commercial buildings 2001	89	kWh/m^2
	average thermal energy consumption per m^2 for offices/commercial buildings 2010	83	kWh/m^2
	average thermal energy consumption per m^2 for healthcare buildings 1980	188	kWh/m^2
	average thermal energy consumption per m^2 for healthcare buildings 2001	168	kWh/m^2
	average thermal energy consumption per m^2 for healthcare buildings 2010	160	kWh/m^2
3. Municipal Buildings			
	Description	**Value**	**Units**
General	average surface of schools build before 1980	1500	m^2
	average surface of schools build between 1981-2001	1702	m^2

	average surface of schools build after 2002	1801	m^2
	Description	**Value**	**Units**
5. CO2 emissions	average electrical energy consumption per m^2 for schools 1980	18	kWh/m^2
	average electrical energy consumption per m^2 for schools 2001	19	kWh/m^2
	average electrical energy consumption per m^2 for schools 2010	20	kWh/m^2
	average thermal energy consumption per m^2 for schools 1980	37	kWh/m^2
	average thermal energy consumption per m^2 for schools 2001	36	kWh/m^2
	average thermal energy consumption per m^2 for schools 2010	36	kWh/m^2
4. Public Lighting			
	Description	**Value**	**Units**
5. CO2 emissions	average time of lights' operation per year	4065	kWh/year
5. Private Transportation			
	Description	**Value**	**Units**
General	average km passing by vehicle on local roads per year	7500	km
	Description	**Value**	**Units**
5. CO2 emissions	% of car in Greece fueled by diesel	17%	%
	% of car in Greece fueled by pertol	83%	%
6. Public Transportation			
	Description	**Value**	**Units**
General	average km passing by vehicle on local roads per year	7500	km
	Description	**Value**	**Units**
5. CO2 emissions	% of car in Greece fueled by diesel	17%	%
	% of car in Greece fueled by pertol	83%	%
	average weight of a passenger on ferry boat	0,0708	ton
	average weight of a heavy duty vehicle on ferry boat	5	ton
	average weight of a bus on ferry boat	5	ton
	average weight of a car on ferry boat	1,5	ton
	average weight of a motorbike on ferry boat	0,2	ton

7. Tourism			
	Description	**Value**	**Units**
General	Average weight of adults tourists	70	kg
	Average weight of minors tourists	40	kg
	Days of consumption for the tourist	3	days
	average surface of hotels build before 1980	1632	m^2
	average surface of hotels build between 1981-2001	2798	m^2
	average surface of hotels build after 2002	3496	m^2
	Description	**Value**	**Units**
1. Agricultural products	average consumption of bread and rolls in g per kg of human mass per day	3,2	g/kg/d
	average consumption of potatoes and potatoes products in g per kg of human mass per day	6,1	g/kg/d
	average consumption of sugars per kg of human mass per day	0,4	g/kg/d
	average consumption of breakfast cereals per kg of human mass per day	1,6	g/kg/d
	average consumption of grain milling products in g per kg of human mass per day	0,9	g/kg/d
	average consumption of legumes, beans, dried per kg of human mass per day	5,4	g/kg/d
	average consumption of fruits (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) in g per kg of human mass per day	53,9	g/kg/d
	average consumption of beer and beer-like, wine, spirits, soft drinks	17,9	g/kg/d
	average consumption of tobacco per day in Europe	10	g/d
	% smokers in Europe	29%	%
	average consumption of rice-based meals per kg of human mass per day	10	g/kg/d
	average consumption of vegetables fats and oils per kg of human mass per day	1,3	g/kg/d
	Description	**Value**	**Units**
2. Livestock products	average consumption of livestock meat (mostly pork) per kg of human mass per day	4,4	g/kg/d
	average consumption of farmed animals (mostly beef) per kg of human mass per day	4,1	g/kg/d

	Description	Value	Units
	average consumption of sausages per kg of human mass per day	2	g/kg/d
	average consumption of poultry in g per kg of human mass per day	3,2	g/kg/d
	average consumption of eggs per kg of human mass per day	2,6	g/kg/d
	average consumption of liquid and concentrated milk and milk based beverages per kg of human mass per day	32,5	g/kg/d
	average consumption of cheese per kg of human mass per day	2	g/kg/d
	average consumption of animals fat, margarine and similar products per kg of human mass per day	0,7	g/kg/d
	Description	**Value**	**Units**
3. Fishery & Aquaculture products	average consumption of fish meat per kg of human mass per day	4,5	g/kg/d
	average consumption of crustaceans, water mollusks, amphibians, reptiles, snails and insects per kg of human mass per day	7,3	g/kg/d
	Description	**Value**	**Units**
5. CO2 emissions	average electrical energy consumption per m^2 for hotels 1980	54	kWh/m^2
	average electrical energy consumption per m^2 for hotels 2001	86	kWh/m^2
	average electrical energy consumption per m^2 for hotels 2010	102	kWh/m^2
	average thermal energy consumption per m^2 for hotels 1980	113	kWh/m^2
	average thermal energy consumption per m^2 for hotels 2001	99	kWh/m^2
	average thermal energy consumption per m^2 for hotels 2010	92	kWh/m^2

The final data needed for the complete evaluation of the CC for the two examined protected areas are those referred to Step 9 of Biocapacity calculation (see Del 3.2, Appendix B) regarding land uses. The specific data were once again estimated according to data provided in Del. 3.1 and the utilization of CORINE databases and GIS models (Table 2-9).

Table 2-9: Estimation of Biocapacity indicators for NP-EMATH (Study Area 1).

1. Cropland					
Indicator code	**Description**	**Value in ha**	**Indicator code**	**Description**	**Value in ha**
Indicator BC 1.1	Area under cultivation and fallow land in ha	52011,17	**Indicator BC 1.1.1**	Arable land in ha	**21563,99**
			Indicator BC 1.1.2	Permanent crops in ha	**29770,53**

			Indicator BC 1.1.3	Heterogenous agricultural areas in ha	**676,53**
2. Grazing Land					
Indicator code	**Description**	**Value in ha**	**Indicator code**	**Description**	**Value in ha**
Indicator BC 2.1	Pastures in ha	4528,36	**Indicator BC 2.1.1**	Pastures - transitional wood land / shrumb in ha	**120,68**
			Indicator BC 2.1.2	Pastures - shrumb and / or herbaceous vegetation associations in ha	**2148,97**
			Indicator BC 2.1.3	Pastures - Open spaces with little or no vegetation in ha	**2258,71**
3. Fishing Ground					
Indicator code	**Description**	**Value in ha**	**Indicator code**	**Description**	**Value in ha**
Indicator BC 3.1	Area under water in ha	12283,86	**Indicator BC 3.1.1**	Inland waters in ha	**840,50**
			Indicator BC 3.1.2	Inland wetlands in ha	**3641,76**
			Indicator BC 3.1.3	Coastal wetlands in ha	**7801,6**
4.Forest and Energy Land					
Indicator code	**Description**	**Value in ha**	**Indicator code**	**Description**	**Value in ha**
Indicator BC 4.1	Forests and semi-natural ares in ha	860,54	**Indicator BC 4.1.1**	Forests in ha	**739,86**
			Indicator BC 4.1.2	Transitional wood land / shrumb in ha	**120,68**
Indicator BC 4.2	Area under cultivation and fallow land that produces energy	50,1			
5.Build-up Area					
Indicator code	**Description**	**Value in ha**	**Indicator code**	**Description**	**Value in ha**
Indicator BC 5.1	Areas occupied by the locality (buildings, roads, etc) in ha	1799,99	**Indicator BC 5.1.1**	Urban fabric in ha	**1228,85**
			Indicator BC 5.1.2	Industrial and commercial units in ha	**269,84**
			Indicator BC 5.1.3	Transport units in ha	**147,12**

			Indicator BC 5.1.4	Mine , dump and construction sites	**154,18**
			Indicator BC 5.1.5	Artificial, non agricultural vegetated areas sport and cultural activity sites	**0**

The combination of the information included in Tables 2-1 to 2-7 and assumptions in Table 2-8, and land use data on Table 2-9 enable the calculation of all CC, EF and CF indicators and the complete implementation of BIO2CARE methodological framework. In order to support quick and effective calculations, a supportive excel file was developed (Figure 2-1), building upon the guidelines provided in Del. 3.2, and is available. The excel file calculates the CC, EF, and CF of the examined protected area .

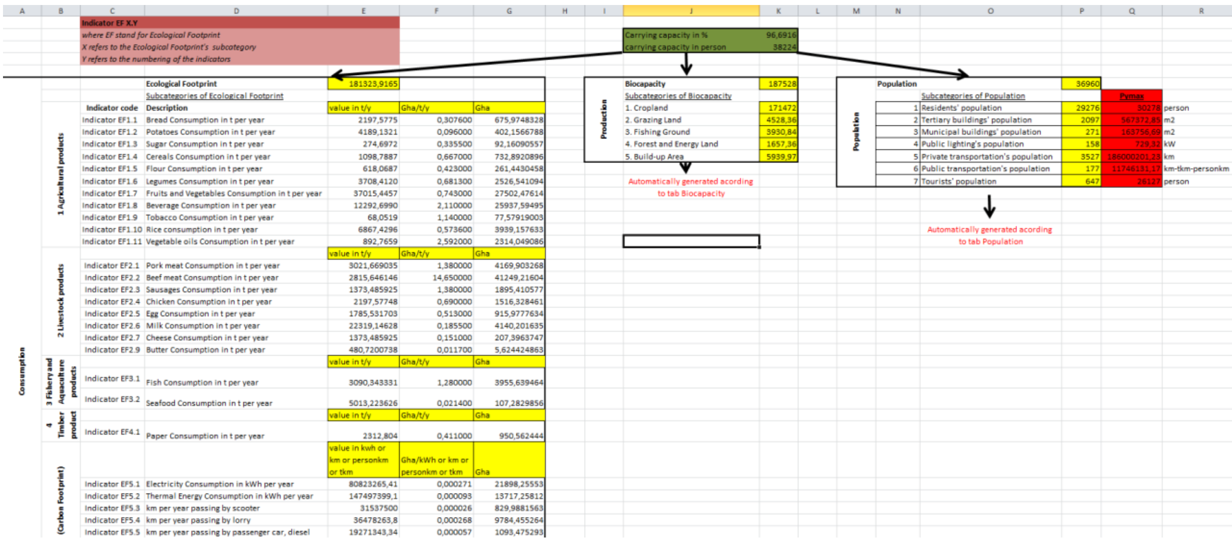

Figure 2-1: Excel-based supportive tool to perform CC calculations in BIO2CARE.

The results from the implementation of the BIO2CARE framework are comprehensively presented in the following Chapters.

2.2 Carrying Capacity results

According to the results of the implementation of the methodological framework for the assessment of the carrying capacity developed by the project team, this indicator was estimated at 38,224 equivalent persons. This figure means 30,278 permanent residents (of which 24,045 adults and 6,233 minors) and 26,127 visitors (of which 19,595 adults and 6,532 minors). In other words, the Carrying Capacity of the protected area of NP-EMATH at that time (reference year 2013) is covered at 97%.

The carrying capacity indicator is directly depended on the ecological footprint and the biocapacity of the area under study. The ecological footprint, when the biocapacity is stable, affects negatively the carrying capacity, i.e. when the ecological footprint increases, the area's carrying capacity is reduced. In the contrary, the biocapacity affects positively the size of the carrying capacity, when the ecological footprint remains stable. The ecological footprint is directly depended on the number of equivalent residents and their consumption patterns. If one of the two, or both of those figures change, then this will result in a change of the size of the carrying capacity indicator. If, for example, the population grows or its standard nutritional and energy needs grow, or both of them grow at the same time, then the ecological footprint will increase.

Biocapacity depends on the existing land, land use, and its productivity. The first two parameters can be changed by the new legislation of the Greek state. The third parameter can be changed when the agricultural, livestock, fisheries and forestry practices, and energy systems change. These changes are also limited and regulated by Greek legislation.

Results obtained from the calculations of the Carrying Capacity indicator for the NP-EPAMATH are summarized and commented in order to strengthen the decision-making process of the Managing Authority regarding the evaluation of existing / new activities:

- The Carrying Capacity of the area is met by the existing profile of anthropogenic activities (coverage 97%). This results in the possibility of developing new activities within the NP-EPAMATH, provided that they do not exceed the limits of control of the carrying capacity, and will respect the relevant spatial rules and environmental impacts.
- Although tourism is a frequent problem in protected areas, internationally, in the case of NP-EMATH, there is considerable space for growth (the annual number of visitors may potentially increase tenfold without overcoming the Area's Carrying Capacity).

The Carrying Capacity provides general guidelines for assessing the environmental performance of NP-EMATH and the impact of anthropogenic activities on the natural environment.

2.3 Ecological Footprint results

2.3.1 Total Ecological Footprint of the National Park of Eastern Macedonia and Thrace in Greece (NP-EMATH) (Study Area 1)

The total ecological footprint of NP-EMATH was estimated to **181,324 Gha** as an absolute value, or **6.19 Gha per inhabitant.** The Bio-capacity of NP-EMATH rose to **187,528 Gha**. This result indicates the capacity of the area to cover its current consumer needs of its inhabitants. It is to be noted that these calculations apply for the reference year and for the current consumer patterns and cultivation methods. The ecological footprint of NP-EMATH comprises the agricultural, livestock and fisheries and aquaculture, timber products and the quantity of power generated (CO_2 emissions), was calculated to **177,363 Gha**. In **Figure 2-2** the percentage contribution of each production sector to the ecological footprint of the area is presented.

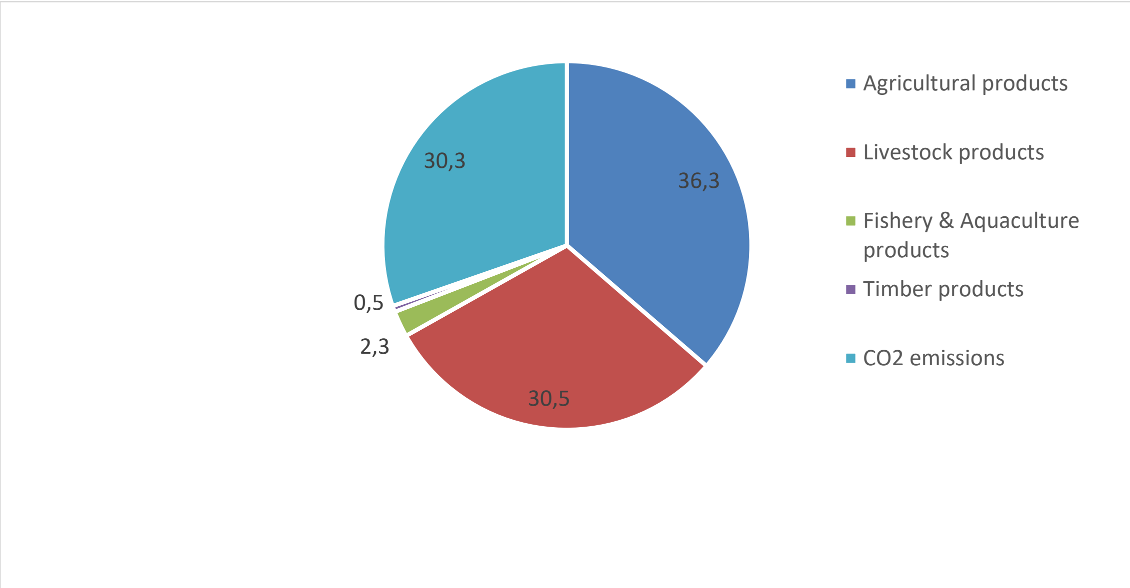

Figure 2-2: **Percentage contribution of production sectors to the ecological footprint (it concerns production activities).**

It is noted that agricultural and livestock products together with CO2 emissions are the main sectors that form the ecological footprint of NP-EMATH, forming together about 97% of it.

Most available biologically productive land, both in ha and in Gha, is used as cropland. The built up area and the grazing land follow in terms of Gha. The fishing ground comes second in terms of ha. The summary of the available areas of biologically productive land to meet the needs of individual productive sectors is given in **Table 2-10**.

Table 2-10: **Available areas of biologically productive land to meet the needs of individual productive sectors.**

Type of biologically productive land	Available biologically productive land	
	in Gha	In ha
Cropland	171,472	51,961
Grazing land	4,528	4,528
Fishing ground	3,931	12,284
Forest and Energy land	1,657	911
Built up area	5,940	1,800

In **Table 2-11** we present the main sectors that contribute to the ecological footprint of NP-EMATH, according to the method Ecological Footprint.

Table 2-11: Main sectors that contribute to the ecological footprint of NP-EMATH.

A/A	Sector of evaluation	Unit	
		Gha	Percentage (%)
1	Households	$14.36 X 10^4$	80.9
2	Tertiary	$1.03 X 10^4$	5.8
3	Municipal buildings	$0.13 X 10^4$	0.7
4	Public lighting	$0.08 X 10^4$	0.5
5	Private transportation	$1.73 X 10^4$	9.8
6	Public transportation	$0.09 X 10^4$	0.5
7	Tourism	$0.32 X 10^4$	1.8
	Total ecological footprint	$17,74 X 10^4$	100

The households contribute most (~81%) to the total ecological footprint. Private transportation and tertiary come second and third respectively (around 10% and 6% respectively). The fourth contributing sector is tourism (~2%). The remaining sectors, i.e. municipal buildings, public transportation and public lighting contribute only marginally to the total ecological footprint of the area. As a result, the first priority axis aimed to reduce the ecological footprint of NP-EMATH would be to work towards a more sustainable use in households. This would substantially improve the NP-EMATH ecological footprint.

However, related actions do not fall under the Managing Authority's responsibility, with the result that the substantial reduction in the ecological footprint is basically the consumer behavior of the households of the National Park. These results are in line with the international literature[1] which indicates that the satisfaction of both the consumer and energy needs are the key parameters of contribution to the ecological footprint of areas where human activity exists. The results are then analyzed by sector of activity.

[1] http://environmentvictoria.org.au/content/our-ecological-footprint#.VPsponysWgs

2.3.2 Results per sector

In this chapter we analyze and evaluate the housing and tourism sectors. The sector of housing includes the consumption of products by local residents, the use of private vehicles on local roads and energy consumption by households. Tourism includes the consumption of products by visitors to the area, energy consumption in the buildings of the hotel sector in the area and the use of vehicles for tourist transportation.

2.3.2.1 Household sector

The ecological footprint of households within the NP-EMATH was calculated at 143,628 Gha, which corresponds to a rate of 79% of the total ecological footprint. The main factors contributing to the ecological footprint of households are: a) consumption of products (121,780 Gha), b) energy consumption (20,898 Gha), while a small contribution is due to c) paper consumption (950.6 Gha). The consumption of products, mainly beef, fruits and vegetables and beverages, mostly contributes to the ecological footprint of households, followed by energy and thermal energy consumption. The ten main processes that contribute to the ecological footprint of households of NP-EMATH are presented in **Figure 2-3.**

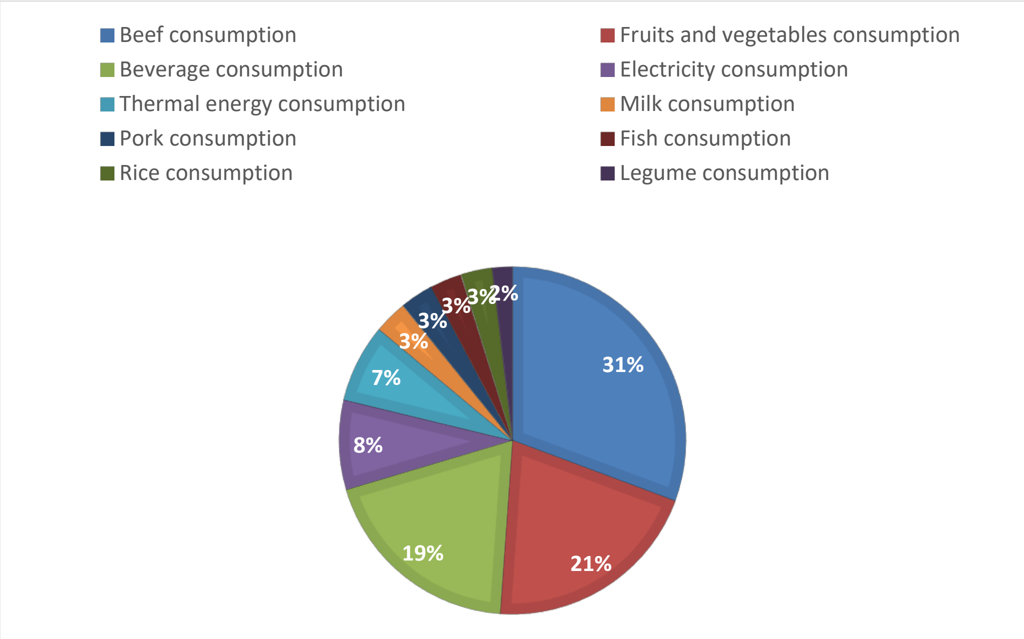

Figure 2-3: Contribution (in percentage) of the ten main processes in the ecological footprint of households (in descending order).

The large contribution of product consumption to the household ecological footprint (84.8%) can be justified by the fact that the ecological footprint analysis was carried out by integrating the LCA into its basic methodology. The software used takes into account, in addition to the land required for the production needs of the products in question, all the processes and materials necessary for the production, processing, transport and disposal of the products. In this way, the approach used in this study integrates in its calculations the contribution of both agriculture and industry. At this point, it should be stressed that the indirect contribution of these two sectors is limited only to the quantities of products consumed within the NP-EMATH. In other words, the agriculture and industry sectors of the area contribute to the ecological footprint with the quantities of products for local consumption, while the products exported "burden" the area in which they are consumed.

The results of the ecological footprint of product consumption are generally in line with international literature, as shown in **Figure 2-4**[2], although the relatively high contribution of fruits and vegetables is noted. The products that contribute to the ecological footprint (in descending order) are: (a) beef; (b) dairy products; (c) oils and fats; (d) pork and chicken; (e) pulses and eggs; f) sweeteners and g) fruits and vegetables. As far as global data is concerned[3], meat production accounts for 70% of the available agricultural land and for 20% of the anthropogenic emissions of greenhouse gases. The impacts of livestock farming include the reduction of biodiversity by constant land use changes (forests that are turned into pastures).

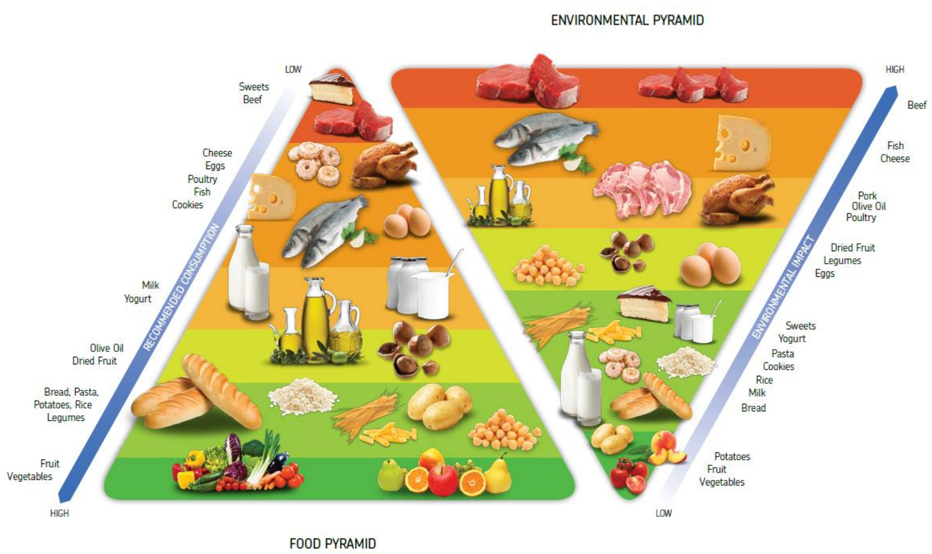

Figure 2-4: Contribution of products to the ecological footprint.

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[2] Barilla center for food and nutrition
[3] Barilla center for food and nutrition

Energy consumption in residential buildings contributes 14.6% to the household ecological footprint and is distributed in decreasing order of consumption of (a) electricity (7.8%) and (b) heating (6.8%). The use of passenger cars for the transportation for households contributes 9.5% in the total ecological footprint of NP-EMATH.

2.3.2.2 Tourism sector

The ecological footprint of tourism was estimated to **3,173 Gha** or 1.75% of the total ecological footprint. The main processes that contribute to the ecological footprint of the tourism sector are energy consumption (both electricity and thermal energy, 2,33 **Gha**, or 73% of the footprint of tourism sector). In **Figure 2-5** we present the five main processes that contribute mostly to the ecological footprint of tourism in NP-EMATH.

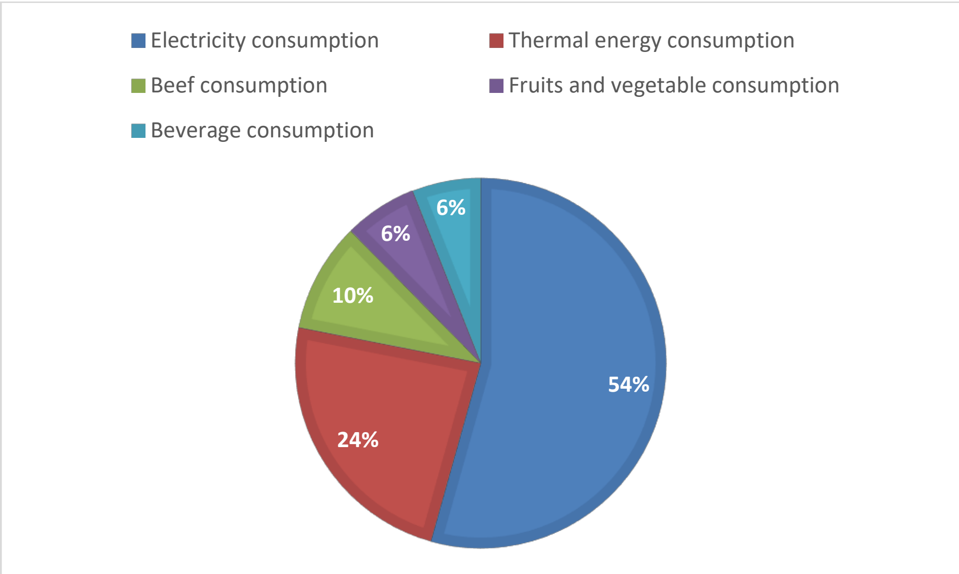

Figure 2-5: The five main processes of the tourism sector contributing mostly to its ecological footprint (data in descending order).

The consumption of products in the tourism sector accounts for 0.47% of the total ecological footprint and 0.7% of the ecological footprint of the consumption of products (**Figure 2-6**). The processes contributing to the ecological footprint of the consumption of products in the tourism sector are the consumption of beef (33.7%), followed by fruit and vegetables (22.4%) and beverage consumption (21.2%).

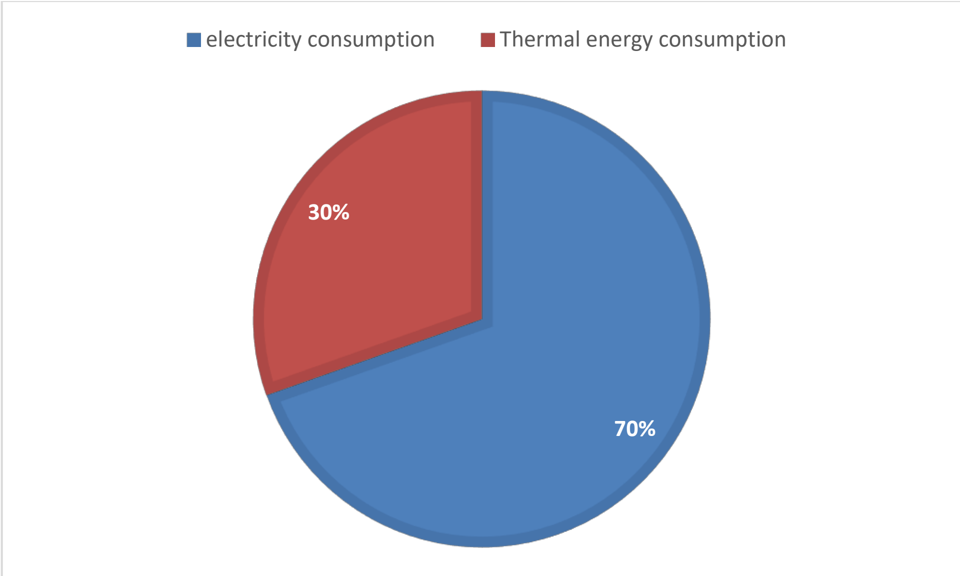

Figure 2-6: Contribution of consumption of electric and thermal energy to the ecological footprint of energy consumption in hotels in NP-EMATH.

2.3.3 Results of ecological footprint per activity

The results of the ecological footprint per population are presented in **Table 2-12.**

Table 2-12. Results per population.

Population		36,960	
	Subcategories of Population		**Pymax**
1	Residents' population	29,276	30,278 person
2	Tertiary buildings' population	2,097	567,372.85 m^2
3	Municipal buildings' population	271	163,756.69 m^2
4	Public lighting's population	158	729.32 kW
5	Private transportation's population	3,527	186,000,201.23 km
6	Public transportation's population	177	11,746,131.17 km-tkm-personkm
7	Tourists' population	647	26,127 person

It is noted that the number of residents' population is very close to the maximum for the area, comprising around 97% of this maximum value. With regard to the tourists, currently the population is well below the maximum number (2.5% of the maximum value). Further, the results of ecological footprint per consumption activity are presented in **Table 2-13.**

Table 2-13. Results of ecological footprint per consumption activity

	ECOLOGICAL FOOTPRINT	**181,324**		
	Subcategories of Ecological Footprint			
1 Agricultural products	**Description**	**value in t/y**	**Gha/t/y**	**Gha**
	Bread Consumption in t per year	2,197.58	0.31	675.97
	Potatoes Consumption in t per year	4,189.13	0.10	402.16
	Sugar Consumption in t per year	274.70	0.34	92.16
	Cereals Consumption in t per year	1,098.79	0.67	732.89
	Flour Consumption in t per year	618.07	0.42	261.44
	Legumes Consumption in t per year	3,708.41	0.68	2,526.54
	Fruits and Vegetables Consumption in t per year	37,015.45	0.74	27,502.48
	Beverage Consumption in t per year	12,292.70	2.11	25,937.59
	Tobacco Consumption in t per year	68.05	1.14	77.58
	Rice consumption in t per year	6,867.43	0.57	3,939.16
	Vegetable oils Consumption in t per year	892.77	2.59	2,314.05
2 Livestock products		**value in t/y**	**Gha/t/y**	**Gha**
	Pork meat Consumption in t per year	3,021.67	1.38	4,169.90
	Beef meat Consumption in t per year	2,815.65	14.65	41,249.22
	Sausages Consumption in t per year	1,373.49	1.38	1,895.41
	Chicken Consumption in t per year	2,197.58	0.69	1,516.33
	Egg Consumption in t per year	1,785.53	0.51	915.98
	Milk Consumption in t per year	22,319.15	0.19	4,140.20
	Cheese Consumption in t per year	1,373.49	0.15	207.40
	Butter Consumption in t per year	480.72	0.01	5.62
3 Fishery and Aquaculture products		**value in t/y**	**Gha/t/y**	**Gha**
	Fish Consumption in t per year	3,090.34	1.28	3,955.64
	Seafood Consumption in t per year	5,013.22	0.02	107.28
4 Timber products		**value in t/y**	**Gha/t/y**	**Gha**
	Paper Consumption in t per year	2,312.80	0.41	950.56

		value in kwh or km or personkm or tkm	Gha/kWh or km or personkm or tkm	Gha
5 CO2 emissions (Carbon Footprint)	Electricity Consumption in kWh per year	80,823,265.41	0.00027	21,898.26
	Thermal Energy Consumption in kWh per year	147,497,399.09	0.00009	13,717.26
	km per year passing by scooter	31,537,500.00	0.00003	829.99
	km per year passing by lorry	36,478,263.80	0.00027	9,784.46
	km per year passing by passenger car, diesel	19,271,343.34	0.00006	1,093.48
	km per year passing by passenger car, petrol	94,089,499.86	0.00006	5,882.85
	km per year passing by regular bus	924,662.40	0.00035	322.27
	personkm per year passing by train	1,533,000.00	0.00001	18.84
	tkm per year passing by barge tanker	358,730.41	0.00001	3.08
	tkm per year passing by ferry boat	2,152,672.63	0.00001	19.88
	personkm per year passing by passenger aircraft	4,851,199.18	0.00004	214.80
	tkm per year passing by freight aircraft	7,259.84	0.00044	3.21
6 Built-up surfaces		**value in ha**	**Cropland EqF**	**Gha**
	Built-up areas	1,799.99	2.0	3,959.98

2.3.4 Comparison of results with other studies

The innovative and holistic approach of the ecological footprint model of NP-EMATH does not allow a direct comparison of the results with those of other corresponding studies. However, in order to better document the validity of the calculations and to evaluate the Ecological Footprint of NP-EMATH it was decided to compare the results with reliable data available at the national level (since the anthropogenic activities within the National Park are similar to rural - semi-urban areas).

According to the Global Footprint Network, the average national per capita ecological footprint for Greece for 2007 was 5.4 Gha/cap[4], the European equivalent was 4.7 Gha /cap and the global average was 2.7 Gha per capita. The ecological footprint per capita for NP-EMATH stands for 6.19 Gha/cap.

The comparison of the results of the present study with the data from studies carried out in other parts of the world should be made with caution since: (a) each region has its own specific characteristics; (b) the reference year of the ecological footprint is different; c) thresholds differ as most studies worldwide are limited to examining the tourism sector of protected areas.

[4] http://www.footprintnetwork.org/en/index.php/GFN/

Considering all the above, it can be concluded that the NP-EMATH ecological footprint (6.19 Gha per inhabitant) is considered satisfactory with room for improvement and is in line with the international literature.

2.4 Carbon Footprint results

2.4.1 Total carbon footprint of Study Area 1

According to the estimates of carbon dioxide equivalent emissions for the reference year, the total carbon footprint of Study Area 1 was estimated at 225,366 tonnes of CO2-eq at or 7,7 tonnes per inhabitant of the National Park, as shown on **Table 2-14**.

Table 2-14: Carbon Footprint results of study area 1.

Total Carbon Footprint (tonnes CO2eq)	**225.365,93**
Total Carbon Footprint per capita (tonnes CO2eq)	**7,70**
Total Carbon Footprint (per Equivalent Person-Population)	**6,20**

Table 2-15 shows the main processes contributing to the carbon footprint of study area 1. Electricity consumption (including households, municipal and tertiary buildings, and public lightning) is the most contributing process (33.2%) to the total carbon footprint, followed by a small difference in the consumption of thermal energy for heating (including households, municipal and tertiary buildings) (32%) and the use of heavy trucks (16,24%). It is therefore suggested, as expected, the importance of the objective of reducing energy needs (or changing the energy mix) to substantially improve the carbon footprint of study area 1.

Table 2-15: Processes contributing to the carbon footprint of study area 1.

S/N	Process	Unit	
		tn CO_2 eq.	%
1	Electricity consumption	74.836	33,2
2	Heating oil consumption	72.185	33,0
3	Use of heavy trucks	36.607	16,2
4	Car use (oil)	22.193	9,8

More specifically, housing (42.5%), private and commercial transport within the local / provincial road network (30,8%) and buildings/installations in the tertiary sector (19,17%) are the sectors that affect carbon footprint the most. Specific proposals for action by the Managing Authority are described in detail in Chapter 4. It should be noted that the tertiary sector includes business premises / freelancers who do not offer a material product but provide their customers with services. Such services are indicative of those provided by freelancers (eg lawyers) or organized businesses, eg. cleaning, real estate, transportation, banking, health, etc. These results are in line with the international literature that suggests the satisfaction of the building's energy needs as the key factor in the contribution to the coal mining of areas where urban activity occurs. The results are then analyzed more accurately by segment activity.

2.4.2 Results per sector/activity

Households

The total carbon footprint of the building/housing sector within study area 1 was estimated at around **95,807 tonnes of CO2-eq**. which corresponds to a percentage of **42,5%** of the total carbon footprint. The main contributors to the carbon footprint of the household buildings are (**Table 2-16**): (a) electricity consumption at 41,188 tonnes CO2 eq; (b) thermal energy consumption (for heating) at 54,619 tonnes CO2 eq.

Table 2-16: Study area 1 households contribution on carbon footprint.

Households					**95.806.745,90**
	Indicator code	**Description**	**value**	**Kg CO2eq/kwh**	**Kg CO2eq**
5. CO2 emissions	Indicator CF5.1.1	Electricity Consumption in kWh per year	41.187.497,42	1,00	41.187.497,42
	Indicator CF5.2.1	Thermal Energy Consumption in kWh per year	140.771.258,98	0,39	54.619.248,48

According to data from the National Statistical Service of Greece (NSSG), about 71% of Greek buildings were constructed before 1980, have no thermal insulation and low energy efficiency, while most of them have old, inadequately maintained electromechanical installations. During the first decade of application of the Building Thermal Insulation Regulation, which became mandatory in 1979, the majority of buildings did not adequately apply thermal insulation according to the minimum requirements and only recent constructions (> 1990) have thermal insulation in the load bearing structure and , therefore, uniform insulation in the building shell in order to avoid the appearance of thermal bridges. As a result, the existing buildings are largely insulated, despite the fact that heating rates exceed 2600 in the northern part of the country. It should be stressed here that the heating grade days are the size used to determine the heating / cooling needs in the interiors of a building. The base temperature in Greece for the interiors of a building is considered to be 18 ° C for the heating period and 26 ° C for the cooling period.

It is therefore estimated that the major cause of the large heat losses that the building potential of both the domestic and the tertiary sector and consequently of the large thermal / refrigerant loads required for heating / cooling is high is the excessive absence of thermal insulation of external walls and ceilings, especially in constructions prior to 1980 which make up about 71% of the total building stock.

In addition, significant thermal losses are also observed in the transparent building blocks of the exposures in a large proportion of the existing Greek buildings that are still present, even today, with single glazing. Thermal losses due to the absence of double or triple glazing lead to a further increase in thermal loads in the winter and refrigerant loads in the summer. Last but not least, the most problematic point in the building sector (irrespective of end-use) is the old electromechanical installations which, both in their terminal units and in the heat / cooling distribution networks and in the production units (boilers / burners), are poorly insulated, losses, low efficiency and high operating and maintenance costs. The absence of insulation in the boiler / burner system results in losses of ~ 5%, while an incorrectly maintained boiler also adds up to ~10% losses to the heating / cooling system and, of course, an increase in the gaseous pollutants produced.

By refining the final use of a building, in the case of the Greek buildings in the residential sector and, by extension, of the buildings within study area 1, the most important additional problems of energy losses identified are the following:

- poor gaskets due to the absence of thermal insulation combined with the existence of double-glazed windows that provide undesirably high air-tightness (the building does not "breathe").
- The absence of use of solar systems (collectors) for the production of hot water (DHW) and passive solar systems, taking into account the geographical location of the country (high annual percentage of sunshine).
- the undue use of lamps, air-conditioning systems and, more generally, the use of "white" appliances with low energy efficiency.
- the absence of ventilation, cooling and shading systems.

Of particular interest is the use of wood for heating which has an increasing demand. In these calculations it was considered that wood is a percentage of the biomass consumed nationwide, as there was no reliable data on the actual consumption of timber within the boundaries of study area 1 (or the municipalities that are included in it). In this context, the calculations regarding timber consumption may be underestimated as consumption in Northern Greece is particularly high compared to the rest of Greece. The uncontrolled movement of timber of unknown origin, as well as its inefficient burning in non-energy fireplaces, are important issues with which the Managing Authority (and the competent municipalities) could deal more extensively. Carbon dioxide emissions from "unsustainable" timber (cutting from natural forests, incineration in inefficient fireplaces, etc.) are very high and burden not only the total carbon footprint of study area 1 and its environmental performance as a whole, but also the quality of the urban atmosphere particularly in conditions that do not favor the diffusion of air pollutants.

Tertiary buildings

The total carbon footprint of tertiary sector buildings within study area 1 was estimated at **43,197 tonnes of CO2-eq**. which corresponds to a percentage of **19,2%** of the total carbon footprint. The main factors contributing to the carbon footprint of these buildings are (**Table 2-17**): (a) electricity consumption (**27,889 tonnes CO2 eq**); and (b) consumption of heating oil **(15.308 tonnes CO2 eq)**

Table 2-17: Study area 1 tertiary buildings contribution on carbon footprint.

Tertiary buildings					**43.197.397,25**
	Indicator code	**Description**	**value**	**Kg CO2eq/kwh**	**Kg CO2eq**
5. CO2 emissions	Indicator CF5.1.2	Electricity Consumption in kWh per year	27.889.270,00	1,00	27.889.270,00
	Indicator CF5.2.2	Thermal Energy Consumption in kWh per year	39.453.936,20	0,39	15.308.127,25

The main problems related to the tertiary sector buildings are identified with the problems described for the residential sector. By refining the use of a building, it can be said that in the case of tertiary sector buildings, particularly in the case of office and service buildings with a large area and number of floors and an extensive network of electromechanical installations, additional problems are:

- the widespread, reckless use of air-conditioning systems, often of low energy efficiency, which could be offset by the use of ceiling fans and the provision of natural cooling and shading.
- the widespread and often unreasonable use of low-energy lamps.
- the absence of automation systems such as thermostats and "intelligent lighting" systems with motion sensors, lighting, lighting level adjustment, etc., which in extensive facilities prove to be extremely efficient.
- the absence of building management systems (BMS).

Finally, a basic problem of Greek reality is the lack of "energy education". Irrespective of the building sector, problem and solution-intervention for energy saving, the user of the building and the cooling, heating, air-conditioning and ventilation systems plays an important role.

Transportation sector

The total carbon footprint of the transportation sector with study area 1 was estimated at **69,405 tonnes of CO2-eq** (including both private and public transportation), which corresponds to a percentage of **30.8%** of the total carbon footprint. **Tables 2-18** and **2-19** present an in depth analysis of the results between private and public transportation.

Table 2-18: Study area pubic transportion contribution on carbon footprint.

Public Transportation					3.226.145,83
	Indicator code	**Description**	**value**	**Kg CO2eq/km**	**Kg CO2eq**

				or personkm or tkm	
5. CO2 emissions	Indicator CF5.3.6	km per year passing by public scooter	52.500,00	0,10	5.460,00
	Indicator CF5.4.6	km per year passing by public lorry	937.500,00	1,03	965.625,00
	Indicator CF5.5.6	km per year passing by public passenger car, diesel	91.800,00	0,21	19.645,20
	Indicator CF5.6.6	km per year passing by public passenger car, petrol	448.200,00	0,24	106.223,40
	Indicator CF5.7.6	km per year passing by regular bus	924.662,40	1,32	1.220.554,37
	Indicator CF5.8.6	personkm per year passing by train	1.533.000,00	0,00	3.280,62
	Indicator CF5.9.6	tkm per year passing by barge tanker	358.730,41	0,03	11.802,23
	Indicator CF5.10.6	tkm per year passing by ferry boat	2.152.672,63	0,04	76.204,61
	Indicator CF5.11.6	personkm per year passing by passenger aircraft	4.851.199,18	0,17	805.299,06
	Indicator CF5.12.6	tkm per year passing by freight aircraft	7.259,84	1,66	12.051,33

Transportation using the road network contribute almost totally to the carbon footprint of the transport sector. This specific result is justified by the fact that, due to its size, study area 1 includes significant areas of national and provincial roads, part of the Egnatia Odos (European E90 motorway), while also provides access to the island of Thassos resulting in high traffic especially during the summer months.

Table 2-19: Study area 1 private transportation contribution on carbon footprint.

Private Transportation					**66.178.837,06**
	Indicator code	**Description**	**value**	**Kg CO2eq/km**	**Kg CO2eq**
CO2 emissions	Indicator CF5.3.5	km per year passing by private scooter	31.485.000,00	0,10	3.274.440,00
	Indicator CF5.4.5	km per year passing by private lorry	35.540.763,80	1,03	36.606.986,71
	Indicator CF5.5.5	km per year passing by private passenger car, diesel	19.179.543,34	0,21	4.104.422,28
	Indicator CF5.6.5	km per year passing by private passenger car, petrol	93.641.299,86	0,24	22.192.988,07

Public Lightning

The total carbon footprint due to power consumption to meet the needs of public/municipal lighting within study area 1 was estimated at **2.867 tonnes of CO2-eq**. which corresponds to a percentage of **1,3%** of the total carbon footprint. These results are characterized by relatively high uncertainty due to the lack of detailed and reliable data on the power and types of lamps used (incomplete city-level recording system). The project team made some unplanned field observations in various areas of the National Park, observing that incandescent bulbs (> 150W) are used in many cases. Possible replacement with other technology (e.g. LED) lamps will result in significant electricity savings and emissions.

Tourism Sector

In the effort to quantify the carbon footprint of tourism, all the elements that make up the environmental impact of tourism activities in terms of carbon dioxide equivalent emissions (tourist / visitor movements, hotel / hotel energy needs) were separated. The calculations also include the impact of the visitors on the island of Thassos. These data were modeled separately from the general categories previously described to extract their relevant carbon footprint.

The total carbon footprint of tourism activities carried out within study area 1 was estimated at **8,930 tonnes of CO2-eq**. which corresponds to a percentage **of 3,96%** of the total carbon footprint. As we can see, the contribution of tourism to the total carbon footprint of study area 1 is relatively low, and does not raise significant concerns at the existing levels.

Industrial and agricultural sector

Due to the approach followed, carbon dioxide emissions from industrial and agricultural activity are considered to be included in the products that are produced and counted in the Ecological Footprint section of the study. This assumption is in line with the EU's proposals whereby industrial and agricultural activity is excluded from study boundaries, as local authorities cannot carry out substantial interventions to improve these areas (environmental control is basically through national regulations / legislation).

2.5 Water Footprint results

2.5.1 Total Water Footprint for NP-EMATH

Total Water Footprint for NP-EMATH, has been calculated equal to **$5{,}40\times10^{8}$ m^3/yr or 18.825 m^3/yr/rcapita**. Agriculture contributes with 99,4% to Total Water Footprint, while industry contributes with 0,2% and household with 0,4%. This is a reasonable result, as agriculture remains the most important economic activity in the area, while industry is limited.

2.5.2 Water Footprint for agricultural sector

Total Water Footprint for agricultural sector for year 2007 equals to 3,8×10^4 m^3/tn, for year 2008 equals to 3,5×10^4 m^3/tn and for year 2009 equals to 3,9×10^4 m^3/tn. the Total Water Footprint, as also its three components (green, blue and grey), are presented on **Table 2-20**.

Table 2-20: Green, blue and grey components and total water footprint for agricultural sector

WF (m^3/tn)	2007	2008	2009
WF_{green}	9.693	6.471	14.492
WF_{blue}	16.721	17.032	13.280
WF_{grey}	8.331	8.331	8.331
WF	34.745	31.834	36.103

It should be noted that on among aforementioned three years, the year 2009, was the one with highest rainfall, the year 2008 was the one with lowest rainfall, while the year 2007 was the one with average rainfalls.

We are observing that on 2008, the use of green water (water from rainfalls), is lower about 8.000 m^3/tn (-55%), comparing to rainy year of 2009. At the same time, we are observing that the use of blue water is higher about 3.800 m^3/tn (+ 22%). Grey water footprint remains stable, as the needs for crops fertilization and yields remains the same for all three years. Reduction on rainfalls implies increase of irrigated water, as it is perceived that water volume consumed is the one needed to fully cover crop needs for evapotranspiration.

Figure 2-7 presents the percentage of green, blue and grey water footprint comparing to total water footprint for respective three years.

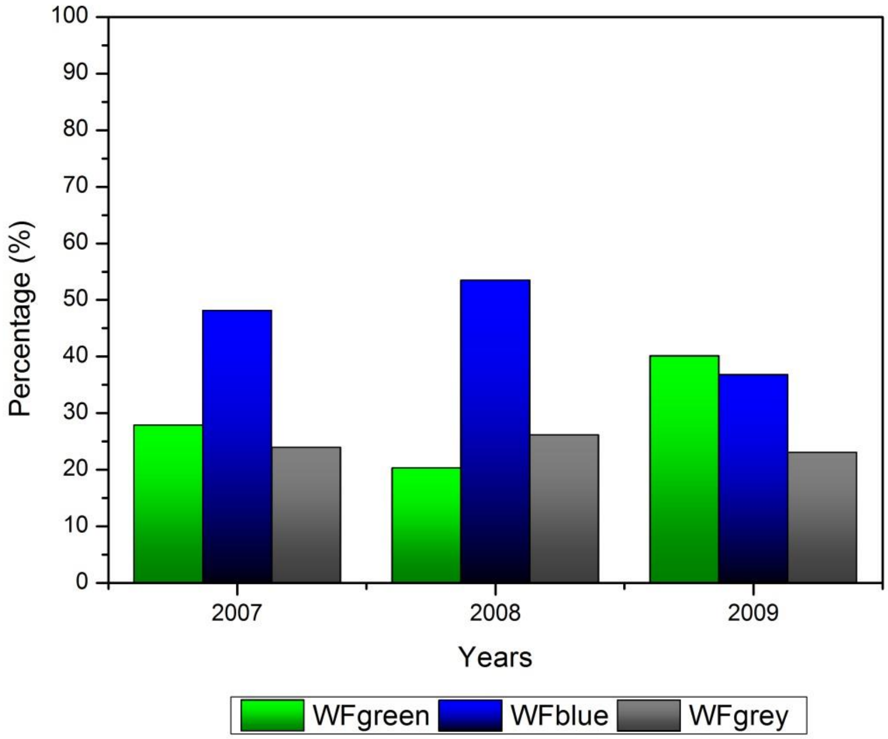

Figure 2-7: Percentage of green, blue and grey water footprint comparing to total water footprint for respective three years.

For year 2008, crops total water needs has being satisfied by 20% from green water and by 53% from irrigated (blue) water. For year 2009 green water equals to 40% of total water, so needs for irrigated water has been reduced to 36%. Grey water is about 25% of total consumption.

Tables that are presented below, show the results for every single water footprint component (green, blue and grey water) as also show the total water footprint for three consecutive years. On last column we can see the contribution of each crop (percentage) to the total water footprint. Dry crops do not have a blue component, while crops grown without fertilizer application have a zero grey component.

Table 2-21: Crops water footprints for the year 2007 (average rainfalls).

Crop type	WF_{green} (m^3/tn)	WF_{blue} (m^3/tn)	WF_{grey} (m^3/tn)	WF (m^3/tn)	%
Wheat	921,80	436,75	400,42	1.758,96	5,1
Barley	913,26	302,62	413,55	1.629,43	4,7
Corn	110,61	425,98	309,64	846,24	2,4
Rice	173,99	1.093,22	183,33	1.450,53	4,2
Beans	132,02	1.227,91	340,24	1.700,17	4,9

Chickpeas	338,00	646,00	305,81	1.289,81	3,7
Cotton watered	481,39	1.637,46	496,23	2.615,08	7,5
Cotton dry	1.022,03	0,00	351,18	1.373,21	4,0
Sunflower	625,46	2.135,84	521,02	3.282,32	9,4
Sugar beet	19,95	68,13	9,23	97,31	0,3
Hay	71,40	63,95	99,78	235,12	0,7
Blinds	599,76	537,18	209,53	1.346,47	3,9
Watermelons + Melons	31,00	120,02	156,12	307,14	0,9
Potatoes	45,26	142,77	120,24	308,27	0,9
Cabbage	17,76	142,19	77,65	237,60	0,7
Cauliflowers	18,43	147,52	80,56	246,51	0,7
Spinach	111,28	117,92	487,30	716,50	2,1
Leek	125,66	381,20	206,73	713,60	2,1
Onions dry	251,35	320,22	365,25	936,82	2,7
Garlic dry	111,70	235,90	137,61	485,21	1,4
Green pea	101,40	371,50	91,74	564,64	1,6
Lettuce	37,85	52,69	180,58	271,12	0,8
Tomatos	49,13	153,59	61,91	264,63	0,8
Green beans	104,78	285,01	193,62	583,41	1,7
Okra	243,13	907,72	306,39	1.457,24	4,2
Zucchini	147,80	1.202,00	513,63	1.863,43	5,4
Cucumbers	86,72	337,91	470,79	895,43	2,6
Eggplants	102,82	188,01	175,83	466,66	1,3
Asparagus	644,68	829,61	254,55	1.728,85	5,0
Olive trees	1.358,77	1.335,96	536,51	3231,24	9,3
Fruit trees	693,64	875,00	273,88	1842,53	5,3
Total	9692,83	1.6721,78	8.330,84	34.745,46	100

Table 2-22: Crops water footprints for the year 2008 (low rainfalls).

Crop type	WF_{green} (m^3/tn)	WF_{blue} (m^3/tn)	WF^{grey} (m^3/tn)	WF (m^3/tn)	%
Wheat	517,05	515,60	400,42	1.433,07	4,5
Barley	465,49	402,39	413,55	1.281,43	4,0
Corn	91,35	398,17	309,64	799,17	2,5
Rice	116,44	1.111,73	183,33	1.411,50	4,4
Beans	163,55	1.153,36	340,24	1.657,15	5,2
Chickpeas	281,67	675,00	305,81	1.262,48	4,0
Cotton watered	366,00	1.595,27	496,23	2.457,50	7,7
Cotton dry	777,05	0.00	351,18	1.128,23	3,5

Sunflower	362,45	2.130,79	521,02	3.014,26	9,5
Sugar beet	16,38	89,49	9,23	115,10	0,4
Hay	63,08	65,58	99,78	228,43	0,7
Blinds	529,87	550,88	209,53	1.290,29	4,1
Watermelons + Melons	20,36	118,07	156,12	294,55	0,9
Potatoes	14,85	146,66	120,24	281,75	0,9
Cabbage	11,98	140,11	77,65	229,74	0,7
Cauliflowers	12,43	145,36	80,56	238,35	0,7
Spinach	118,05	154,57	487,30	759,92	2,4
Leek	110,12	376,92	206,73	693,77	2,2
Onions dry	174,24	345,44	365,25	884,93	2,8
Garlic dry	83,05	241,10	137,61	461,76	1,5
Green pea	84,50	346,30	91,74	522,54	1,6
Lettuce	27,56	62,68	180,58	270,81	0,9
Tomatos	24,53	152,65	61,91	239,09	0,8
Green beans	73,76	274,35	193,62	541,73	1,7
Okra	173,33	906,38	306,39	1.386,10	4,4
Zucchini	132,12	1.124,74	513,63	1.770,49	5,6
Cucumbers	59,44	334,24	470,79	864,46	2,7
Eggplants	116,24	202,96	175,83	495,02	1,6
Asparagus	354,60	886,08	254,55	1.495,23	4,7
Olive trees	747,37	1.443,56	536,51	2.727,44	8,6
Fruit trees	381,53	941,87	273,88	1.597,28	5,0
Total	6.470,43	17.032,31	8.330,84	31.833,58	100

Table 2-23: Crops water footprints for the year 2009 (high rainfalls).

Crop type	**WF_{green} (m^3/tn)**	**WF_{blue} (m^3/tn)**	**WF_{grey} (m^3/tn)**	**WF (m^3/tn)**	**%**
Wheat	1.256,41	295,04	400,42	1.951,87	5,4
Barley	1.196,94	207,95	413,55	1.818,45	5,0
Corn	169,84	339,22	309,64	818,70	2,3
Rice	256,98	955,06	183,33	1.395,38	3,9
Beans	374,56	1.043,59	340,24	1.758,39	4,9
Chickpeas	594,00	515,67	305,81	1.415,48	3,9
Cotton watered	704,96	1.322,66	496,23	2.523,85	7,0
Cotton dry	1.496,68	0,00	351,18	1.847,86	5,1
Sunflower	850,10	1.637,60	521,02	3.008,71	8,3
Sugar beet	31,74	75,07	9,23	116,04	0,3
Hay	166,34	45,46	99,78	311,58	0,9

Blinds	1.397,31	381,87	209,53	1.988,72	5,5
Watermelons + Melons	45,07	93,85	156,12	295,03	0,8
Potatoes	51,20	118,66	120,24	290,10	0,8
Cabbage	11,61	138,81	77,65	228,07	0,6
Cauliflowers	12,05	144,01	80,56	236,62	0,7
Spinach	98,66	138,10	487,30	724,07	2,0
Leek	212,72	297,67	206,73	717,13	2,0
Onions dry	323,54	291,96	365,25	980,74	2,7
Garlic dry	211,80	186,15	137,61	535,56	1,5
Green pea	178,20	264,20	91,74	534,14	1,5
Lettuce	45,42	44,74	180,58	270,74	0,7
Tomatos	59,01	125,92	61,91	246,85	0,7
Green beans	166,72	194,16	193,62	554,50	1,5
Okra	371,04	725,87	306,39	1.403,30	3,9
Zucchini	356,63	914,52	513,63	1.784,77	4,9
Cucumbers	123,93	281,21	470,79	875,93	2,4
Eggplants	138,56	152,36	175,83	466,75	1,3
Asparagus	858,19	656,75	254,55	1.769,50	4,9
Olive trees	1.808,77	1.006,72	536,51	3.352,00	9,3
Fruit trees	923,37	685,28	273,88	1.882,53	5,2
Total	14.492,36	13.280,14	8.330,85	36.103,34	100

By analysing tables 14-1, 14-2 και 14-3, we can conclude that the most demanding crops are the sunflower (3.100 m^3/tn), olive trees (3.100 m^3/tn), cotton (2.539 m^3/tn), zucchini (1.805 m^3/tn) wheat (1.714 m^3/tn) and green beans (1.705 m^3/tn).

Finally, we have calculated the total water footprint in m^3/yr, in order to be available to add it with industrial and household use of water.

Table 2-24: Agriculture water footprint expressed in m^3/yr.

WF (m^3/yr)	2007	2008	2009
WF_{green}	$1,14\times10^8$	$0,80\times10^8$	$1,69\times10^8$
WF_{blue}	$2,99\times10^8$	$2,91\times10^8$	$2,39\times10^8$
WF_{grey}	$1,66\times10^8$	$1,66\times10^8$	$1,66\times10^8$
WF	$5,79\times10^8$	$5,37\times10^8$	$5,74\times10^8$

Vistonida lake and Nestos river area

On this section, we had calculated the agriculture water footprint for Vistonida lake and Nestos river area. We selected 2009 as a reference year, the most recent year with available data. To do that we had calculated water footprint of crops cultivated in the Vistonida lake and Nestos river area. Calculations are presented in **Table 2-25**.

Table 2-25: Vistonida lake and Nestos river areas water footprint.

Area	WF_{green} (m^3/tn)	WF_{blue} (m^3/tn)	WF_{grey} (m^3/tn)	WF (m^3/yr)
Vistonida	15.558	13.952	9.062	38.572
Nestos	14.247	12.469	8.256	34.972
NP-EMATH	14.492	13.280	8.331	36.103

Nestos area water footprint is lower than this for Vistonida area by 10%. Both areas water footprint is close to NP-EMATH water footprint, while water footprint for Vistonida is alittle bit higher (6%) and Nestos area water footprint is a little bit lower (3%). According to the spatial distribution of the licensed drillings it is concluded that 80% of the wells are concentrated in the area of Vistonida and the rest in the Nestos area, which is irrigated mainly by canals. The area of Nestos therefore mainly uses surface water while Vistonida underground water.

2.5.3 Water Footprint for industrial sector

Industrial water use was calculated to be 1.23 × 10^6 m3 / yr. As mentioned earlier, it was calculated by subtracting the data of the River Basin Management Plan of the Thrace Aquatic Area for the area of NP-EMATH.

2.5.4 Urban use of water

Urban water use was estimated to be 2.1 × 10^6 m3 / yr. As mentioned, urban water use was calculated theoretically, adopting an average daily consumption value for residents and tourists. Urban water use according to the Management Plan was estimated to be 2.5 × 106 m3 / yr, almost the same as that calculated theoretically.

2.5.5 Comparison of results with other studies

As in the case of Ecological and Carbon Footprint, the innovation and holistic nature of the calculations did not allow direct comparison with other National Parks (lack of corresponding data). However, in order to better document the validity of the calculations and the evaluation of the NP-EMATH Water Footprint it was decided to compare the results with reliable data available globally.

<u>Total water footprint</u>

Researchers as Chapagain et al. (2004)[5] calculated the average total water consumption in Greece for the period 1997-2001. It was found to be 16,4 × 10^9 m^3 / yr (crop requirement 14,8 × 10^9 m^3 / yr, industrial

[5] Chapagain, A.K. and Hoekstra, A.Y. (2004) Water footprints of nations, Value of Water Research Report Series No. 16, UNESCO-IHE, Delft, the Netherlands, www.waterfootprint.org/Reports/Report16Vol1.pdf.

use 0,775 × 10^9 m^3 / yr, household use 0,83 × 10^9 m^3 / yr) and 2,389 m3 / yr / resident. For NP-EMATH respectively it was calculated at 5.40 × 10^9 m^3 / yr and 18.225 m3 / yr / inhabitant. The water footprint per inhabitant is very high compared to the national water footprint. This can be explained by the fact that the area consists mainly of arable land and is sparsely populated. However, comparing the total consumption per year of the EMRP with the national consumption, it is estimated that this corresponds to 3.3% of the national consumption, which is considered reasonable. Therefore, for the area of NP-EMATH, a better picture is given by the use of water per year and not the use of water per year per inhabitant.

The Worldwide Water Footprint for the period 1996-2005 is 9.087 × 10^9 m^3 / yr. Agriculture contributes 92% to 7,404 × 10^9 m^3 / yr. Of this 78% is green water, 12% blue and 10% gray water[6]. According to the results in the area of NP-EMATH, agriculture contributes 99.4%. The blue and green water changes depending on the rainfall. For example, for year 2009, a year with high rainfall, green WF is 40% and blue WF is 37% of the total HM. Respectively for 2008 (low rainfall) the use of green MS is 20% increasing the demand for blue water to 54%. Gray WF ranges around 25%.

Crops water footprint

A comparison of some crops with national and global watermarks will be shown below. The cultures that occupy the largest area and were found more waterbed in the area of NP-EMATH were selected.

- The water footprint of the wheat was higher than the corresponding national but very close to the corresponding world.
- For maize the water footprint was found to be lower than the corresponding global one, but very close to the national one.
- The water footprint for barley was higher than the corresponding national, but quite close to the corresponding world.
- For the sunflower the YA value is much higher than the national water footprint, but less than the global water footprint.
- For cotton the value of the water footprint calculated is about 1,000 m^3 / tn higher than that of Greece, but it is lower by 1,500 m^3 / tn relative to the world.
- The OA of olive trees for NP-EMATH is very close to the global one, and increased by 500 cubic meters per ton but by the national.

Generally speaking, there is a trend of overestimating the WF compared to national levels, and there is a better correlation with global data. Please note that grey water is not calculated when calculating national watercourses.

[6]Mekonnen, M.M. and Hoekstra, A.Y. (2010) The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft, the Netherlands.

Table 2-26: Comparing some crops water footprints with national and international data.

Crop	WF_{NPNDVL} (m^3/tn)	WF_{GREECE} (m^3/tn)[1]	WF_{global} (m^3/tn)[2]
Wheat	1.714	1.231	1.827
Corn	821	706	1.222
Barley	1.576	1.112	1.423
Sunflower	3.100	943	3.366
Cotton	2.539	1.534	4.029
Olive trees	3.100	2.606	3.015

Comparison of the results of the present study with the foregoing data should be made with caution as they refer to different time intervals and different assumptions have been made for the calculations.

2.6 Further analysis of results

The ecological footprint measures the amount of natural resources consumed by a person, a society or a country at a given time; it is calculated by adding the footprint of all inhabitants (Kitzes and Wackernagel, 2009) and converting them into corresponding equivalent hectares using conversion factors (Monfreda et al., 2004). The environmental sustainability is assessed by comparing the ecological footprint with bioactivity (the area that is ecologically productive in the study area). If the ecological footprint is less than bioactivity then the system is viable and can export its difference in the form of products or services (Stoeglehner and Narodoslawsky, 2008).

Some of the results obtained from the calculation of the **ecological footprint** of NP-EMATH are summarized and commented on, in order to strengthen the decision making capabilities of the Management Authority regarding the evaluation of existing / new activities related to the management of the biologically productive land of the area:

- Households is the main sector within the NP-EMATH; it comprises 81% of the total ecological footprint. The key contributing factors are the consumption of livestock and agricultural products and energy.

- Product consumption, formed by agricultural, livestock and fish products, contributes most (69%) to the total ecological footprint. Energy consumption in the building sector, including thermal energy, is the second contributing process/sector (20%). Vehicle use contributes 10% to the ecological footprint.

- The most important parameters contributing to the total ecological footprint are mainly the consumption of beef, of fruits and vegetables and of food and beverages. A potential change in the dietary habits of the local residents by theoretically totally replacing beef with pork or chicken would lead to a reduction in the total ecological footprint.

The consumption of local products reduces the ecological footprint of the area as the transport needs that contribute to it are avoided.

It is noted that the improvement of the environmental performance of the National Park of Eastern Macedonia and Thrace (NP-EMATH), in this category, lies in two general directions: a) to the increase of biocapacity and b) to the reduction of the Ecological Footprint. Practices for the reduction of the ecological footprint include the rational use of fertilizers and pesticides, and suggest regular organic cultivations. Taking into account the importance of land use for ecological footprint calculations (factor of equivalence 2.2) and the percentage (74.5%) of the total area of NP-EMATH, which is covered by agricultural crops, it is suggested that the improvement of the environmental performance of agriculture can contribute to a very high extent to the reduction of the ecological footprint and to the increase of biocapacity. Many of the actions related to the improvement of the ecological footprint are directly linked to the reduction of the Carbon Footprint through the reduction / improvement of the energy balances in the area.

Specific suggestions for improving the ecological footprint of study area 1 are provided in Chapter 4.1 of this study.

With regard to the **carbon footprint**, some of the results obtained from its calculation for NP-EMATH are summarized and commented on in order to strengthen the decision making of the Managing Authority regarding the evaluation of existing / new activities related to the emissions of greenhouse gases:

- Electricity consumption is the most contributing process to the total carbon footprint, followed by a small difference in the consumption of heating oil. The satisfaction of the energy and thermal needs of the households within study area 1 and private/commercial transport, are key parameters of carbon footprint burden. Consequently, the awareness and information actions of the Managing Authority should aim beyond the visitors and residents of the area to improve their energy behavior.

- The carbon footprint due to tourist activities within the National Park (taking into account the transfer of travelers to Thassos using the Port of Keramoti) is a relatively small percentage of the total carbon footprint. As a result, the further increase in tourism activities within study area 1 is expected to have a relatively low impact on greenhouse gas emission levels, and can be further developed.

- Carbon footprint reflects the contribution/impact of a system on issues of a broader spatial interest (climate change - large dispersion of air pollutants) and therefore cannot indicate specific areas within the National Park with a strong environmental problem due to anthropogenic activities. However, areas with higher urbanization (e.g. Chrysoupolis) or areas near high traffic streets are expected to have lower air quality (with regard to combustion gases).

Specific suggestions for improving the carbon footprint of study area 1 are provided in Chapter 4.2 of this study.

The Water Footprint (WF) is usually comprised of three components (Hoekstra et al., 2011): a) Blue WF refers to the volume of surface and groundwater consumed, mainly by evaporation, in the production of a product or service; b) Green WF refers to the volume of water consumed by atmospheric precipitation (mainly rainwater) and c) Grey WF refers to the volume of water required to reduce the concentration of pollutants and to restore the quality of the water system to the desired levels.

Some of the results obtained from the NP-EMATH **water footprint** are summarized and commented on in order to strengthen the decision of the Management Body regarding the evaluation of existing / new activities related to the reduction of water consumption:

- Agriculture is the main contributor to the region's water footprint.
- Dry periods reduce the green water footprint and increase the need for irrigation, while the wet periods increase the green water footprint and reduce the need for irrigation water.
- The water footprint of crops decreases as their yield increases.
- In the area of NP-EMATH the most demanding crops in water are the sunflower (3.100 m^3 / tn), the olive trees (3.100 m^3 / tn) and the cotton (2.539 m^3 / tn) followed by the zucchini (1.805 m^3 / tn) (1,714 m^3 / t) and beans (1,705 m^3 / t).

The total water footprint per inhabitant does not capture the status of the NP-EMATH in relation to the water requirement. It is preferable to select the water footprint per year.

It is noted that the agricultural sector is the main water consumer at the National Park of Eastern Macedonia and Thrace (NP-EMATH), so proposals should aim to save water, thus substantially improve the water footprint. Specific suggestions for improving the ecological footprint of this study area are provided in Chapter 4.3 of this study.

Finally, it is noted that in the context of sustainability within the decision-making process, environmental, societal and economic issues, should be incoroporated within the planning and implementation framework of activities in NP-EMATH. With regard to the environmental aspect, the biodiversity impact of symbiotic activities that exert ecological, carbon and water footprints should be identified.

Chapter 3 - Implementation of framework in Study Area 2

3.1 Data inventory and calculations

The implementation of the BIO2CARE framework in Study Area 2 (Rila National Park of Bulgaria (RNPD) including the catchment area of the river basin of Blagoevgradska Bistrica) was performed also using the results from D3.2 and in line with the parallel process in Study Area 1 in Greece. All available sources of information were used incl. national and regional statistics, current data from Rila NP Directorate and data from RNP Management Plan, data from Blagoevgrad Municipality, etc.

Table 3-1: Data inventory for examined Sector No 1: Households.

Input code	Description	Value for Study Area 2 (BG)
Input 1.1	Number of adult residents	59,336
Input 1.2	Number of minor residents	10,253
Input 1.3	Surface (m^2) of single dwellings build before 1980	87,116
Input 1.4	Surface (m^2) of single dwellings build between 1981-2001	17,424
Input 1.5	Surface (m^2) of single dwellings build after 2002	34,846
Input 1.6	Surface (m^2) of apartment buildings build before 1980	114,603
Input 1.7	Surface (m^2) of apartment buildings build between 1981-2001	343,813
Input 1.8	Surface (m^2) of apartment buildings build after 2002	152,806

Table 3-2: Data inventory for examined Sector No 2: Tertiary.

Input code	Description	Value for Study Area 2 (BG)
Input 2.1	Number of offices/commercial buildings build before 1980	169
Input 2.2	Number of offices/commercial buildings build between 1981-2001	271
Input 2.3	Number of offices/commercial buildings build after 2002	373
Input 2.4	Number of healthcare buildings build before 1980	69
Input 2.5	Number of healthcare buildings build between 1981-2001	4
Input 2.6	Number of healthcare buildings build after 2002	2

Table 3-3: Data inventory for examined Sector No 3: Municipal buildings.

Input code	Description	Value for Study Area 2 (BG)
Input 3.1	Number of schools build before 1980	14

Input 3.2	Number of schools build between 1981-2001	3
Input 3.3	Number of schools build after 2002	3

Table 3-4: Data inventory for examined Sector No 4: Public lighting.

Input code	Description	Value for Study Area 2 (BG)
Input 4.1	Installed power for public lighting in kW	500

Table 3-5: Data inventory for examined Sector No 5: Private transportation.

Input code	Description	Value for Study Area 2 (BG)
Input 5.1	Number of private passenger cars moving on local roads	42000
Input 5.2	Number of private passenger cars moving on highway	0
Input 5.3	Number of private scooters moving on local roads	0
Input 5.4	Number of private lorries moving on local roads	15262
Input 5.5	Number of private lorries moving on highway	0
Input 5.6	km of highway set within the boundaries of protected area	0

Table 3-6: Data inventory for examined Sector No 6: Public transportation.

Input code	Description	Value for Study Area 2 (BG)
Input 6.1	Number of public passenger cars moving on local roads	188
Input 6.2	Number of public scooters moving on local roads	0
Input 6.3	Number of public lorries moving on local roads	46
Input 6.4	Number of annual passengers moving by train on local railway	0
Input 6.5	km of local railway within the boundaries of the protected area	0
Input 6.6	t loaded/ unloaded from or/and to barge tanker in each port	0
Input 6.7	km boarding in each port	0
Input 6.8	Passengers loaded in ferry boat in each port	0
Input 6.9	Lorries loaded in ferry boat in each port	0
Input 6.10	Buses loaded in ferry boat in each port	0
Input 6.11	Passenger cars loaded in ferry boat in each port	0
Input 6.12	Scooters loaded in ferry boat in each port	0
Input 6.13	Number of passengers arrived by airplane in each airport	0
Input 6.14	Number of passengers left by airplane in each airport	0
Input 6.15	t loaded to airplane in each airport	0
Input 6.16	t unloaded from airplane in each airport	0
Input 6.17	km passing by airplane during landing in each airport	0
Input 6.18	km passing by airplane during taking off in each airport	0

Input 6.19	km passing by bus within the boundaries of protected area	0

Table 3-7: Data inventory for examined Sector No 7: Tourism.

Input code	Description	Value for Study Area 2 (BG)
Input 7.1	Number of adult tourists	19872
Input 7.2	Number of minor tourists	9740
Input 7.3	Number of hotels build before 1980	9
Input 7.4	Number of hotels build between 1981-2001	12
Input 7.5	Number of hotels build after 2002	27

Table 3-8: Assumptions applied to estimate the EF and CF indicators of BIO2CARE methodology for Rila NP & Blagoevgradska Bistritsa River catchment area (Study Area 2).

1. Households			
	Description	**Value**	**Units**
General	Average weight of adult residents	70	kg
General	Average weight of minor residents	40	kg
General	Days of consumption for the residents	365	days/year
General	% fuel combustion for heating due to poverty	78%	%
	Description	**Value**	**Units**
1. Agricultural products	average consumption of bread and rolls in g per kg of human mass per day	4	g/kg/d
1. Agricultural products	average consumption of potatoes and potatoes products in g per kg of human mass per day	1.2	g/kg/d
1. Agricultural products	average consumption of sugars per kg of human mass per day	0.4	g/kg/d
1. Agricultural products	average consumption of breakfast cereals per kg of human mass per day	0.3	g/kg/d
1. Agricultural products	average consumption of grain milling products in g per kg of human mass per day	0.7	g/kg/d
1. Agricultural products	average consumption of legumes, beans, dried per kg of human mass per day	0.3	g/kg/d
1. Agricultural products	average consumption of fruits (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) in g per kg of human mass per day	4.2	g/kg/d
1. Agricultural products	average consumption of beer and beer-like, wine, spirits, soft drinks per kg of human mass per day	4.3	g/kg/d

	Description	Value	Units
	average consumption of tobacco per day in Bulgaria	19.4	g/d
	% smokers in Bulgaria	37%	%
	average consumption of rice-based meals per kg of human mass per day	0.3	g/kg/d
	average consumption of vegetables fats and oils per kg of human mass per day	0.6	g/kg/d
	Description	**Value**	**Units**
2. Livestock products	average consumption of livestock meat (mostly pork) per kg of human mass per day	1.5	g/kg/d
	average consumption of farmed animals (mostly beef) per kg of human mass per day	-	g/kg/d
	average consumption of sausages per kg of human mass per day	0.6	g/kg/d
	average consumption of poultry in g per kg of human mass per day	2.6	g/kg/d
	average consumption of eggs per kg of human mass per day	6.5	g/kg/d
	average consumption of liquid and concentrated milk and milk based beverages per kg of human mass per day	2.3	g/kg/d
	average consumption of cheese per kg of human mass per day	0.5	g/kg/d
	average consumption of animals fat, margarine and similar products per kg of human mass per day	0.1	g/kg/d
	Description	**Value**	**Units**
3. Fishery & Aquaculture products	average consumption of fish meat per kg of human mass per day	0.2	g/kg/d
	average consumption of crustaceans, water mollusks, amphibians, reptiles, snails and insects per kg of human mass per day	-	g/kg/d
	Description	**Value**	**Units**
4. Timber products	average consumption of paper and board per capita in Greece per year	20	kg/cap
	Description	**Value**	**Units**
5. CO2 emissi	average electrical energy consumption per m^2 for single dwellings 1980	6.69	kWh/m^2

	Description	Value	Units
	average electrical energy consumption per m^2 for single dwellings 2001	10.3	kWh/m^2
	average electrical energy consumption per m^2 for single dwellings 2010	18.71	kWh/m^2
	average electrical energy consumption per m^2 for apartment buildings 1980	5	kWh/m^2
	average electrical energy consumption per m^{2}for apartment buildings 2001	8.3	kWh/m^2
	average electrical energy consumption per m^{2}for apartment buildings 2010	17	kWh/m^2
	average thermal energy consumption per m^2 for single dwellings 1980	42.8	kWh/m^2
	average thermal energy consumption per m^2 for single dwellings 2001	41.2	kWh/m^2
	average thermal energy consumption per m^2 for single dwellings 2010	58.7	kWh/m^2
	average thermal energy consumption per m^2 for apartment buildings 1980	32.5	kWh/m^2
	average thermal energy consumption per m^{2}for apartment buildings 2001	34.03	kWh/m^2
	average thermal energy consumption per m^{2}for apartment buildings 2010	54.7	kWh/m^2
	% of thermal energy resulting from oil burning	0.95%	%
	% of thermal energy resulting from logs burning	61.14%	%
	% of thermal energy resulting from natural gas burning	0.79%	%
	% of thermal energy resulting from electricity use	37.01%	%
2. Tertiary			
	Description	**Value**	**Units**
General	average surface of offices/commercial buildings build before 1980	908	m^2
General	average surface of offices/commercial buildings build between 1981-2001	1330	m^2
General	average surface of offices/commercial buildings build after 2001	1100	m^2
General	average surface of healthcare buildings build before 1980	1653	m^2
General	average surface of healthcare buildings build between 1981-2001	6943	m^2
General	average surface of healthcare buildings build after 2001	4339	m^2
General	% reduction of fuel combustion for heating due to poverty	78%	%
	Description	**Value**	**Units**
5. CO2 emissi	average electrical energy consumption per m^2 for offices/commercial buildings 1980	32	kWh/m^2

	Description	Value	Units
	average electrical energy consumption per m^2 for offices/commercial buildings 2001	45	kWh/m^2
	average electrical energy consumption per m^2 for offices/commercial buildings 2010	59	kWh/m^2
	average electrical energy consumption per m^2 for healthcare buildings 1980	75	kWh/m^2
	average electrical energy consumption per m^2 for healthcare buildings 2001	88	kWh/m^2
	average electrical energy consumption per m^2 for healthcare buildings 2010	99	kWh/m^2
	average thermal energy consumption per m^2 for offices/commercial buildings 1980	100	kWh/m^2
	average thermal energy consumption per m^2 for offices/commercial buildings 2001	83	kWh/m^2
	average thermal energy consumption per m^2 for offices/commercial buildings 2010	78	kWh/m^2
	average thermal energy consumption per m^2 for healthcare buildings 1980	181	kWh/m^2
	average thermal energy consumption per m^2 for healthcare buildings 2001	162	kWh/m^2
	average thermal energy consumption per m^2 for healthcare buildings 2010	155	kWh/m^2
3. Municipal Buildings			
	Description	**Value**	**Units**
General	average surface of schools build before 1980	1285	m^2
	average surface of schools build between 1981-2001	1676	m^2
	average surface of schools build after 2002	1384	m^2
	Description	**Value**	**Units**
5. CO2 emissions	average electrical energy consumption per m^2 for schools 1980	11	kWh/m^2
	average electrical energy consumption per m^2 for schools 2001	13	kWh/m^2
	average electrical energy consumption per m^2 for schools 2010	15	kWh/m^2
	average thermal energy consumption per m^2 for schools 1980	30	kWh/m^2
	average thermal energy consumption per m^2 for schools 2001	30	kWh/m^2
	average thermal energy consumption per m^2 for schools 2010	31	kWh/m^2
4. Public Lighting			
	Description	**Value**	**Units**

5. CO2 emissions	average time of lights' operation per year	2000	kWh/year
5. Private Transportation			
	Description	**Value**	**Units**
General	average km passing by vehicle on local roads per year	10730	km
	Description	**Value**	**Units**
5. CO2 emissions	% of car in Bulgaria fueled by diesel	43%	%
	% of car in Bulgaria fueled by pertol	57%	%
6. Public Transportation			
	Description	**Value**	**Units**
General	average km passing by vehicle on local roads per year	19080	km
	Description	**Value**	**Units**
5. CO2 emissions	% of car in Bulgaria fueled by diesel	43%	%
	% of car in Bulgaria fueled by pertol	57%	%
	average weight of a passenger on ferry boat	0	ton
	average weight of a heavy duty vehicle on ferry boat	0	ton
	average weight of a bus on ferry boat	0	ton
	average weight of a car on ferry boat	0	ton
	average weight of a motorbike on ferry boat	0	ton
7. Tourism			
	Description	**Value**	**Units**
General	Average weight of adults tourists	70	kg
	Average weight of minors tourists	40	kg
	Days of consumption for the tourist	2	days
	average surface of hotels build before 1980	1720	m^2
	average surface of hotels build between 1981-2001	1513	m^2
	average surface of hotels build after 2002	3006	m^2
	Description	**Value**	**Units**
1. Agricu	average consumption of bread and rolls in g per kg of human mass per day	4	g/kg/d

	average consumption of potatoes and potatoes products in g per kg of human mass per day	1.2	g/kg/d
	average consumption of sugars per kg of human mass per day	0.4	g/kg/d
	average consumption of breakfast cereals per kg of human mass per day	0.3	g/kg/d
	average consumption of grain milling products in g per kg of human mass per day	0.7	g/kg/d
	average consumption of legumes, beans, dried per kg of human mass per day	0.3	g/kg/d
	average consumption of fruits (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) in g per kg of human mass per day	4.2	g/kg/d
	average consumption of beer and beer-like, wine, spirits, soft drinks	4.3	g/kg/d
	average consumption of tobacco per day in Europe	10	g/d
	% smokers in Europe	29%	%
	average consumption of rice-based meals per kg of human mass per day	0.3	g/kg/d
	average consumption of vegetables fats and oils per kg of human mass per day	0.6	g/kg/d
	Description	**Value**	**Units**
2. Livestock products	average consumption of livestock meat (mostly pork) per kg of human mass per day	1.5	g/kg/d
	average consumption of farmed animals (mostly beef) per kg of human mass per day	-	g/kg/d
	average consumption of sausages per kg of human mass per day	0.6	g/kg/d
	average consumption of poultry in g per kg of human mass per day	2.6	g/kg/d
	average consumption of eggs per kg of human mass per day	6.5	g/kg/d
	average consumption of liquid and concentrated milk and milk based beverages per kg of human mass per day	2.3	g/kg/d
	average consumption of cheese per kg of human mass per day	0.5	g/kg/d
	average consumption of animals fat, margarine and similar products per kg of human mass per day	0.1	g/kg/d
	Description	**Value**	**Units**

	Description	Value	Units
3. Fishery & Aquaculture products	average consumption of fish meat per kg of human mass per day	0.2	g/kg/d
	average consumption of crustaceans, water mollusks, amphibians, reptiles, snails and insects per kg of human mass per day	-	g/kg/d
	Description	**Value**	**Units**
5. CO2 emissions	average electrical energy consumption per m^2 for hotels 1980	47	kWh/m^2
	average electrical energy consumption per m^2 for hotels 2001	80	kWh/m^2
	average electrical energy consumption per m^2 for hotels 2010	97	kWh/m^2
	average thermal energy consumption per m^2 for hotels 1980	106	kWh/m^2
	average thermal energy consumption per m^2 for hotels 2001	93	kWh/m^2
	average thermal energy consumption per m^2 for hotels 2010	87	kWh/m^2

Table 3-9: Estimation of Biocapacity indicators for Study Area 2.

1. Cropland					
Indicator code	**Description**	**Value in ha**	**Indicator code**	**Description**	**Value in ha**
Indicator BC 1.1	Area under cultivation and fallow land in ha	18746	**Indicator BC 1.1.1**	Arable land in ha	**0**
			Indicator BC 1.1.2	Permanent crops in ha	**0**
			Indicator BC 1.1.3	Heterogenous agricultural areas in ha	**0**
2. Grazing Land					
Indicator code	**Description**	**Value in ha**	**Indicator code**	**Description**	**Value in ha**
Indicator BC 2.1	Pastures in ha	42802.4	**Indicator BC 2.1.1**	Pastures - transitional wood land / shrumb in ha	**0**
			Indicator BC 2.1.2	Pastures - shrumb and / or herbaceous vegetation associations in ha	**0**
			Indicator BC 2.1.3	Pastures - Open spaces with little or no vegetation in ha	**0**
3. Fishing Ground					

Indicator code	Description	Value in ha	Indicator code	Description	Value in ha
Indicator BC 3.1	Area under water in ha	19	**Indicator BC 3.1.1**	Inland waters in ha	**0**
			Indicator BC 3.1.2	Inland wetlands in ha	**0**
			Indicator BC 3.1.3	Coastal wetlands in ha	**0**
4.Forest and Energy Land					
Indicator code	**Description**	**Value in ha**	**Indicator code**	**Description**	**Value in ha**
Indicator BC 4.1	Forests and semi-natural ares in ha	26977.1	**Indicator BC 4.1.1**	Forests in ha	**0**
			Indicator BC 4.1.2	Transitional wood land / shrumb in ha	**0**
Indicator BC 4.2	Area under cultivation and fallow land that produces energy	47			
5.Build-up Area					
Indicator code	**Description**	**Value in ha**	**Indicator code**	**Description**	**Value in ha**
Indicator BC 5.1	Areas occupied by the locality (buildings, roads, etc) in ha	8472.7	**Indicator BC 5.1.1**	Urban fabric in ha	**0**
			Indicator BC 5.1.2	Industrial and commercial units in ha	**0**
			Indicator BC 5.1.3	Transport units in ha	**0**
			Indicator BC 5.1.4	Mine, dump and construction sites	**0**
			Indicator BC 5.1.5	Artificial, non-agricultural vegetated areas sport and cultural activity sites	**0**

The results from the implementation of the BIO2CARE framework in Study Area 2 are comprehensively presented in the following Chapters.

3.2 Carrying Capacity results

The results received when applying the developed Methodology of Carrying Capacity in the Study Area 1 show some very great differences when applied within the national park and out of it (parts of Blagoevgradska Bistritsa catchment area). This is logical as there are many limitating regimes in the national park and the access to the mountain is also a factor for narrowing anthropogenic impacts.

When analyzing results, it is necessary to take into account the individuality of ecosystems and the complex character of processes running inside them.

When applying the Methodology only to the Park territory, it gives an idea of the value of anthropogenic impact – about 25% of the park resources are spent currently for maintaining a non-permanent human group such as tourists. Here we probably speak of a flaw in the Methodology itself as the percentage should be lower if we consider the status of the protected area and the number of activities which are not banned inside. The Methodology does not allow us to assess the impact of tourists absolutely correctly as the resources these tourists consume originate from territories outside the park – clothes, food, equipment, building materials, etc. The main impact on the natural ecosystems in the park thus would come from deforestation and the decrease of habitats diversity – and those are covered by the Methodology.

The impact of tourists is different inside the park and in the district center of Blagoevgrad. The over-increase of visitor numbers in the park could lead to unrecoverable damage of the environment which does not concern the town of Blagoevgrad itself (and the wider zone of Blagoevgradska Bistritsa River outside the national park).

The results show that the biggest impact within the protected area comes from tourism; that is why the main goal of park management should be the regulation of visitor flows with accent on educational and awareness raising activities related to the behavior in the protected area and assessment of its significance.

Results from applying the Methodology only to that part of Blagoevgradska Bistritsa River catchment area which is located outside the Park boundaries show that human impact of the population of Blagoevgrad Municipality (in particular the town of Blagoevgrad where 90% of municipal population is focused) has exceeded the ability of the territory to generate sufficient resources in order to sustain that population – 110%. Main impact comes from automobile transport and the lack of enough forested areas to compensate that anthropogenic impact. The decrease of emissions from private and public transport, as well as the limitation of the number of vehicles per capita would affect significantly the carbon footprint and hence the ability of the territory to compensate human impact. In the present calculations, data has not been included about the automobile flow of transit vehicles along the International E79 Highway. In order for the Methodology to be more precise, it should be applied to a larger territory.

Yet another factor affecting significantly the carrying capacity results is the consumption of thermal energy in private and public buildings. Most buildings were built before 2001 when there were no strict requirements for energy efficiency of the buildings. A big part of the thermal energy is being used inefficiently and losses are great. The current policy for energy efficiency encompasses about 62% of the blocks of apartments but investments are lacking for the smaller dwellings. This is related to another major problem for all Bulgarian settlements - the pollution from winter heating.

When feeding combined data into the Methodology (for the whole Study Area 2 including the lands within the National Park and those from Blagoevgradska Bistritsa catchment area outside it), the result for the carrying capacity becomes 84.28%. If interpreted on its own, it shows that the carrying capacity for the territory is quite high in consuming (thanks no doubt to the city of Blagoevgrad) but still not exhausted (thanks to the protected area of the National Park and its regimes and norms for anthropogenic activities).

The concept of carrying capacity must concentrate efforts in the estimation of acceptable changes in the natural and social environment in relation to the goals and tasks of management and the use of a certain territory. This is a difficult task and requires a long-term sight as what is acceptable today may not be acceptable in the future. The presented data gives an opportunity to calculate a reliable capacity of the given territory. It allows the defining of maximal acceptable levels of human activities, the number of people, the type of land use and physical development which can be endured by the analyzed territory without causing irreversible damage to the environment.

The calculation of capacity is based on the assessment of thresholds above which changes from human or other activities become unacceptable to the whole system. The analysis of included indicators has shown the dynamics of sustainability in natural ecosystems caused by anthropogenic impacts. Part of this dynamics are also the natural self-regulating processes of the natural system as factors for relative self-restoration of shifted balance in landscape which form the potential of stability in current natural and anthropogenic complex.

The research confirms the scientific applicability and the specific relevance of the concept of ecological carrying capacity from the point of view of sustainable development and the finding of balance between nature protection and nature use.

3.3 Ecological Footprint results

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 implementation of the BIO2CARE framework and the estimation of the ecological foot print in Study Area 2 (the water catchment area of Blagoevgradska Bistritsa River and those parts of Rila National Park which follow within the range of the INTEREG V-A Greece-Bulgaria CBC Programme for the period 2014-2020) has been done identically with the work for Study Area 1 in Greece, with the exception that the territory has been divided into two parts: 2A – zones within the Rila National Park and the eligible area of the Interreg V-A Greece-Bulgaria Programme, and 2B – the territory of Blagoevgradska Bistritsa River catchment area but without the small part falling within the national park. The reason for that is that the two zones are totally different (e.g. no people living in the park and nearly 70000 people living in Blagoevgrad), and combining figures into one average would be a distortion of results. The data used for the calculation of the ecological footprint were collected during the implementation of the deliverables 3.1, 3.2 and 3.3 of working package 3 of the Bio2care project.

Ecological footprint of those parts in Rila National Park which follow within the range of the INTEREG V-A Greece-Bulgaria)

Rila National Park according Bulgarian legislation is a protected territory with very strict regime of protection and inside the park are forbidden any industrial activity, presents of settlements with permanent population any public or private transportation. The only paces for accommodation in the boundary of the park are huts and chalets. That is why the value of the ecological footprint is deducted only based on the consumption of the tourist that are visiting the park, but we have to take in the consideration that the majorities of the visits are shorter than 3 days. Unfortunately the information that regards the number of tourist that are staying for overnight in the boundaries of the park possess very big presents of uncertainty and additional measures have to be taken to improve the process of collecting it.

Table 3-10: Public transportation ecological footprint

6. Public Transportation					9.063232318
	Indicator code	Description	value	Gha/km or personkm or tkm	**Gha**
5. CO2 emissions	Indicator EF5.3.6	km per year passing by public scooter	0	0.000026	0
	Indicator EF5.4.6	km per year passing by public lorry	0	0.000268	0
	Indicator EF5.5.6	km per year passing by public passenger car, diesel	64912.8	0.000057	3.683217185
	Indicator EF5.6.6	km per year passing by public passenger car, petrol	86047.2	0.000063	5.380015133
	Indicator EF5.7.6	km per year passing by regular bus	0	0.000349	0
	Indicator EF5.8.6	personkm per year passing by train	0	0.000012	0
	Indicator EF5.9.6	tkm per year passing by barge tanker	0	0.000009	0
	Indicator EF5.10.6	tkm per year passing by ferry boat	0	0.000009	0
	Indicator EF5.11.6	personkm per year passing by passenger aircraft	0	0.000044	0
	Indicator EF5.12.6	tkm per year passing by freight aircraft	0	0.000443	0

Even inside the park there are no public transport network there are service roads that are used by the park administration in order to protect the park territory and to facilitate the support of the natural ecosystems. Because of that in the calculation process of the ecological foot print are used input data that count the passing km of the cars used by the park administration. The park operates cars that used two types of fuel – Diesel and Gasoline and based on the travel distance for one year the ecological foot print of the public transportation has been calculated to the equivalent of 9.06 Gha. This low values of the EF is due to protected status of the Rila Park territory and the lack of real public transportation.

Table 3-11: Ecological footprint of the tourism

7. Tourism					7.110844299
	Indicator code	**Description**	**value**	**Gha/t/y**	**Gha**
1. Agricultural products	Indicator EF1.1.7	Bread Consumption in t per year	1.14112	0.307600	0.351008512
	Indicator EF1.2.7	Potatoes Consumption in t per year	0.342336	0.096000	0.032864256
	Indicator EF1.3.7	Sugar Consumption in t per year	0.114112	0.335500	0.038284576
	Indicator EF1.4.7	Cereals Consumption in t per year	0.085584	0.667000	0.057084528
	Indicator EF1.5.7	Flour Consumption in t per year	0.199696	0.423000	0.084471408
	Indicator EF1.7.7	Legumes Consumption in t per year	0.085584	0.681300	0.058308379
	Indicator EF1.8.7	Fruits and Vegetables Consumption in t per year	1.198176	0.743000	0.890244768
	Indicator EF1.9.7	Beverage Consumption in t per year	1.226704	2.110000	2.58834544
	Indicator EF1.10.7	Tobacco Consumption in t per year	0.0096976	1.140000	0.011055264
	Indicator EF1.11.7	Rice consumption in t per year	0.085584	0.573600	0.049090982
	Indicator EF1.12.7	Vegetable oils Consumption in t per year	0.171168	2.592000	0.443667456
	Indicator code	**Description**	**value**	**Gha/t/y**	**Gha**
2 Livestock products	Indicator EF2.1.7	Pork meat Consumption in t per year	0.42792	1.380000	0.5905296
	Indicator EF2.2.7	Beef meat Consumption in t per year	0	14.650000	0
	Indicator EF2.3.7	Sausages Consumption in t per year	0.171168	1.380000	0.23621184
	Indicator EF2.4.7	Chicken Consumption in t per year	0.741728	0.690000	0.51179232
	Indicator EF2.5.7	Egg Consumption in t per year	1.85432	0.513000	0.95126616
	Indicator EF2.6.7	Milk Consumption in t per year	0.656144	0.185500	0.121714712
	Indicator EF2.7.7	Cheese Consumption in t per year	0.14264	0.151000	0.02153864
	Indicator EF2.8.7	Butter Consumption in t per year	0.028528	0.011700	0.000333778
	Indicator code	**Description**	**value**	**Gha/t/y**	**Gha**
3 Fishery & Aquaculture products	Indicator EF3.1.7	Fish Consumption in t per year	0.057056	1.280000	0.07303168
	Indicator EF3.2.7	Seafood Consumption in t per year	0	0.021400	0
	Indicator code	**Description**	**value**	**Gha/t/y**	**Gha**
5. CO2 emissions	Indicator EF5.1.7	Electricity Consumption in kWh per year	0	0.000271	0
	Indicator EF5.2.7	Thermal Energy Consumption in kWh per year	0	0.000093	0

Because there are no permanent population inside the boundaries of Rila National Park the main contribution to the ecological footprint in Rila National Park are the number of tourist that are visiting the park. Based on the information gather during the implementation of the activities in deliverable 3.1, 3.2, 3.3 was determined that the number of the tourists in Rila national park (only in the project territory) are 2312 persons/per year. That number exclude the visits to the park that are shortep than 3 days. The Ecological Footprint of the tourist activity is derivative between the number of the tourists and the average consumption of different products per person for a day. The quantities of consumed products after that are transformed in Global hectares. Based on this methodological approach was calculated that the Ecological Footprint of the tourist sector is 7.11 Gha.

Ecological footprint of catchment area of river Blagoevgradska Bistrica

The catchment area of the Blagoevgradska Bistrica river possess bigger anthropogenic load than the territory of Rila National Park. The number of the permanent population inside the catchment area are 59336 persons. The methodology takes in the account the Ecological foot print from the households, tertiary, municipality buildings, public lightening, public transportation, private transportation and tourism and the final footprint of the catchment area is the combined footprints of this sectors.

The total Ecological footprint of the Households are 44662.55037 Gha (Table 3-12) as the main contributor is the food consumption which is responsible for more than 92% of the total households FP. On second place is the Ecological Footprint of the used electricity follow by the used fuel for heating and paper consumption. We have to take in the consideration that the quantities of the used fuel by the population are put in the transport section.
Ecological footprint of the

The total ecological footprint of the tertiary sector (Table 3-13) is 23022,60 Gha. As the Electricity consumption applies for 67 of the footprint and the consumed thermal energy are responsible for the rest.

The ecological footprint of the electricity consumed by the local governments for maintaining public lightening is 270. 94 Gha and the footprint of the electricity and thermal energy used in the municipality owned buildings (Table 3-14) are equivalent to 164,39 Gha. The municipal authorities have been taking measures to decrease this footprint by reducing the consumed electricity due to used of more electricity efficient bulbs and by using natural gas for heating of the local government buildings and social infrastructure.

Table 3-12: Ecological footprint of the households in the catchment area of Blagoevgradska Bistritza river.

1. Households					44662.55037
	Indicator code	**Description**	**value**	**Gha/t/y**	**Gha**
1. Agricultural products	Indicator EF1.1.1	Bread Consumption in t per year	6662.9144	0.307600	2049.512469
	Indicator EF1.2.1	Potatoes Consumption in t per year	1998.87432	0.096000	191.8919347
	Indicator EF1.3.1	Sugar Consumption in t per year	666.29144	0.335500	223.5407781
	Indicator EF1.4.1	Cereals Consumption in t per year	499.71858	0.667000	333.3122929
	Indicator EF1.5.1	Flour Consumption in t per year	1166.01002	0.423000	493.2222385
	Indicator EF1.6.1	Legumes Consumption in t per year	499.71858	0.681300	340.4582686
	Indicator EF1.7.1	Fruits and Vegetables Consumption in t per year	6996.06012	0.743000	5198.072669
	Indicator EF1.8.1	Beverage Consumption in t per year	7162.63298	2.110000	15113.15559
	Indicator EF1.9.1	Tobacco Consumption in t per year	155.4585399	1.140000	177.2227355
	Indicator EF1.10.1	Rice consumption in t per year	499.71858	0.573600	286.6385775
	Indicator EF1.11.1	Vegetable oils Consumption in t per year	999.43716	2.592000	2590.541119
	Indicator code	**Description**	**value**	**Gha/t/y**	**Gha**
2. Livestock products	Indicator EF2.1.1	Pork meat Consumption in t per year	2498.5929	1.380000	3448.058202
	Indicator EF2.2.1	Beef meat Consumption in t per year	0	14.650000	0
	Indicator EF2.3.1	Sausages Consumption in t per year	999.43716	1.380000	1379.223281
	Indicator EF2.4.1	Chicken Consumption in t per year	4330.89436	0.690000	2988.317108
	Indicator EF2.5.1	Egg Consumption in t per year	10827.2359	0.513000	5554.372017
	Indicator EF2.6.1	Milk Consumption in t per year	3831.17578	0.185500	710.6831072
	Indicator EF2.7.1	Cheese Consumption in t per year	832.8643	0.151000	125.7625093
	Indicator EF2.8.1	Butter Consumption in t per year	166.57286	0.011700	1.948902462
	Indicator code	**Description**	**value**	**Gha/t/y**	**Gha**
3. Fishery & Aquaculture products	Indicator EF3.1.1	Fish Consumption in t per year	333.14572	1.280000	426.4265216
	Indicator EF3.2.1	Seafood Consumption in t per year	0	0.021400	0
	Indicator code	**Description**	**value**	**Gha/t/y**	**Gha**
4. Timber products	Indicator EF4.1.1	Paper Consumption in t per year	1391.78	0.411000	572.02158
	Indicator code	Description	value	Gha/kwh	**Gha**
5. CO2 emissions	Indicator EF5.1.1	Electricity Consumption in kWh per year	7438606.8	0.000271	2015.416126
	Indicator EF5.2.1	Thermal Energy Consumption in kWh per year	23614449.99	0.000019	442.7523476

Table 3-13: Ecological footprint of tertiary sector

2. Tertiary					**23022.59713**
	Indicator code	**Description**	**value**	**Gha/kwh**	**Gha**
5. CO2 emissions	Indicator EF5.1.2	Electricity Consumption in kWh per year	57194847	0.000271	15496.37185
	Indicator EF5.2.2	Thermal Energy Consumption in kWh per year	80927153.58	0.000093	7526.225283

Table 3-14: Ecological footprint of the municipality buildings

3. Municipal Buildings					164.390618
	Indicator code	**Description**	**value**	**Gha/kwh**	**Gha**
5. CO2 emissions	Indicator EF5.1.3	Electricity Consumption in kWh per year	325534.00	0.000271	88.20018196
	Indicator EF5.2.3	Thermal Energy Consumption in kWh per year	819252	0.000093	76.190436

Table 3-15: Ecological footprint of the public lightening

4. Public Lighting					270.94
	Indicator code	Description	value	Gha/kwh	**Gha**
5. CO2 emissions	Indicator EF5.1.4	Electricity Consumption in kWh per year	1000000	0.000271	270.94

Table 3-16: Ecological footprint of the transport sector

5. Private Transportation					66152.47494
	Indicator code	Description	value	Gha/km	**Gha**
5. CO2 emissions	Indicator EF5.3.5	km per year passing by private scooter	0	0.000026	0
	Indicator EF5.4.5	km per year passing by private lorry	152620000	0.000268	40936.80474
	Indicator EF5.5.5	km per year passing by private passenger car, diesel	180600000	0.000057	10247.4246
	Indicator EF5.6.5	km per year passing by private passenger car, petrol	239400000	0.000063	14968.2456
6. Public Transportation					196.3355822
	Indicator code	Description	value	Gha/km or personkm or tkm	**Gha**
5. CO2 emissions	Indicator EF5.3.6	km per year passing by public scooter	0	0.000026	0
	Indicator EF5.4.6	km per year passing by public lorry	225000	0.000268	60.351075
	Indicator EF5.5.6	km per year passing by public passenger car, diesel	973950	0.000057	55.26289695
	Indicator EF5.6.6	km per year passing by public passenger car, petrol	1291050	0.000063	80.7216102
	Indicator EF5.7.6	km per year passing by regular bus	0	0.000349	0
	Indicator EF5.8.6	personkm per year passing by train	0	0.000012	0
	Indicator EF5.9.6	tkm per year passing by barge tanker	0	0.000009	0
	Indicator EF5.10.6	tkm per year passing by ferry boat	0	0.000009	0
	Indicator EF5.11.6	personkm per year passing by passenger aircraft	0	0.000044	0
	Indicator EF5.12.6	tkm per year passing by freight aircraft	0	0.000443	0

Ecological footprint of the transport sector is divided on two subcategories footprint of the private transportation - 66152.48 Gha and footprint of the public transport – 196.34 (Table 3-16). The total ecological footprint of the transport activity in the catchment area of Blagoevgradska Bistritza river are the equivalent of 66 348,82 Gha. It is obvious that the distance passing by private cars is much bigger than the traveled distance by the public transportation, that is why there is a substantial difference between the ecological footprint of the private sector and the footprint of the public transportation as the first is responsible for 99 % of the total transport footprint.

The catchment area of Blagoevgradska Bistritza river is not very popular tourist destination although It has a great tourist potential mainly due to proximity of Riula National Park which possess great potential for development of green and eco-tourism. Beside the natural factors inside the catchment area is situated the town of Blagoevgrad with numerous cultural and sites and also it is the headquarter of the two Universities – South-West University "Neofit Rilski"; American University in Bulgaria. Although the great tourist potential the tourist sector is not very well developed in the area of Blagoevgradska Bistritza River as the number of the tourist are limited to 27300 people per year. The total ecological footprint of the tourism in the catchment area (Table 3-17) is 1475. 43 Gha and it is come mainly from used electricity (958.84 Gha) and thermal energy (434.94 Gha). Because of the relatively lower number of the tourist per year the Ecological footprint of the tourist sector is lower than the one cause by the activity of the community and the local government.

Table 3-17: Ecological footprint of the tourist sector

7. Tourism					1475.433944
	Indicator code	Description	value	Gha/t/y	Gha
1. Agricultural products	Indicator EF1.1.7	Bread Consumption in t per year	13.104	0.307600	4.0307904
	Indicator EF1.2.7	Potatoes Consumption in t per year	3.9312	0.096000	0.3773952
	Indicator EF1.3.7	Sugar Consumption in t per year	1.3104	0.335500	0.4396392
	Indicator EF1.4.7	Cereals Consumption in t per year	0.9828	0.667000	0.6555276
	Indicator EF1.5.7	Flour Consumption in t per year	2.2932	0.423000	0.9700236
	Indicator EF1.7.7	Legumes Consumption in t per year	0.9828	0.681300	0.66958164
	Indicator EF1.8.7	Fruits and Vegetables Consumption in t per year	13.7592	0.743000	10.2230856
	Indicator EF1.9.7	Beverage Consumption in t per year	14.0868	2.110000	29.723148
	Indicator EF1.10.7	Tobacco Consumption in t per year	0.10556	1.140000	0.1203384
	Indicator EF1.11.7	Rice consumption in t per year	0.9828	0.573600	0.56373408
	Indicator EF1.12.7	Vegetable oils Consumption in t per year	1.9656	2.592000	5.0948352
	Indicator code	Description	value	Gha/t/y	Gha
2 Livestock products	Indicator EF2.1.7	Pork meat Consumption in t per year	4.914	1.380000	6.78132
	Indicator EF2.2.7	Beef meat Consumption in t per year	0	14.650000	0
	Indicator EF2.3.7	Sausages Consumption in t per year	1.9656	1.380000	2.712528
	Indicator EF2.4.7	Chicken Consumption in t per year	8.5176	0.690000	5.877144
	Indicator EF2.5.7	Egg Consumption in t per year	21.294	0.513000	10.923822
	Indicator EF2.6.7	Milk Consumption in t per year	7.5348	0.185500	1.3977054
	Indicator EF2.7.7	Cheese Consumption in t per year	1.638	0.151000	0.247338
	Indicator EF2.8.7	Butter Consumption in t per year	0.3276	0.011700	0.00383292
	Indicator code	Description	value	Gha/t/y	Gha
3 Fishery & Aquaculture products	Indicator EF3.1.7	Fish Consumption in t per year	0.6552	1.280000	0.838656
	Indicator EF3.2.7	Seafood Consumption in t per year	0	0.021400	0
	Indicator code	Description	value	Gha/t/y	Gha
5. CO2 emissions	Indicator EF5.1.7	Electricity Consumption in kWh per year	3538946	0.000271	958.8420292
	Indicator EF5.2.7	Thermal Energy Consumption in kWh per year	4676790	0.000093	434.94147

Conclusions

Bulgarian part of the project area combine two territories with different natural and anthropogenic features. That part of the study area that is situated in Rila Natational Park possess high bio-capacity, but due to the It's high protection status the used of this territory for economical purposes is very limited and there are not permanent residents inside It. The second part of the territory although it's substantial bio-capacity has grater anthropogenic load. Because of these differences the two territories possess very different ecological footprints- 132680.33 Gha for the catchment area of Blagoevgradska Bistritza River and 15503 for this territory of Rila National Park that aligns with the territorial scope of the INTERREG Greece-Bulgaria program.

The main contribution to the Ecological footprint of the catchment area is the footprint of the Transport sector, as the combine footprint of the public and private transport are 66 378,8 Gha, but we have to take in consideration that the private transport due to the bigger number of the private vehicles is responsible for more than 99% of the ecological footprint caused by the transport activity. Households also have great contribution to the ecological footprint of the catchment area and the footprint of the local households are 44662.55 Gha, as 92% of the total households FP comes from food consumption follow by the used electricity and thermal energy.

Ecological footprint of the tourist activity (1475.43 Gha) is relatively small in the catchment area due to the small numbers of tourist and underdeveloped potential of the catchment area. Majority of the tourist visits in Rila National Park are with duration less than 3 days that is why the total number of the tourist for one year are only 2312 tourist/year because of that the EF of the tourism are only 7.11 Gha.

3.4 Carbon Footprint results

3.4.1 Carbon footprint of Blagoevgradska Bistritza River catchment area

Sector: Energy

The inventorying of greenhouse gases in an area usually includes gases which have been discharged during the production of some product within that area. In the project territory in Bulgaria there is no production of electricity from non renewable sources from which we can directly calculate emissions. For this reason the emissions of greenhouse gases from the sector of energetics will be calculated as part of the national emissions as a result of the consumption of electricity and fuels in the catchment area. The data taken from the International Energy Agency and according to the data from the national greenhouse gas inventory of the Republic of Bulgaria for production of electricity, divided by the total production of electricity in the country from all types of sources, an indicative value of 0.819 t CO_2-eq for each produced MWh of electricity is obtained.

Heating/cooling

Regarding the installed heating and cooling systems in households and public, commercial and private premises the received data are very limited because the Municipalties doesn't have any additional register of installed heating and cooling systems in households and other type of premises, so there is a lack of now days relevant data. According the existing data It is evident that most of the households, use wood (biomass) for heating. The biomass consumed for production of heat is not part of the net value of the greenhouse gas emissions, since it is considered a renewable source of energy. Most of the remaining part of the population uses electricity for heating. The consumption of coal is calculated based on the average quantities needed to heat an apartment of 60 sq m. For the purpose of the calculation is accepted that the period when the hesat is operational is 8 hours per day. The specific heat load per m^3 is equal to 0.055kwh/m^3

Table 3-18: Type of heating of households.

Region	Households/ residence	Central Heating System	Individual Heating System					
			Electricity	Coal	Biomass /pellets	Liquid Fuels	Gas	woods
Blagoevgradska Bistritza C.Area	31571		11685	7636	107	61	569	11558

Table 3-19: Coal consumption by households for 2016.

	Coal Consumption Tj/year	**EF t CO_2/tj**	**Emissions t CO_2/tj**	**Emissions t CO_2e/tj**
Blagoevgradska Bistritza River catchment area	378	94.17	35 596	
total				35 596
	Coal Consumption Tj/year	EF kg CH_4/tj	Emissions t CH_4/tj	Emissions T CO_2e/tj
Blagoevgrad	378	300	113. 4	
total				2181.4
	Coal Consumption Tj/year	EF kg N_2O/tj	Emissions t N_2O/tj	Emissions T CO_2e/tj
Blagoevgrad	378	1.5	0.567	
total				175.77

The total carbon foot print from coal consumption by households in the catchment area of Blagoevgrdska Bistrica Catchment area are 37 953,17 t CO_2e/tj

Electricity consumption

In order to calculate the CO_2 emissions to be attributed to electricity consumption, it is necessary to determine the emission factor. The same emission factor will be used for all electricity consumption, including in the rail transportation. The general principle is that the national or a European emission factor may be used. In addition, if the local authority has decided to include measures related to local electricity production in the SEAP, or if it purchases certified green electricity, then a local emission factor for electricity will be calculated, which reflects the CO_2 gains that these measures provide. The following simple rule may be used in such cases:

EFE = [(TCE - LPE - GEP) * NEEFE + CO2LPE + CO2GEP] / (TCE)

Where

- EFE = local emission factor for electricity [t/MWhe]

- TCE = Total electricity consumption in the local authority (as per Table A of the template) [MWhe]
- LPE = Local electricity production (as per Table C of the template) [MWhe]
- GEP = Green electricity purchases by the local authority (as per Table A) [MWhe]
- NEEFE = national or European emission factor for electricity (to be chosen) [t/MWhe]
- CO2LPE = CO2 emissions due to the local production of electricity (as per Table C) [t]
- CO2GEP = CO2 emissions due to the production of certified green electricity [t]

In the exceptional case where the local authority would be a net exporter of electricity, then the calculation formula would be:

EFE = (CO2LPE + CO2GEP) / (LPE + GEP

For local emission factor for electricity consumption in the local authority is accepted the national EF for electricity consumption, which for Bulgharia is 0.819 t CO2/MWhe and the emissions of CO2 are calculated by the following formula

Emissions=AD*EF

Table 3-20: Electricity consumption bu the local government

	Electricity Consumption MWhe	EF t CO2/MWhe	Emissions t CO2/MWhe
Blagoevgrad	5 708, 182	0.819	4675

The total CO2 emissions from electricity consumption in the Catchment area of Blagoevgradska River Catchment area prodiced by the local government are 4675 CO2 t/MWhe.

Table 3-21: Electricity consumption by the local comunitieas for 2016

	Electricity Consumption MWhe	EF t CO2/MWhe	Emissions t CO2/MWhe
Blagoevgradska Bistritza catchment area	142 950	0.819	117 076.05

The total CO2 emissions from used electricity by the local comuty are 174 709.08 CO2e t/MWhe

Transportation

Road transport is defined as a key category, as a result of the considerable amount of CO2 emissions from the use of diesel, gasoline, LPG presented below.

The transportation sector includes the greenhouse gas emissions of many types of transportation vehicles, such as cars, trucks, tractors, motorcycles etc. These transportation vehicles run on different types of fuels: gasoline, diesel and LPG, the use of which causes emission of greenhouse gases CO2 (carbon dioxide), CH4 (methane) and N2O (nitrous oxide) as well as other gases (CO, NMVOCs, PM, NOx) which cause air pollution in the municipality. The greenhouse gas emissions can be calculated according to the used fuel on the territory of the municipality (the fuel sold at the petrol stations) or according to the mileage traveled by the vehicles in the municipality. The determination of the emission factors for CO2 is made by selecting the standard CO2 emission factors for each fuel type. For CH4 and N2O,the applied emission factors are appropriate to the type of fuel and the type of vehicle. These emission factors are in accordance with the national selection of emission factors proposed in the document "National emission factors" for CO2 and non-CO2 gases for the key Sectors of emissions in the air pursuant to the IPCC and CORINAIR methodologies".

A unique feature of the Bulgarian vehicle fleet is its age structure. In 2015 more than 86% from the vehicles are above 10 years old, while new vehicles (1 to 5 years) are 4% from the total and 11% are 5 to 10 years old. Road transport has the biggest share in total fuel consumption in Transport subsector in the investigated municipalities. In 2015 road transport consumed 94.4% from the total energy in the sector. The most significant contributor to GHG emissions are passenger cars, followed by heavy-duty vehicles, light-duty vehicles and motorcycles and mopeds. Passenger cars account for 65.1%, light-duty vehicles are responsible for 13.7%, and heavy duty vehicles (incl. buses) account for 20.9% of total GHG CO2e emissions, with the share of passenger cars increasing over the time series. The remaining 0.3% were shared among and mopeds and motorcycles. Whereas CO2 emissions are closely linked to fuel consumption, CH4 and N2O emissions are considerably impacted by engine technology and do not follow the trend in the fuel consumption. As it can be observed in the following figure N2O emissions and implied emission factors tend to fluctuate for the period of the inventory following the introduction to the market of different engine technologies implementing EURO emission standards and different fuel quality standards (e.g. lead and sulphur content). The CO2 emissions are best calculated based on the amount and type of fuel combusted and its carbon content. The emissions of CH4 and N2O are more difficult to be estimated accurately because emission factors depend on vehicle technology, fuel and operating characteristics.

<u>Emission factors</u>

According to the IPCC guidelines, an emission factor is defined as the average emission rate of a given GHG for a given source, relative to units of activity. Whereas, an implied emission factor (IEF) is defined as emissions divided by the relevant measure of activity:

<u>IEF = Emissions / Activity data</u>

IEF are not equivalent to the emissions factors for emissions calculations. IEF are more as of results providing average values for complex categories such as road transport, where the emissions are dependent on many parameters related to the vehicle fleet distribution. The emission factors used for the calculations of GHG emissions form road transport subsector are based on the algorithms of COPERT 4, version 11. The emission factors are internal parameters that depend both on the input data (e.g. average trip distance, driving and climatic conditions, etc.) and COPERT algorithms. However, COPERT model uses different emission factors for each vehicle category and technology. Thus, it is only possible to provide the implied emission factors which take into account the calculated emissions of greenhouse gases per fuel by the model related to the reported fuel consumption.

The decrease in the CH_4 implied emission factor (IEF) for gasoline and diesel fuel is a result of the gradual increase in the number of vehicles that meet the standards set out in the EU directive on emissions from motor vehicles (mostly EURO 2 and EURO 3 vehicles), which slowly replaced the older technologies. It has to be noted, that in Bulgaria are mostly sold second hand vehicles, imported from Western Europe, which leads to a delay of the introduction of each new vehicle technology by 4 to 7 years compared to other countries. It is also a bit more complex to model the vehicle distribution matrix, since it is influenced both by the sales of new vehicles and by the imports of second hand vehicles. At the same time there is still a very large number of very old vehicles –the average vehicle age is much higher than in the other European countries. For inventarization of the GHG in the project area are used EF from the national report for inventarization of the GHG in Bulgaria for year 2014.

Table 3-22: Emission factors for the sector of Transportation in Bulgaria– Road traffic

	Unit	Emission Factor CO2 t/tj	Emission Factor CH4 kg/tj	Emission Factor N20 kg/tj
Motor gasoline	kg/TJ	72.30	16.57	2.62
Diesel	kg/TJ	75.12	3.15	1.72
LPG	kg/TJ	65.95	13.37	2.88

Table 3-23: Greenhouse gas emissions from road traffic in Blagoevgradska Bistrica River Catchment area

Municipality	EF CO2 t/tj	EF CH4 kg/tj	EF N20 kg/tj	Fuel Consumption tj	Fuel types	Emiss. CO2 t/tj	Emiss CH4 kg/tj in t/CO2e	Emiss N20 kg/tj in t/co2e
Blagoevgradska Bistrica River Catchment area	72.30	16.57	2.62	418	Gazoline	30221	6926	1095
	75.12	3.15	1.72	377	Diesel	28 320	1187	648
	65.95	13.37	2.88	52	LPG	3429	695	149

The total carbon foot print from road traffic in the Blagoevgradska Bistritza Catchment area are 72 670 t CO2e

Sector: Agriculture

The estimation of greenhouse gas emissions from Sector Agriculture were calculated based on the following categories:

- Domestic livestock activities with enteric fermentation and manure management,
- Urea fertilization.
- Agricultural soils, and
- Agricultural residue burning.

Methane emissions from enteric fermentation

Methane is emitted as part of the normal digestive process in animals. The quantity of emitted methane depends on two basic things:

• The type of digestive system in animals has an important impact on the rate of emissions of methane. Ruminants have the highest rate of emissions since significant quantity of methane is produced during the fermentation of food in the rumen (front stomach). In the calculations for the inventory, ruminants that have been considered include cattle, goats and sheep. The pseudo-ruminants (horses, mules and donkeys) and monogastric animals (pigs) emit relatively less methane during food digestion.

• The type and quantity of food that animals eat has an important role in the quantity of emitted methane. Logically, larger quantity of food leads to higher emissions. The quantity of consumed food depends on the size of the animal, the speed of growth and the production (such as production of milk, production of wool, pregnancy etc.).

For the purpose of assessment of methane emissions from enteric fermentation, a methodology has been used which is in accordance with the Revised IPCC guidelines and the same has been conducted in 3 basic steps:
Step 1: Division of the population of domestic animals into subgroups and characterization of each one of them. It is recommendable to use average annual values, taking into consideration the production cycles and the seasonal impacts on the number of population.
Step 2: Assessment of emission factors by subgroup, expressed in kilograms of methane per animal per year.
Step 3: Multiplication of the emission factors of the subgroups with the population of the subgroups in order to assess the emissions of a given subgroup and collection of the values of all subgroups in order to obtain the total emissions.

The emission factors for enteric fermentation are taken from the revised IPCC Guidebooks.

Table 3-24: Methane emissions from enteric fermentation

Blagorvgradtska Bustritza River Catchment area			
Type of animal	Emission factor for enteric fermentation	Number of animals	Methane emissions from enteric fermentation
Unit	kg/head/y	No.	(tons/y)
Dairy cattle Cows	109.85	n/a	
Cattle that does not produce milk	62.35	3639	226.9
Sheep	7.11	7113	50.8
Goats	5	2632	13.16
Horses	18	76	1,4
Mules and donkeys		n/a	
Pigs	1.5	388	0.58
Poultry	109.85	n/a	
Total emmisions:			292.84

Entheric emissions of CH_4 for 2016 are 292.84 t CH_4/year, which is 6149,64 t CO_2e/year

Methane emissions from fertilizer management

The term “fertilizer” is jointly used for feces and urine (solid and liquid matters) derived from animals. The breakdown of fertilizers under anaerobic conditions (in absence of oxygen), during storage and processing, produces methane. These conditions are most common when many animals are in a small closed space (farms for dairy cows, facilities for cattle fattening, poultry and pig farms) and in case of liquid system of fertilization. The main factors that have an impact on methane emissions are the quantity of produced fertilizer and the part of the fertilizer that breaks down anaerobically. The quantity of fertilizer depends on the rate of fertilizer production per animal and on the number of animals, and the anaerobic breakdown depends on the system of fertilizer management. When the fertilizer is stored and processed as liquid (lagoons, ponds, pit etc.), anaerobic breakdown occurs, and formation of significant quantities of methane. The temperature and the time period of storage of the fertilizer have considerable influence on the produced quantity of methane. When the fertilizer is processed in solid state (piles) or when it is spread in pastures, it is prone to aerobic breakdown and produces much smaller quantities of methane.

For the purpose of calculation of the emissions, a simple method was used, that requires data about the population of domestic animals according to animal type/category and the climate region or temperature in combination with standard emission factors according to IPCC. Considering that some of the emissions that originate from fertilizers are especially sensitive to temperature differences, what is considered as a good practice is the performance of an assessment of average annual temperature at the locations of the fertilizer.

The calculation of the emissions from fertilizer management is performed in the following steps:
Step 1: Collection of data about the population from the characterization of the population of domestic animals;
Step 2: Application of standard values or development of emission factors specific for the country for each subcategory of animals expressed in kilograms of methane per animal per year;
Step 3: Multiplication of the emission factors from the subcategories of animals with the population of the same subcategory of animals;
Step 4: Collection of all emissions from all subcategories of animals in order to obtain the total value of emissions from all types of domestic animals.

Table 3-25: Methane emissions from manure management

Blagorvgradtska Bustritza River Catchment area			
Type of animal	Emission factor for enteric fermentation	Number of animals	Methane emissions from enteric fermentation
Unit	kg/head/y	No.	(tons/y)
Dairy cattle Cows	15	n/a	
Cattle that does not produce milk	8	3639	29.11
Sheep	0.19	7113	1.4
Goats	0.13	2632	0.34
Horses	1.56	76	0.1
Mules and donkeys	0.76	n/a	n/a
Pigs	3	388	1.2
Poultry	0.03	n/a	n/a
Total emmisions:			32,15

Manure management emissions of CH_4 for 2016 are 32,15 t CH_4/year, which is 675,15 t CO_2e/year

Emissions from agricultural residue burning

This sector covers the emissions of non-CO_2 greenhouse gases from the burning (in the field) of crop residue and other agricultural waste on site. Despite field burning is prohibited by the Bulgarian law, this “tradition” continues and is emission source not only of main GHGs but also of GHGs-precursors.

The estimations are based on the expert judgement that 3% of the vegetal residues, left on the fields after yielding the crops, are burned. Activity data for harvested production by crops is provided by the Statistical Department of the MAF. Specific parameters used for calculations of the emissions are provided from the Agricultural University of Plovdiv.

Table 3-26: Agricultural areas

Grains	Blagoevgrad
Wheat (ha)	4200
Maize (ha)	400
Barley (ha)	300
Rice (ha)	n/a
Other grains (ha)	2700
Total	7600

Area of industrial crops	Blagoevgrad
Soybean (ha)	/
Sunflower (ha)	/
Oilseed rape (ha)	2200
Tobacco (ha)	/
Sugar beet (ha)	/
Other industrial crops (ha)	/
Total (ha)	2200

Area of forage crops	Blagoevgrad
Fodder beet (xa)	/
Alfalfa (xa)	/
Clover (xa)	/
Maize for green mass (xa)	/
forage mixtures (xa)	/
Other forage crops (xa)	/

Table 3-27: Quantity of direct and indirect greenhouse gas emission in incomplete combustion of the residues from the agricultural crops

Greenhouse gas (tons)	Blagoevgrad
CH_4 in CO2e	1.02
CO	588
N_2O in CO2e	21.7
Total	610.72

Total emissions from incomplete combustion of the residues are 610 tCO2e

Sector: Waste

Methane emissions from solid waste landfills

In order to calculate the emissions of waste generated in the Blagoevgradska Bistritza River catchment area, it is necessary to use indicators (population, economic growth etc.). The most important data for this calculation is the number of population. The data were provided from the State Statistical Office of the Republic of Bulgaria.

The values of the correction factor for calculation of the methane emissions are taken from the Revised IPCC guidebooks for inventory preparation and they comply with the methodology which is used for calculation of the national greenhouse gas emissions.

Table 3-28: Values of the correction factor for calculation of the methane emissions

Landfill type	Waste ratio (by weight) in a landfeel	Correction factor for methane	Measured average correction factor for each type of landfill
Managed Landfill	0,283	1	0,28
Unmanaged deep >=5m waste	0,318	0,8	0,26
Unmanaged deep < 5m waste	0,4	0,4	0,16
Total	***1***	***0,6***	***0,70***

The key parameter in the determination of the total methane emissions from the landfills, is the value of the degradable organic carbon and it directly depends on the different fractions of waste that is being disposed on the landfills. The values of these fractions are taken from the revised IPCC guidebooks, whereby this value is calculated and it is equal to 19,23%. The methane emissions in one year are calculated according to the equation: CH_4 emitted in the year (kt/year) = [CH_4 generated in the year – R(ton)] •(1-OX) Where: R – methane that has been reused, OX – oxidation factor. In these calculations, R and OX are taken with a value of 0.

Treatment like disposal of municipal, industrial and other solid waste produces significant amounts of methane (CH_4). CH_4 produced at SWDS contributes approximately 3 to 4 percent to the annual global anthropogenic greenhouse gas emissions (IPCC 2001). The major greenhouse gas emissions from Waste sector are CH_4, CO_2 and N_2O. The methodology used to estimate emissions from waste management activities requires country-specific knowledge on waste generation, composition and management practice. The main parameters that influence the estimation of the emissions from landfills, apart from the amount of the disposed waste, are: the waste composition, fraction of methane in landfill gas and amount of landfill gas that is collected and treated. These parameters are strictly dependent on the waste management policies throughout the waste streams which start from waste generation through collection and transportation, separation for resource recovery, recycling and energy recovery and terminate at landfill sites. The improvements of quality and quantity of data are visible in last couple of years. Effort was done in order to evaluate and compile data coming from different sources and adjust them to recommended IPCC methodology which is used for GHGs emissions estimation. At present in this enventarization are used country specific data like amount of waste gerated per capita, where they are available. Default values are used when such data are not available. Emissions from solid waste disposal on land have been calculated using the First Order Decay (FOD) method, the IPCC Tier 2 method given in the 2006 IPCC Guidelines.

Table 3-29: Methane emission from solid waste

Municipality	**Population**	Waste generation rate kg/person/day	**Total waste generated T/Year**	Fraction of MSW disposed	**Waste disposed at landfills**		**CH4 emissions t/year**
Blagoevgrad	77440	1.21	93.70	0.694	65.02		1356
Total							1356

The total emissions from solid waste are 1356 CH4 t/year or 28 476 CO2e t/year

Methane emissions from residential/commercial organic wastewater and sludge

Wastewater can be an important source of methane. Sewers can be open or closed. Usually in urban areas they are closed and underground and they can have purification systems. These types of sewers are not important methane emitters unlike open systems which are present in rural areas. For this reason, it is important for municipal inventories to calculate the methane emission from organic wastewaters. Methane emissions directly depend on the degradable organic matter in water and they increase with the growth of temperature. The basic parameter for calculation of the content of organic matter is the biochemical oxygen demand (BOD). The concentration of BOD represents a quantity of carbon that is aerobically degradable. Standard measurement of BOD includes testing of the sample within 5 days. This value has been taken as a standard parameter from the Revised IPCC guidebooks.

This sector includes CH4 emissions from wastewater when treated or disposed anaerobically and indirect N2O emissions as the CO2 emissions from wastewater are not considered in the 2006 IPCC Guidelines. For Bulgaria according to NSI data, domestic wastewater has been treated in centralized aerobic treatment plants, septic systems, latrines and discharged into water bodies (sea, river, lakes). In 2015 about 62.3 % of the population is connected to centralized aerobic treatment plants, 13.2 % is connected to the public sewerage, but without treatment (sea, river, lake) and 24.5 % of the country population use septic systems and latrines.

The methodology for the calculation of the methane emissions from domestic wastewater handling consists of three components: 1) definition of the total organically degradable material in domestic wastewater (TOW); 2) definition of emission factor for each domestic wastewater treatment/discharge pathway or system and 3) emission estimation. The first step in the calculations is to define the total organically degradable material in domestic wastewater (TOW), which is the AD for this source category. TOW is expressed in the term of biochemical oxygen demand (kg BOD/year). Based on the demographic data acquired by the National Statistical Institute for the respective inventory years, we calculate TOW with the following equation:

TOW = P ● BOD ●0.001 ● I ●365

Where:

- TOW – total organics in the wastewater in inventory year, kg BOD/yr
- P – Municipality population in inventory year
- BOD – country specific per capita BOD in inventory year, g/person/day
- Default value = 60 g/person/day
    - - conversion from grams BOD to kg BOD
- I - correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, used in calculations)

The next step of the calculation is to define the Emission factor. The emission factor for wastewater treatment and discharge pathway and system is a function of the maximum CH4 producing potential (Bo) and methane correction factor (MCF) for wastewater treatment and discharge system.

The Equation for calculation of EF is: $\boldsymbol{EFj = B0 \bullet MCFj}$

Where:

- EFj – emission factor, kg CH4/kg BOD
- j – each treatment/discharge pathway or system
- Bo – maximum CH4 producing capacity, kg CH4/kg BOD
- $MCFj$– methane correction factor (fraction)
- 2006 IPCC Guidelines provides the default value for domestic wastewater:
- Bo = 0,60 kg CH4 /kg BOD

The first step for the definition of MCF is to characterize the systems for wastewater treatment in the municipality.

a) waters without treatment discharged in the water sources (sea, rivers and lakes) MCF = 0.1

b) waters discharged trough sewer system into centralized aerobic wastewater treatment plant – MCF = 0.3

c) waters treated in septic systems – MCF = 0.5

d) waters treated in latrines – MCF =0.1

After determination of TOW, wastewater treatment systems and discharge pathways and respective MCF, we can calculate the CH4 emissions from domestic wastewater as follows:
$CH4\ Emissions$= [Σ(Ui•Ti,j•EFj)i,j](TOW−S)−R

Where:

- CH4 emissions – CH4 emissions in inventory year, kg CH4/yr
- TOW – total organics in wastewater in inventory year, kg BOD/yr
- S – organic component removed as sludge in inventory year, kg BOD/yr
- R – amount of CH4 recovered in inventory year, kg CH4/yr
- Ui – fraction of population in income group i in inventory year
- Ti,j – degree of utilization of treatment/discharge pathway or system, j, for each income group fraction i in inventory year
- i – income group: rural, urban high income and urban low income
- j – each treatment/discharge pathway or system
- EF – emission factor, kg CH4/yr

Table 3-30: Methane emission from wastewater

Municipality	Population	TOW kg BOD/yr	Emission factors kg CH4/kg BOD	Emissions CH4 t/year
Blagoevgradska Bistritza catchment area	77441	2 119 947	0.18	381,6
Total				**381,6**

The total emissions CH4 from wastewaters in the project area are 381,6 CH4 t/year or 8 013 CO2e t/year

Nitrous oxide emissions from sewers

The nitrous oxide (N2O) is a consequence of the breakdown of nitrous components in wastewater, such as urea, nitrates and proteins. The residential wastewater includes sewerage mixed with another type of wastewater such as water from washing machines, water that is used in agriculture etc. This water is mostly discharged in larger body of water (such as a river, a lake).

Direct emissions of nitrous oxide are generated by two processes: nitrification and denitrification of the nitrogen that is present in the compound where nitrous oxide is an intermediate product and in both processes. In order to calculate these emissions, the key data is the consumption of proteins per capita, which is taken from the database of FAOSAT for Bulgaria and it has a value of 27,92 kg/resident/year.

For estimation of N2O from domestic wastewater effluent, 2006 IPCC Guidelines suggest a single methodology for calculations with no higher TIERS and decision tree provided. Nitrous oxide emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea. This section addresses indirect N2O emissions from wastewater treatment effluent that is discharged into aquatic environments. 2006 IPCC Guidelines suggests a methodology for calculation of N2O emissions.

The calculations of the emissions follow the general equation

Equation

N2O Emissions = *N Effuent* ● *EF Effluent* ●44/28,

Where:

- N2O emissions - N2O emissions in inventory year, kg N2O/yr
- N Effluent - nitrogen in the effluent discharged to aquatic environments, kg N/yr
- EF *Effluent* - emission factor for N2O emissions from discharged to wastewater, kg N2O-N/kg N
- The factor 44/28 is the conversion of kg N2O-N into kg N2O.

Choice of emission factors

The default IPCC emission factor for N2O emissions from domestic wastewater nitrogen effluent is 0.005 (0.0005-0.25) kg N2O-N/kg N.

Choice of Activity data

The activity data that are needed for estimating N2O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (kg/person/yr). Per capita protein generation consists of intake (consumption) of protein, available at FAO statistics, multiplied by factors to account for additional "non-consumed" protein and for industrial protein discharged into the sewer system. The total nitrogen in the effluent is estimated, using equation 6.8 (p. 6.25) :

Equation

N *Effluent* = (P ● Protein ● F *NPR* ● F *NON-CON* ● F *IND-COM*) - N sludge,

Where:

- N *Efflent* - total annual amount of nitrogen of the wastewater effluent, kg N/yr
- P- human population (municipality specific)
- Protein - annual per capita protein consumption, kg/person/yr
- F *NPR* – fraction of nitrogen in protein, default = 0.16 kg N/kg protein
- F *NON- CON – factor for none-consumed protein added to the wastewater (1.4)*
- *F IND-COM – factor for industrial and commercial co-discharged protein into the sewer system (1.26)*
- *N Sludge – nitrogen removed with sludge (default = zero), kg N/yr*

Based on this methodolgy are calculated the emissions of NO2 from wastewaters in the five municipalities that are in the project area.

Table 3-31: Nitrous oxide emissions from sewerage inside Blagovgradska Bistritza Catchemnt area

Municipality	*Protein consumed*	*Population*	*FracNPR*	*N Efflent - total annual amount of nitrogen of the wastewater effluent, kg N/yr*	*Emission Factor*	*Emissions N2O*
Units	*(protein kg/man/year)*	*(Number)*	*(kgN/kg protein)*	*(kg N/year)*	*EF6 (кг N_2O-N/кг канал.-N)*	***Tons/y***
Blagoevgrad	*27.92*	*77441*	*0.16*	*610 245*	*0.005*	***4.8***
Total						*4.8*

The total emissions NO2 from wastewaters in the catchment area are 4.8 N2O t/year or 1488 CO2e t/year

Sector: Forestry

For defining forest, Bulgaria uses the definition in the Bulgarian Forest Act (last amendment 07.08.2012, SG №60):

"***Area over 0.1 ha, covered with forest tree species higher than 5 meters and tree crown cover over 10% or with trees which can reach these parameters in natural environment***".

Areas of natural forest regeneration outside urban areas with a size of more than 0.1 ha also represent "forest". City parks with trees, forest shelter belts, and single row trees do not fall under the category "forests. According to their functions, forests are divided into: forests for timber production, protective and recreation forests and forests in protected areas.

Forests are also: areas which are in a process of recovering and are still under the parameters, but it is expected to reach forest crown cover over 10% and tree height 5 meters; areas, which as the result of anthropogenic factors or natural reasons are temporarily deforested, but will be reforested; protective forest belts, as well as tree lines with an area over 0.1 ha and width over 10 meters; cork oak stands. All forests in Bulgaria are managed.

The evaluation of the emissions/removals from Forest land is made In accordance with the IPCC Guidelines. The total area cover with forest in the area of interest is 119 318 ha. as the biggest area is occupied by Dediduous forest.

Table 3-32: Forestry in the Blagoevgradska Bistrica River Catchment area

	Total area in ha.	Deciduous forest in ha	Coniferous forest in ha.	Removals т CO2e
Blagoevgrad	23309	12897	10412	75 987,34

In total the project area has absorption capacity of 75 987,34 thousand CO2 t/year.

3.4.2 Carbon footprint of Rila National Park

“Rila” National Park corresponds to the 2nd category of protected area under IUCN. There are 4 reserves in the park corresponding to the 1st category of protected area under IUCN. Pursuant to the national legislation (Protected Areas Act), the following activities are forbidden in the national park:

1. construction except for tourist shelters and chalets, drinking water intake, treatment facilities, buildings and facilities needed by the park management and for visitors’ servicing, underground communications, repairs of existing buildings, roads, sports and other facilities;
2. production activities except for maintenance and reclamation activities in forests, lands and water areas;
3. clear fellings;
4. using artificial fertilizers and other chemical means;
5. introduction of flora and fauna species not typical of the region;
6. goat pasture, as well as grazing in forests beyond meadows and pasture lands;
7. picking herbs, wild berries and other plants and animals on particular places;
8. taking fossils and minerals, damaging rock formations;
9. disturbing the natural state of water areas, water flows, their banks and belonging territories;
10. game breeding and hunting unless for the regulation of the numbers of animal species;
11. amateur fishing and fish-breeding at particular places;
12. polluting water and terrains with domestic, industrial and other waste;
13. bivouacking and kindling fires beyond the designated places;
14. interfering with biological diversity;
15. taking rare, endemic, relict and protected species, except for scientific purposes;
16. other activities identified in the order for declaring the protected area and management plan.

The park management plan introduces some additional bans for the territory of the entire park for limitation to the maximum extent of the human impact, which is provided through the maximum reduction of the negative anthropogenic effect.

It is taken into consideration that no industrial sites are located within the territory of the park, and considering the character of infrastructure, tourists’ profile and the existing road network, it can be concluded that the carbon footprint of the territory of “Rila” National Pak is close to zero.
The only sectoral carboon footprint that can be measured in the territory of the Rila National Park is the electricity consumption by the turist chalets. There is 17 chalets inside the boundary of the Park. But accurate data about the exact countyty of the used electricity can not be obtain.

The total area cover with forest in Rila National Park is 53 481 ha. as the biggest area is occupied by coniferous forests. They posses huge absorption capacity.

Table 3-33: Area with Forests in Rila National Park

	Total area in ha.	Deciduous forest in ha	Coniferous forest in ha.	Removals т CO2e
Blagoevgrad	53 481	2 366,4	51 114,6	85 569,6

In total Rila National Park has absorption capacity of 85 569,6 thousand CO2 t/year.

3.5 Water Footprint results

3.5.1 Water footprint of Blagoevgradska Bistritza Catchment Area

The water footprint was calculated 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 the region of Blagoevgradska Bistritza Catchment area. This water footprint may be partly inside the region and partly outside of it, depending on whether the products are locally produced or imported, but to avoid double accounting the water used for the production of the goods is calculated were the goods are used not where they were produced. The calculated water footprint regards only the consumed food products unfortunetly there is no available imformation that regards the consumption of other products and services. Because of that they are not included in this research.

Data about the consumption are extracted from the European Statistical Service and represent the average consumption of food products per citizen/day. Assumption codes represents the codes that are used in excel table that represent the methodology approach for calculating the water footprint.

Table 3-34: Average consumption of food and other products per capita.

1. Households				
	Assumption code	**Description**	**value**	**units**
General	Assumption EF G.1.1	Average weight of adults residents	70	kg
	Assumption EF G.3.1	Days of consumption for the residents	365	days/year
	Assumption EF G.4.1	% fuel combustion for heating due to poverty	70%	%
	Assumption code	**Description**	**value**	**units**

1. Agricultural products	Assumption EF1.1.1	average consumption of bread and rolls in g per kg of human mass per day	3,2	g/kg/d
	Assumption EF1.2.1	average consumption of potatoes and potatoes products in g per kg of human mass per day	6,1	g/kg/d
	Assumption EF1.3.1	average consumption of sugars per kg of human mass per day	0,4	g/kg/d
	Assumption EF1.4.1	average consumption of breakfast cereals per kg of human mass per day	1,6	g/kg/d
	Assumption EF1.5.1	average consumption of grain milling products in g per kg of human mass per day	0,9	g/kg/d
	Assumption EF1.6.1	average consumption of legumes, beans, dried per kg of human mass per day	5,4	g/kg/d
	Assumption EF1.7.1	average consumption of fruits (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) in g per kg of human mass per day	53,9	g/kg/d
	Assumption EF1.8.1	average consumption of beer and beer-like, wine, spirits, soft drinks per kg of human mass per day	17,9	g/kg/d
	Assumption EF1.9.1a	average consumption of tobacco per day in Bulgaria	20	g/d
	Assumption EF1.9.1b	% smokers in Bulgaria	40%	%
	Assumption EF1.10.1	average consumption of rice-based meals per kg of human mass per day	10	g/kg/d
	Assumption EF1.11.1	average consumption of vegetables fats and oils per kg of human mass per day	1,3	g/kg/d
	Assumption code	**Description**	**value**	**units**
2. Livestock products	Assumption EF2.1.1	average consumption of livestock meat (mostly pork) per kg of human mass per day	4,4	g/kg/d
	Assumption EF2.2.1	average consumption of farmed animals (mostly beef) per kg of human mass per day	4,1	g/kg/d
	Assumption EF2.3.1	average consumption of sausages per kg of human mass per day	2	g/kg/d
	Assumption EF2.4.1	average consumption of poultry in g per kg of human mass per day	3,2	g/kg/d
	Assumption EF2.5.1	average consumption of eggs per kg of human mass per day	2,6	g/kg/d
	Assumption EF2.6.1	average consumption of liquid and concentrated milk and milk based beverages per kg of human mass per day	32,5	g/kg/d
	Assumption EF2.7.1	average consumption of cheese per kg of human mass per day	2	g/kg/d

	Assumption EF2.8.1	average consumption of animals fat, margarine and similar products per kg of human mass per day	0,7	g/kg/d

Table 3-35: The water foot print of different food items (source: waterfootprint.org)

Food item	Unit	Global average water footprint (litres)
Apple or pear	1 kg	700
Banana	1 kg	860
Beef	1 kg	15,500
Beer (from barley)	1 glass of 250 ml	75
Bread (from wheat)	1 kg	1,300
Cabbage	1 kg	200
Cheese	1 kg	5,000
Chicken	1 kg	3,900
Chocolate	1 kg	24,000
Coffee	1 cup of 125 ml	140
Cucumber or pumpkin	1 kg	240
Dates	1 kg	3,000
Groundnuts (in shell)	1 kg	3,100
Lettuce	1 kg	130
Maize	1 kg	900
Mango	1 kg	1,600
Milk	1 glass of 250 ml	250
Olives	1 kg	4,400
Orange	1 kg	460
Peach or nectarine	1 kg	1,200
Pork	1 kg	4,800
Potato	1 kg	250
Rice	1 kg	3,400
Sugar (from sugar cane)	1 kg	1,500
Tea	1 cup of 250 ml	30
Tomato	1 kg	180
Wine	1 glass of 125 ml	120

Table 3-36: Water food print based on the consumption of different products in the Blagoevgrdska Bistritza River Catchment area.

Assumption code	Description	value	units	Water foot print Liter/year/human	Total water foot prin liter/year/70 880 citizens
Assumption EF1.1.1	average consumption of bread and rolls in g per kg of human mass per day	3,2	g/kg/d	122 640	8692 723200
Assumption EF1.2.1	average consumption of potatoes and potatoes products in g per kg of human mass per day	6,1	g/kg/d	38 962,5	2761662000
Assumption EF1.3.1	average consumption of sugars per kg of human mass per day	0,4	g/kg/d	15 000	1063200
Assumption EF1.4.1	average consumption of breakfast cereals per kg of human mass per day	1,6	g/kg/d	65408	4636119040
Assumption EF1.7.1	average consumption of fruits (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) in g per kg of human mass per day	53,9	g/kg/d	964 001, 5	68 328 426 320
Assumption EF1.8.1	average consumption of beer and beer-like, wine, spirits, soft drinks per kg of human mass per day	17,9	g/kg/d	54 881,4	3 889 993 632
Assumption EF1.10.1	average consumption of rice-based meals per kg of human mass per day	10	g/kg/d	868 700	61573456000
Assumption EF1.11.1	average consumption of vegetables fats and oils per kg of human mass per day	1,3	g/kg/d	5978,7	423 770 256
Assumption code	**Description**	**value**	**units**		
Assumption EF2.1.1	average consumption of livestock meat (mostly pork) per kg of human mass per day	4,4	g/kg/d	539 616	38 247 982080
Assumption EF2.2.1	average consumption of farmed animals (mostly beef) per kg of human mass per day	4,1	g/kg/d	163702, 5	115 08803320

Assumption EF2.5.1	average consumption of eggs per kg of human mass per day	2,6	g/kg/d	166 075	11771 396000
Assumption EF2.6.1	average consumption of liquid and concentrated milk and milk based beverages per kg of human mass per day	32,5	g/kg/d	207 593, 75	14714245000
Assumption EF2.7.1	average consumption of cheese per kg of human mass per day	2	g/kg/d	255 500	18 109 840000
Total footprint in liters					244 659 480 048
Total foot print in cubic meters					244 659 480

The total water foot print of the catchment area of Blagoevgradska Bistritza river is 244659 480 litre/year

3.5.2 Water footprint of Rila National Park

"Rila" National Park corresponds to the 2nd category of protected area under IUCN. There are 4 reserves in the park corresponding to the 1st category of protected area under IUCN. Because of that there is no permanent population inside the park the water footprint can be calculated only from the data that regards the food consumption by the tourist inside the park.

Table 3-37: Average consumption of food and other products per tourist

1. Tourism				
	Assumption code	**Description**	**value**	**units**
General	Assumption EF G.1.7	Average weight of adults tourists	70	kg
	Assumption EF G.3.7	Days of consumption for the tourist	3	days
	Assumption code	**Description**	**value**	**units**
1.	Assumption EF1.1.7	average consumption of bread and rolls in g per kg of human mass per day	3,2	g/kg/d

	Assumption EF1.2.7	average consumption of potatoes and potatoes products in g per kg of human mass per day	6,1	g/kg/d
	Assumption EF1.3.7	average consumption of sugars per kg of human mass per day	0,4	g/kg/d
	Assumption EF1.4.7	average consumption of breakfast cereals per kg of human mass per day	1,6	g/kg/d
	Assumption EF1.5.7	average consumption of grain milling products in g per kg of human mass per day	0,9	g/kg/d
	Assumption EF1.6.7	average consumption of legumes, beans, dried per kg of human mass per day	5,4	g/kg/d
	Assumption EF1.7.7	average consumption of fruits (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) in g per kg of human mass per day	53,9	g/kg/d
	Assumption EF1.8.7	average consumption of beer and beer-like, wine, spirits, soft drinks	17,9	g/kg/d
	Assumption EF1.9.7a	average consumption of tobacco per day in Europe	10	g/d
	Assumption EF1.9.7b	% smokers in Europe	29%	%
	Assumption EF1.10.7	average consumption of rice-based meals per kg of human mass per day	10	g/kg/d
	Assumption EF1.11.7	average consumption of vegetables fats and oils per kg of human mass per day	1,3	g/kg/d
	Assumption code	**Description**	**value**	**units**
2. Livestock products	Assumption EF2.1.7	average consumption of livestock meat (mostly pork) per kg of human mass per day	4,4	g/kg/d
	Assumption EF2.2.7	average consumption of farmed animals (mostly beef) per kg of human mass per day	4,1	g/kg/d
	Assumption EF2.3.7	average consumption of sausages per kg of human mass per day	2	g/kg/d
	Assumption EF2.4.7	average consumption of poultry in g per kg of human mass per day	3,2	g/kg/d
	Assumption EF2.5.7	average consumption of eggs per kg of human mass per day	2,6	g/kg/d
	Assumption EF2.6.7	average consumption of liquid and concentrated milk and milk based beverages per kg of human mass per day	32,5	g/kg/d
	Assumption EF2.7.7	average consumption of cheese per kg of human mass per day	2	g/kg/d
	Assumption EF2.8.7	average consumption of animals fat, margarine and similar products per kg of human mass per day	0,7	g/kg/d

Assumption code	Description	value	units	Water foot print liters/ tourist	Total water foot print Liters/tourists/year (29250 tourist)
Assumption EF1.1.7	average consumption of bread and rolls in g per kg of human mass per day	3,2	g/kg/d	873,6	25 552 80
Assumption EF1.2.7	average consumption of potatoes and potatoes products in g per kg of human mass per day	6,1	g/kg/d	320,25	9360000
Assumption EF1.3.7	average consumption of sugars per kg of human mass per day	0,4	g/kg/d	126	3685500
Assumption EF1.7.7	average consumption of fruits (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) in g per kg of human mass per day	53,9	g/kg/d	7923	231 747750
Assumption EF1.8.7	average consumption of beer and beer-like, wine, spirits, soft drinks	17,9	g/kg/d	451,08	13194090
Assumption EF1.10.7	average consumption of rice-based meals per kg of human mass per day	10	g/kg/d	7140	208845000
Assumption code	**Description**	**value**	**units**		
Assumption EF2.1.7	average consumption of livestock meat (mostly pork) per kg of human mass per day	4,4	g/kg/d	4435,2	129 723750
Assumption EF2.2.7	average consumption of farmed animals (mostly beef) per kg of human mass per day	4,1	g/kg/d	133 885,5	3916150875
Assumption EF2.5.7	average consumption of eggs per kg of human mass per day	2,6	g/kg/d	1365	39926250
Assumption EF2.6.7	average consumption of liquid and concentrated milk and milk based beverages per kg of human mass per day	32,5	g/kg/d	1706,25	49900500

Assumption EF2.7.7	average consumption of cheese per kg of human mass per day	2	g/kg/d	2100	61 425000
Total WF L/year					5025849995
Total WF cubic meters/year					5 025849,1

The total water foot print of the catchment area of Blagoevgradska Bistritza river is 502584995 litre/year

3.6 Further analysis of results

Data for the two parts of Study Area 2 – (1) the territories of Rila National Park falling within the range of the INTERREG V-A Greece-Bulgaria 2014-2020 Programme, and (2) the catchment area of Blagoevgradska Bistritsa River is hardly comparable as the first is a 2nd Category of IUCN site with strict regimes of usage and there is no population inside plus very limited anthropogenic activities. The other part, on the contrary, includes the town of Blagoevgrad – the administrative, economic and demographic center of the whole Southwest Bulgaria and anthropogenic impacts are huge.

So, speaking of **ecological footprint,** the factors affecting it inside the Rila NP, are limited to some public transportation related mostly to maintenance and control activities by the park staff (equivalent value of 9.06 Gha) and consumption by tourists who are however unevenly distributed around the territory (7.11 Gha). The highest impact in the second part of the Study Area, that of Blagoevgradska Bistritsa River catchment area, comes naturally from households consumption (44662.55 Gha, with 92% attributing to food consumption, mostly beverages, bread, fruit and vegetables, plus pork and paultry), followed by private transport (66152.48 Gha). Then come used electricity and fuel for heating (total ecological footprint of the tertiary sector - 23022,60 Gha, 67% attributed to electricity consumption). Ecological footprint of tourism here is insignificant compared to the above figures.

Concerning the **carbon footprint**, it is again natural that results for Blagoevgradska Bistritsa River catchment area are much higher than within the National Park. In the first territory, electricity consumption by households shows highest impact on the carbon footprint, about 5 times bigger than, for example, the coal consumption. It is also about 2.5 times higher that carbon footprint from road traffic (mostly private transport). Waste management also needs improvement as carbon footprint from waste, though far from the values of energy consumption, is not to be underestimated. Carbon footprint of tourism (excluding the transport services) is very low. Data for the territory of Rila National Park, in comparison to the adjacent zone of Blagoevgradska Bistritsa River catchment area, has such low values that it can be considered irrelevant.

As for the **water footprint,** calculations were made on the basis of consumption and therefore relate mainly to the part of Study Area 1 covering the Blagoevgradska Bistritsa River catchment area where population is concentrated. Farming and livestock breeding are the main contributors to the region's water footprint, starting with the production of cheese and pork.

In general, efforts of future interventions should be focused on the territories outside the National Park boundaries but still close enough to affect the protected area – which is the case with Blagoevgradska Bistritsa River catchment area. As results show, such interventions should be targeted at the development of a more environmentally-friendly and responsible behaviour of local residents which could include information and awareness raising campaigns, demonstration projects, spreading of good practices (national/international) and others.

Chapter 4 - Propose actions of improvement

4.1 How to improve Carrying Capacity and Ecological Footprint

The improvement of the environmental performance of the 1) National Park of Eastern Macedonia and Thrace, NP-EMATH (Study Area 1) and 2) Rila National Park of Bulgaria (RNPD) including the catchment area of the river basin of Blagoevgradska Bistrica (Study Area 2)., lies in two general components: a) to the increase of biocapacity, and b) to the reduction of the Ecological Footprint. Many of the actions related to the improvement of the ecological footprint are directly linked to the reduction of the Carbon Footprint through the reduction / improvement of the energy balances in the two areas. In this section, emphasis will be set on the proposals related to production/consumption of products, land use change, awareness-raising actions etc. which can lead to the reduction of the ecological footprint.

4.1.1 Consumption of Products

The consumption of products contributes to the formation of the ecological footprint. The proposed actions of the Managing Authority that can reduce the ecological footprint are to inform and raise awareness of both residents and visitors, about the practices and methods for improving their environmental performance by changing their behavioural patterns. Similar actions have been implemented by the Managing Authorities of the National Parks of Axios Delta - Loudias - Aliakmonas, Koronia - Volvi, Lake Kerkini and the National Park of Mountain Olympus at the first Green Party organized in Thessaloniki, where volunteers informed attendees about ways for reducing the ecological footprint.

The Managing Authorities of the two Study Areas should launch campaigns for informing residents and visitors about the importance of choosing food and consumption models that can reduce the ecological footprint and showcasing how existing patterns might increase or reduce the impact of consumption to the climate change. Some of the proposals for reducing the ecological footprint are the following:

- <u>Preference for local products</u>. By reducing the distance that a product needs in order to reach the final consumer, the fuel required for this transport is reduced. In addition, local products often do not require special maintenance in refrigerators and storage facilities, thus saving potential energy consumption required for the operation of refrigerators and cooling equipment.
- <u>Cultivation of fruits and vegetables in private gardens.</u> The use of less fertilizers and pesticides, commonly used in private gardens, protects the environment from toxic waste and fauna from dangerous ingredients.
- <u>Avoidance of processed foods.</u> Processed foods require large amounts of energy, water and raw materials for their production, cooling, packaging and distribution to the final consumer.
- <u>Preference in seasonal fruits and vegetables</u>. Preference in seasonal fruits and vegetables avoids

the long-distance food transport and energy consumption for preservation purposes.

- Preference in products without or with minimal packaging. The packaging of products, not only requires a lot of energy for the production of the materials, but also causes large volumes of waste.
- Avoid the consumption of large quantities of meat and dairy products. The cultivation of feeding stuff, harvesting, housing, feeding of animals, their transport, slaughtering, packaging, preservation and cooking of these foods require the consumption of large amounts of energy and resources.
- Rational consumption of foods in order to avoid the rejection of large quantities of food. Product waste contributes negatively to the ecological footprint not only through the greater demand for productive land but also for the greater space for waste disposal.
- Composting of food waste This method can provide local residents with a rich organic fertilizer and at the same time it can reduce the required land for food waste disposal.

4.1.2 Agricultural sector

The irrational use of fertilizers and pesticides affects the ecosystem's balance and put in risk the fauna of the area. Practices for the reduction of the ecological footprint include the rational use of fertilizers and pesticides, and suggest regular organic cultivations. Taking into account the importance of land use on the ecological footprint calculations (factor of equivalence 2.2) and the percentage of the total area of NP-EMATH and RILA National Park, which is covered by agricultural crops, it is suggested that the improvement of the environmental performance of agriculture can contribute to a very high extent to the reduction of the ecological footprint and to the increase of biocapacity.

Managing Authorities can provide advice and guidance regarding ways to achieve this objective by informing the farmers of the area about the benefits of organic cultivations. The use of little or no amount of fertilizer and pesticides requires up to 40% less energy consumption and supports high levels of wildlife. Organic farming sets animal welfare as a priority, contrary to the conventional land use methods. **The purchase and consumption of organic farming products can reduce the ecological footprint by 5%.**

4.1.3 Livestock sector

According to the results of the ecological footprint, Managing Authorities should focus on the livestock sector. The production of meat and dairy products requires large amounts of energy and raw materials, as mentioned above. The Managing Authority's contribution to this sector should have a consulting role and encourage farmers to use feeding stuff produced by organic production methods. Moreover, the reduction of ecological footprint can be achieved by limiting the production of high-value products, such as beef meat.

4.1.4 Power generation

The Managing Authority of NP-EMATH and Rila National Park of Bulgaria (RNPD) including the catchment area of the river basin of Blagoevgradska Bistrica should support the power generation from photovoltaic systems since a theoretical increase in the production from 43% to 100% of the total consumed electricity would lead to a reduction in the ecological footprint of up to 10%.

4.2 How to improve Carbon Footprint

The majority of proposals for improving the carbon footprint of protected areas are related to energy saving actions and/or improving the energy behavior of residents and visitors of the National Parks. Many of the proposed actions require the active involvement of the Municipalities within the parks in the effort to improve the carbon footprint of the respective regions and in order to increase the effectiveness of the proposed actions. The ultimate aim of these actions is to promote coordination and dissemination of information on energy and environmental issues.

4.2.1 Municipal Buildings

Trends in both European and international legislation are preparing the processes of both erection of new public buildings and conversion of existing public buildings into nearly zero energy buildings and CO_2 emissions. The respective procedures will be gradually required from 2018 onwards and will have a compulsory character. Proposals to improve the carbon footprint of public buildings can be divided into two main axes:

- Implement energy saving programs / retrofitting interventions at the buildings of the two Managing Authorities
- Awareness raising on how competent Municipalities in the topic have benefited from implementing energy saving programs / retrofitting interventions in the buildings they manage and what were the requirements for achieving their aim. Publishing the results of this study and communicating them to theMunicipalities of the Study Areas in the CB region can be a first point in launching the Agency's efforts to promote holistic strategies for sustainable development.

The main objective of both axes is to highlight the potential for reducing the carbon footprint at the municipal buildings of NP-EMATH and the RILA National Park. in general, as examples for the residents to imitate, and towards facilitating the adoption of policies and practices for sustainable development. The conversion of public buildings into zero emission buildings indirectly contributes to the reduction of carbon footprint through efficient communication of benefits to third parties and citizens' awareness.

In line with international practice and the European Directives, i.e Energy Performance of Buildings ED

2002/91 EC, successful and sustainable measures that could be applied to public buildings and facilities by improving their energy performance can be divided into three main categories:

- No-cost actions: Non-dedicated or capital-funded measures. These measures are applied on a regular basis and are part of the normal operation and maintenance of the building while they are often related to changing the behavior of the users of the building.
- Low cost interventions: One-off interventions that can be funded from the existing annual building management budget. The cost of interventions is often repaid within the same management year and usually in less than two years.
- Reconstruction operations: One-off capital injections due to the significant initial cost for their implementation and their average or long repayment period. These interventions often involve a specific economic and technical evaluation study.

Energy savings in existing buildings (municipal and the Agency) can be achieved through functional rationalization interventions, while in new upgrades through "green" interventions (quoted without a ranking) such as:

1. Applying bioclimatic design principles to building projects (new buildings or renovations of older buildings) both inside and outside the building. passive ventilation and shading systems as well as in the surrounding area eg. tree planting.
2. Participation in national or European energy saving financing tools addressed to Municipalities.
3. Integration of small RES systems (eg photovoltaic, solar thermal hot water systems) on the terraces of municipal buildings.
4. Addition of thermal insulation (where required especially in buildings erected before 1980) in the exterior wall and roof of buildings.
5. Replacement of lamps with other high economy.
6. Adding an automation system e.g. use motion detectors on the premises of buildings to enable / disable the E / M systems (lighting, cooling, etc.).
7. Replacement of frames.
8. Replacing air conditioning units with new more efficient ones (energy class A).
9. Upgrading / replacing E / M systems (where possible and after relevant study) with new systems such as solar thermal heating devices (water or air), direct evaporation cooling devices or central heating system replacement.
10. Shading of the roof openings to improve comfort conditions.
11. Performing an energy audit and displaying profits from the energy certification of buildings.
12. Promotional and upgrading policies for upgraded and energy-conscious buildings.

4.2.2 Domestic and tertiary sector

The building sector consumes 40% of the total energy in EU countries and is usually the largest consumer of energy in urban areas. Corresponding results were also observed for the management area of the Agency, due to the large number of anthropogenic activities of urban profile observed within its boundaries. The Agency's capacity to intervene in this category is particularly limited in private buildings, so it is proposed to seek the design and implementation of internationally recognized good practices such as:

1. Viewing efforts in their own buildings as a promotional successes (see previous section).
2. Mobilization and cooperation of the stakeholders of the domestic and tertiary sector to implement measures in areas such as tourism, craft and trade. In particular, such measures in the form of a Good Practice Guide, particularly in the craft sector, could be:
    - step-by-step startup of the equipment to avoid spikes, setting the operating point according to other elements (timing, employment, outdoor temperature);
    - reducing consumption peaks by selectively shutting down systems in periods exceeding the maximum level,
    - optimizing startups and shutdowns of equipment,
    - equipment shutdown during low demand and consequently poor performance times.
3. Active promotion of national and European policies and goals within its boundaries.
4. Collaborate with organizations to promote energy saving and sustainable development.

An important step is the mobilization and cooperation of the stakeholders in an informal structure (forum) to discuss proposals and joint actions for fostering sustainable development at the city or the regional level of the CB area. Through such a structure or similar information / education actions, the forum will also seek to promote national / European policies related to energy and the environment and lead to a reduction in CO2 emissions. Indicatively, the discussion topics could indicatively be informed by:

- The European Directives 2002/91 and 2010/31 and the corresponding Greek institutional framework (Law 3661/2008).
- The institution of energy audit and gains from energy certification and upgrading of residential and tertiary buildings.
- Directive 2006/32 and the relevant Greek institutional framework (Law 3855/2010) on the possibilities of concluding Energy Efficiency Contracts with Energy Services Companies.
- Financial opportunities such as "EXCELLENT FINANCE" and "BUILDING THE FUTURE".

At the same time, the Agency may make use of the results of this study to issue guides, brochures or any other documentation necessary to inform / educate the residents / visitors of the National Park (or to distribute them to municipalities) on energy saving solutions, and environmental benefits resulting from the change in energy behavior and the implementation of low cost energy saving measures. Accordingly, in the tertiary sector, the Agency is proposing to seek to inform / sensitize the companies / entrepreneurs in the region about the direct economic and environmental benefits of energy saving actions and interventions in the areas of changing the energy behavior of workers and implementing low energy saving measures costs (e.g. through the organization of relevant workshops).

4.2.3 Public / municipal lighting

Improvements to this category concern mainly municipalities and the Managing Authority cannot substantially contribute to the reduction of the carbon footprint resulting from the lighting needs without neglecting the fact that over-lighting (lack of lighting) effects may affect the region's fauna. Municipal lighting is an area where energy savings can be achieved by replacing existing lamps with new energy savings. Such replacement may, for economy reasons, also be made on a case-by-case basis, ie when a lamp is being broken or the infrastructure of a road is renewed or replaced. In addition to replacing lamps, the Technical Services of the Municipality should monitor the technical developments for solutions and applications that may be related to:

1. New types of lamps with even lower power consumption for the same brightness values and technical specifications.
2. New reflectors or covers.
3. Municipal lighting technologies using RES, for example. autonomous solar lighting poles.
4. Technologies for controlling the intensity of municipal lighting.

The Agency may propose that a lighting study be carried out for all the municipal lighting needs of a municipality, ensuring the conditions of safety and visual comfort imposed by the relevant regulations. It is estimated that the extra energy savings resulting from an electrification study is at least 5% of the total electricity consumed by a municipality.

4.2.4 Vehicles and transportation

Vehicles

Interventions related to the reduction of fuel consumption by vehicles serving the needs of the Managing Authority (and municipal vehicles), although it leads to a reduction in its operating costs in the medium term, but does not have a significant impact on the total CO2 footprint of EMRATH due to small number of vehicles in circulation compared to those in the private sector. However, the proper visibility of actions and results related to these vehicles can serve as an example and guide for citizens and professionals in the city, as is the case with buildings. As actions for Vehicle / Municipal Vehicles based on both international and European practice can be proposed:

1. The conversion of heavy oil vehicles to high blends of biofuel. Biodiesel can replace or mix with conventional diesel in different proportions for use in diesel engines. The practice of blending is very common in many countries, with 5% being the most common, ie 5% biofuels, 95% diesel. The physical and chemical properties of biodiesel are very similar to oil and conventional engines do not need to be converted to blends of up to 5%. In fact, most modern engines can work with blends of up to 30%, but special care must be taken, as the use of blends with more than 5% of biodiesel can cancel several of the manufacturers' warranties. The European standard EN 590 for diesel fuel allows mixing up to 5% of biodiesel. The use of 100% biodiesel must meet the European quality standard EN 14214.

2. Replace heavy oil vehicles with gas vehicles. According to data from the World Association of Natural Gas Vehicles, today around 5 million vehicles are circulating around the world. In some countries, a favorable tax policy for gas vehicles has led to a significant proliferation of these vehicles. More than 400 gas buses circulate in Athens. Natural gas when compressed is not liquefied and is therefore stored on the vehicle as compressed natural gas (CNG) under very high pressure, usually 200 bar, or cryogenically liquefied natural gas (LNG) at temperatures below -180oC. There are three types of natural gas vehicles: gas-fueled vehicles, gas-fueled gasoline or gasoline vehicles, and gasoline and Diesel blend vehicles where the rates of the two fuels vary depending on the speed and load engine. Natural gas vehicles are generally very environmentally friendly in terms of emissions of gaseous pollutants, ie emissions to human health such as particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx) and carcinogenic hydrocarbons (HC). Natural gas vehicles have virtually zero particulate emissions, which gives them a big advantage over diesel and is one of the main reasons for replacing heavy diesel vehicles with natural gas. Like other alternative fuel vehicles, natural gas vehicles are also characterized by higher purchase costs, but this differential cost is quickly extinguished by lower fuel costs.
3. Replacement of gasoline vehicles with hybrid or electric vehicles.
4. Adoption and adoption of practices such as Eco-Driving (COM 490/2009).

The purchase of gas, dual fuel (gas and petrol) or hybrid (gas and gas) vehicles can be promoted to replace existing vehicles after the end of life. The energy and economic efficiency of new vehicles over their lifetime is documented and proven by their own manufacturers. These data can be used to justify the decision to purchase such vehicles through green procurement procedures. There are also proposed more general actions relating to vehicle management or how to use and drive them in order to reduce the number of vehicles used and more efficient use of vehicles, while it is crucial to educate and involve drivers in any shape eventually adopted. These actions mainly concern larger fleets than the Managing Authority (e.g. municipal fleets), but for completeness of the study they were included in the proposals. Indicatively, actions include:

1. Purchase of energy-efficient vehicles whenever replacement of old vehicles is required. Especially for uses where the transport of objects is not required, it is possible to choose the solution of mopeds, small electric vehicles,
2. Installation of GPS systems in fleet vehicles in order to achieve better planning, control and evaluation of routes and fuel consumption of vehicles.
3. Create a driver's registry related to the driver's energy behavior, adopt consumption targets per vehicle and driver and create a reward scheme for those contributing to fuel savings.
4. Adoption of an energy efficiency scheme by all those involved in the municipal fleet (office, maintenance, drivers). According to COM 490/2009 (Eco-Driving), the fuel savings rates achieved according to driving behavior are indicative:

a) Light Vehicles:	• Eco-driving: 8% • Engine Shutdown: 5%

	• Use of small cars: 50% • Use of hybrid cars: 10 – 35% • Use of low consumption tires: 4% • Regular air filter checks: 10% • Regular engine checks: 4% • Regular tire checks: 3%
b) Tracks – Buses:	• Eco-driving: 8% • Engine Shutdown: 5% • Use of aerodynamic aids: 11% • Weight of vehicle: 5% • Use of low consumption tires: 3% • Use of low friction mineral oil: 2% • Regular air filter checks: 10% • Regular engine checks: 4% • Regular tire checks: 3%
c) Continuous driver training in eco-driving practices such as:	• Correct use of gearbox • Prudent driving (acceleration, deceleration) • Avoiding unnecessary weight • Avoiding unnecessary aerodynamic obstacles • Regular tire checks
d) Avoiding the use of service vehicles for short distances. Alternative use of bicycles, electric mopeds, etc.	

Transportations

The choice of use and driving behavior of both private and public vehicles operating within the boundaries of the two study areas are limited. Nevertheless, it is proposed that the transport operator should move on two distinct axes:

1. Information / awareness of drivers / visitors about the benefits of new types of vehicles with reduced fuel consumption, eco-driving and reduced use of short-haul vehicles within the city.
2. Exploring and implementing actions to increase the use of public transport and alternative means of transport (particularly for access to information centers and points of particular interest to the National Parks).

According to the first axis of action, the Agency can develop citizens awareness / awareness campaigns on the potential of modern vehicles with alternative fuels, dual-fuel vehicles or hybrid vehicles, and save fuel and reduce their $CO2$ emissions. In addition, emphasis may be placed on the principles of eco-driving and the reduced use of private vehicles for short distances within the two study areas in the CB region..

The second pillar concerns the study and implementation of actions to increase the use of public transport and alternative means of transport (according to the corresponding European practices - Action Plan and Urban Mobility). For example, these could include, in cooperation with other competent bodies and their respective Municipalities:

i. The creation of further pedestrian-walking routes.

ii. Set up a cycle path network linking key National Park sights with key transport points (bus stops, taxis).

iii. Upgrading public transport - accessibility to information centers to provide a high level of service.

iv. Installation and use of bicycle or electric motorcycle infrastructure (rental / lending) for visitors to information centers.

4.2.5 Renewable energy sources

Besides saving energy, the EU also promotes the production of energy from Renewable Energy Sources (RES) to cover 20% of the energy consumed by 2020. In Greece, for instance the framework for the production of electricity and thermal energy by RES is defined by Laws 3468/2006 on "Production of Electricity from RES and CHP", 3734/2009 on "Promotion of cogeneration of two or more useful forms of energy", and 3851/2010 on "Accelerating the development of Renewable Sources Energy to deal with climate change. The production of energy from PV systems within the Region of East Macedonia and Thrace is particularly high (around 40% of the electricity consumed is produced locally via PV systems). In this context, the Managing Authority can continue to support the efforts to produce energy from RES, without, however, deeming it necessary to prioritize this issue (contrary to other areas in Greece characterized by very low energy production by RES). Indeed, the Agency has the "luxury" due to its very good performance on this issue to focus on side effects related to the installation and operation of PV parks (eg efficient fencing / lighting that does not pose a risk to the fauna of the area), through a stricter process of licensing young people and / or controlling existing PV plants.

4.2.6 Other proposed actions

<u>Supplies</u>

In line with both international and European practice, public bodies should now recognize the multiple benefits of adopting "green procurement" procedures as:

i. Energy savings with corresponding economic and environmental benefits are achieved.

ii. Typically, energy-saving products have a longer life span and better manufacturing quality, reducing the time they need to buy and replace them. They come from recycled materials and are usually innovative products.

iii. CO_2 emissions from product use are reduced.

iv. The Agency gives a good example of the importance and benefits of energy saving as well as the purchase and use of eco-products.

The EU estimates that, on average, the full adoption of green procurement by public / municipal bodies leads to a 25% reduction in CO2 emissions and a 1.2% reduction in total economic costs (product life cycle). In the coming years, public / municipal bodies will have to follow and comply with the requirements of the institutional framework (European Directives 2004/17/18 / EC) which require the adoption of green procurement by public sector bodies, to support efforts to develop the market for environmentally friendly products and, finally, to help provide information to stakeholders.

The European Commission has already adopted green criteria which can be used, inter alia, in the process of drawing up calls for tenders and competitions, and involves ten groups of products and services which, due to their environmental impact or environmental improvement margins or economic impact of their policy or exemplary function - have been judged to be the most appropriate for 'environmental integration' in the context of Green Public Procurement. Criteria are formulated for products that fall under the following product and service groups:

- Paper for writing and for copies
- Cleaning products and services
- Office equipment
- Constructions
- Transportation
- Furnishings
- Electricity
- Food and catering services
- Textiles
- Gardening products and services

4.3 How to improve Water Footprint

The agricultural sector is the main water consumer at the two National Parks in the two study areas , so the proposals in this section aim to save water, thus substantially improve the water footprint. In order for the water footprint to be reduced, the crop yield needs to be increased. Farmer's efforts to achieve an increase in production, result in excess use of irrigation water. For this reason the maximization of water productivity (ton/m3) must be targeted instead of their crop yield (ton/hec.).

The following water-saving policies proposed can be promoted by the Managing Authorities (mainly through advisory actions, e.g. hardware development/ information office and / or incentives):

- Implementation of new, more efficient irrigation methods such as the precision irrigation. With the precision irrigation, the cultivated plant is irrigated according to its needs, taking into account soil and climatic conditions. Precision irrigation reduces water consumption as well as irrigation and energy costs.

- Installation of modern irrigation systems, such as drip irrigation, which save significant amounts of water. Modernization of irrigation equipment in order to minimize any water losses during transfer.
- Actions to inform farmers about water saving, when to start or stop irrigation, how to regulate the amount of water that is used depending on the rainfall, the type of crop or the arable land. Information for the rational use of fertilizers and pesticides.
- Selection of crops depending on the rainfall, irrigation water availability and crop yield. Also transfer of cultivations from areas with lower water productivity to areas with higher water productivity.
- Replacement of the conventional crops with organic. Organic cultivations require less water and lubrication than conventional ones.
- Rational use of fertilizers (quantity and type) and pesticides according to the needs of the crop and according to the experts' instructions. Implementation of organic disease control methods when possible.
- Water reuse. Processed urban waste waters instead of being disposed of to aquifers can be used for the irrigation of the farmland. In this way the degradation of the water quality of the recipient can be avoided and at the same time it enriches the soil with nutrients (nitrogen, phosphorus) which are necessary for the growth of the plant. This reduces the need for fertilizers.

The ally of the implementation of the above water saving practices is the New Common Agricultural Policy (CAP). The new CAP provides incentives to farmers to develop environmental-friendly practices. More specifically, it subsidizes an additional 30% to those who follow certified environment-friendly farming practices. A farmer in order to receive a subsidy must:

a) cultivate at least three different crops where none of the three will be below 5% and over 70% in an arable land of over 30 hectares,

b) maintain the permanent pasture,

c) leave the 7% of their eligible land uncultivated as ecological focus areas.

4.4 Sensitivity analysis – evaluation of different scenarios

Study Area 1-EMATH

Scenarios of category A: Scenarios prerequisites the consumption patterns to remain the same.

<u>Scenario 1:</u> Assuming that all sectors and consumption patterns remain stable. How much can the tourist population be increased in order to not exceed the carrying capacity of the area?

The Carrying Capacity remains stable (38,224), as the consumption patterns remain the same. If the rest of the sectors remain stable, the tourist population of NP-EPAMATH can reach up to 1911 equivalent person or 74,664 visitors (55,998 adults and 18,666 minors) in order not to exceed the carrying capacity of the area. In other words, tourism can be increased approximately tenfold.

Scenario 2:Assuming that all sectors and consumption patterns remain stable. How much can the permanent residents population be increased in order not to exceed the carrying capacity of the area?

The Carrying Capacity remains stable at 38,224 equivalent persons. The permanent residents of the area, given the non-change in other sectors, can be increased by 4% or 1264 people (1003 adults and 260 minors).

Scenario 3: Increase of the permanent residents population in the area by 5%. How much can the visitors population be increased in order to not exceed the carrying capacity of the area?

As we can see on the second scenario, if the population of permanent residents of the areaincreases more than 4% (30,540) the carrying capacity is fulfilled. In this case no more activities could be added at the NP-EPAMATH..

Scenarios of category B

This category of scenarios is more realistic because of the capacity of the system that is under study. In this category, the impact of the increase or the reduction of the ecological footprint per capita, is studied which stems from a corresponding reduction or increase of the activities in focus, within the NP-EMATH.

Scenario 4: Increase of the tourism sector's needs by 20%. How many equivalent residents can be accommodated in the study area without undergoing any irreversible environmental damage?

The changes that are observed in the calculations of this scenario are negligible, so it is assumed that the carrying capacity of the area remains unchanged.

Scenario 5: Increase of the permanent residents' needs by 20%. How many equivalent residents can be accommodated in the study area without undergoing any irreversible environmental damage?

The potential increase in residents' nutritional and energy needs of the residences by 20% would result in a reduction in the existing carrying capacity by 16,67%, i.e. the equivalent persons that can be accommodated in the area are 31,853. This population consists of 26,137 permanent residents and 22,554 visitors. These populations show that the potential increase by 20% of the nutritional and energy needs of the permanent residents would correspond to a possible filling of the carrying capacity of the NP-EMATH area by 12%.

The five (5) scenarios that were developed and analyzed were selected in order to express in a comprehensible way the implications resulting from the variation of basic anthropogenic parameters in the Carrying Capacity - Ecological Footprint of the area. The scenarios in practice are hundreds, due to the number of elements that affect the results. The development and analysis of additional scenarios on the part of the Managing Authority can be possible by applying the control indicators.

Study Area2 -RILA National Park

Scenarios of category A: Scenarios prerequisites the consumption patterns to remain the same.

Scenario 1: Assuming that all sectors and consumption patterns remain stable. How much can the tourist population be increased in ordernot to exceed the maximum carrying capacity of the area?

The Carrying Capacity remains stable (84,27% or 260,447) for the same number of residents (69589), as the consumption patterns remain the same. If the rest of the sectors remain stable, the tourist population of RILA National Park can reach up to 43,256equivalent person or 554,506 visitors (372,118 adults and 182,389 minors) in order not to exceed the carrying capacity of the area. In other words, tourism can be increased approximately tenfold.

Scenario 2:Assuming that all sectors and consumption patterns remain stable. How much can the permanent residents population be increased in order not to exceed the carrying capacity of the area?

The Carrying Capacity remains stable 260,447 equivalent persons. The permanent residents of the area, given the non-change in other sectors, can be increased by 37% or 40,946 people (34,913 adults and 6,033 minors).

Scenario 3: Increase of the permanent residents population in the area by 5%. How much can the visitors population be increased in order to not exceed the carrying capacity of the area?

The Carrying Capacity increased in 261,439 equivalent persons. The permanent residents of the area, after the increase, amount to 73,068 permanent residents. If the rest of the sectors remain stable, the tourist population of RILA National Park can reach up to 40,381 equivalent person or 516,296 visitors (346,475 adults and 169,820 minors) in order not to exceed the carrying capacity of the area. In other words, tourism can be increased approximately tenfold.

Scenarios of category B

This category of scenarios is more realistic because of the capacity of the system that is under study. In this category, the impact of the increase or the reduction of the ecological footprint per capita, is studied which stems from a corresponding reduction or increase of the activities in focus, within the RILA National Park.

Scenario 4: Increase of the tourism sector's needs by 20%. How many equivalent residents can be accommodated in the study area without undergoing any irreversible environmental damage?

The changes that are observed in the calculations of this scenario are negligible, so it is assumed that the carrying capacity of the area remains unchanged.

Scenario 5: Increase of the permanent residents' needs by 20%. How many equivalent residents can be accommodated in the study area without undergoing any irreversible environmental damage?

The potential increase in residents' nutritional and energy needs of the residences by 20% would result in a no change in the carrying capacity while the equivalent persons that can be accommodated in the area are reduced to 209,767. This population consists of 69589 permanent residents and 29,612 visitors.

The five (5) scenarios that were developed and analyzed were selected in order to express in a comprehensible way the implications resulting from the variation of basic anthropogenic parameters in the Carrying Capacity - Ecological Footprint of the area. The scenarios in practice are hundreds, due to the number of elements that affect the results. The development and analysis of additional scenarios on the part of the Managing Authority can be possible by applying the control indicators.

Chapter 5 - Comparison with relevant frameworks – benchmark analysis

5.1 Frameworks for sustainability assessment

The way in which one perceives and determines the concept of sustainability and the timeframes it poses for controlling its achievement (with the expression of next generations, how many years are meant?) Significantly influence the way (Ness et al., 2007) and the expectations of the results of its valuation (Bond and Morrison-Sanders, 2011). Despite the differences between available definitions of viability (see Chapter 1), most of them agree that its assessment should be (Gasparatos et al., 2008):

- Incorporates economic, social and environmental issues and takes into account their interrelationships.
- Takes into account the consequences of current actions in the future.
- Understands the existence of uncertainties as to the impact assessment of current actions.
- Involve the general public.
- To include issues of fairness and impartiality.

A simple definition of sustainability assessment is "a process that drives decision-making towards sustainability" (Hacking and Guthrie, 2008). Devuyst et al. (2001) defined sustainability assessment as "a tool that helps decision-makers and policy makers to decide what action they should take or not in an effort to make society more sustainable." The assessment of viability is mostly developed as a decision-making tool (Pope et al., 2004), as can be seen from these definitions.

Sustainability assessment is a particularly complex process due to the wide range of issues and the complexity of the systems it involves. As Gasparatos et. al. (2008), "the sustainability assessment undertakes the difficult task of discovering, studying and proposing solutions for a large and heterogeneous set of issues that concern the individual concerned and extending to different spatial and temporal scales." Moreover, the assessment of sustainability is not limited to assessing the current situation but also to progress towards sustainability and promoting the desired behavior (Becker, 2004).

The sustainability assessment theory as expressed in the literature has basically evolved from environmental impact assessment, while sustainability assessment is very often seen as the "new generation" of environmental assessment (Pope et al., 2004) . According to Pope et al. (2004), there are two different theories of sustainability assessment. In the first case, the evaluator is guided by the environmental impact assessment, while in the latter case by a specific objective.

The assessment based on the environmental impact assessment attempts to assess whether the environmental, social and economic impacts of a project are acceptable under certain basic conditions. In this context, and in particular in the case of a technical system, it is quite likely that performance in one of the three aspects of sustainability (eg negative impact on the environment) is likely to outweigh if performance in the other two aspects is particularly positive (eg a positive impact on society and the economy) and thus the final cumulative sustainability performance is positive. For this reason: a) the objectives of the sustainability assessment should not be confused with those of environmental impact assessment studies; and b) not to overburden the classical environmental tools through the widening of the valuation to include economic and social axes (Bond and Morrison-Sanders, 2011).

The assessment based on an objective objective assesses whether the implementation of a project will contribute to this objective. Using this approach is more likely to result in a positive sign for all three aspects of sustainability. However, special care should be taken not to confuse objective objectives related to planning processes (eg labor supply, transport) with the assessment of viability (each goal is not necessarily linked to sustainable development). Most definitions of sustainability assessment tend to approach sustainability from the point of view of "targeting towards a goal", ie the path to be followed in order to arrive at a desired situation. Equally important, however, is "distance from the specific target" (Pope et al., 2004).

Once sustainability has been set as the primary objective of modern society, and it concerns all the systems that are "active" on the planet, valuing whether we are moving towards sustainability (and how far we are away from it) is a matter of major importance . Therefore, "the number of methods of assessing viability is of the order of hundreds" (Poveda and Lipsett, 2011). However, this figure is significantly reduced if only the methods that can be used to assess viability at local, regional and national level are calculated.

The United Nations and national governments have been the driving forces behind the promotion of sustainable development and, consequently, most available sustainability assessment methods are targeted at national and local levels (Labuschagne et al., 2005).

The categorization of sustainability assessment methods is a particular challenge (Poveda and Lipsett, 2011). Several surveys are available, which have tried to categorize sustainability assessment methods. Ness et al. (2007) divided the methods into three broad categories: a) indicators and composite indices, which in turn are separated into integrated and non-integrated integers; b) the methods of the evaluation of which is aimed at the product produced; and (c) the integrated valuation methods aimed at evaluating policies and projects. Correspondingly, Poveda and Lipsett (2011) separated the methods of assessing viability into a) general, b) strategies and c) integrated. Following a different approach, Gasparatos (2010) divided the methods into two broad general categories: a) the reductionist and b) the non-reductionist.

The specific examples of research suggest that there is no commonly accepted way to separate the methods.

The above categories are quite general as they had to include methods that evaluate all aspects of sustainability at different levels (eg countries, regions, projects). Since this dissertation aims exclusively at the environmental sustainability of technical systems, the analysis could benefit from adopting a more environmentally-friendly approach and management of technical systems (compared to adopting one of the above categories). For this reason, the methods were divided into five (5) categories that emerged from the study of the reviews and individual articles of the international literature:

1. Individual (set of) indicators
2. Composite indicators
3. Material and energy flow analysis
    a. Material flow
    b. Energy flow
    c. Integrated
4. Life cycle Assessment
5. National Accounting for Sustainability

5.1.1 Individual (set of) indicators

This category includes methods that use individual individual indicators or sets of indicators to evaluate various aspects of environmental sustainability (OECD, 2009). Indicators are rapidly emerging decision-making tools on environmental, economic and social improvement issues (Singh et al., 2012). "The indicators derive from values (we measure that we are interested) and create values (we are interested in that we measure)" (Meadows, 1998). However, as already pointed out, it is important that sustainability indicators be used in such a way by the technical system managing authority to reflect their difference from environmental performance indicators (Wehrmeyer and Tyteca, 1998). The main differences of the sustainability indicators in relation to the environmental performance indicators are as follows:

- Sustainability indicators concern a broader framework for analyzing the impact of activities set up within the technical system. This has the effect of not only analyzing the factors that the controlling authority of the technical system can control or intervene.
- Sustainability indicators are also influenced by the general public, as opposed to environmental indicators, which are developed exclusively by experts.
- The target audience is far greater.
- The environmental improvement framework is much broader and generalized, with the result that more effort is required from the Managing Authority to achieve less clear targets.

The methods included in this category are mostly designed to assess all three aspects of sustainability including environmental sustainability. All in all, they are used in Europe at national and regional level to assess the viability of a particular technical system and compare it with other similar ones. In total, in the category of "individual indicators", five (5) valuation methods have been included and analyzed:

1. Sustainable Development Indicators (SDIs)
2. Environmental Pressure Indicators (ERIs)
3. UNCSD- 58
4. The Dashboard of Sustainability
5. European Common Indicators (ECIs)

5.1.2 Composite indicators

This category includes methods that compose a multitude of different indicators across one or more composite indicators by applying a specific methodology (OECD, 2009). The implementation of normalization, weighting, and aggregation are necessary to extract a final composite environmental sustainability index. Complex indicators are increasingly used to assess the viability of different systems (Gasparatos et al., 2008). Their key advantage is their ability to summarize highly complex concepts in comprehensive and comprehensible information, while providing an efficient way of communicating the results of the valuation to the general public. Most of the methods included in this category can assess both the environmental, economic and social aspects of sustainability. Altogether in the "composite indicators" category, three (3) valuation methods were included and analyzed:

1. Environmental Sustainability Index
2. Fossil Fuel Sustainability Index
3. Carrying Capacity

5.1.3 Material and Energy Flow Analysis

This category includes methods that assess environmental sustainability by quantifying the material and / or energy flows of the technical system under consideration. The methods were divided into three sub-categories: a) methods for analyzing the flow of materials; b) methods for analyzing energy flow; and c) methods for analyzing material and energy flows.

The methods of the first two categories are based on the analytical recording of the mass balance of materials and energy of a fully defined system (Brunner and Rechberger, 2004; Kowalski, 1998). The boundaries of the system are determined by the researcher and may vary from very general (country level) to very specific (city level).

The third category is a useful tool for analyzing material / energy and inventory flow for the system under consideration, while providing important information on the system's operation, thereby enhancing its understanding and supervision and better response to potential future problems (Bertram et al., 2009; Hendriks et al., 2000). In addition, it facilitates the calculation of indicators that are capable of indicating those activities that pose the highest risk to the environment (Eurostat, 2001; Hinterberg et al., 2003). Material and energy flow analysis is particularly useful for addressing environmental sustainability issues such as resource depletion, reducing excessive use of materials and energy, finding recycling opportunities, etc., and can be used to evaluate it (Huang et al. al., 2012). Altogether in the category "Material and energy flow analysis", eight (8) valuation methods were included and analyzed:

1. Material Flow
    - Material Flow Analysis
    - Substance Flow Analysis
    - Physical input-output tables
    - Ecological network analysis
    - Water Footprint
2. Energy Flow
    - Emergy
    - Extended Exergy Accounting
3. Integrated
    - Ecological Footprint

5.1.4 Life Cycle Assessment

This category includes methods that incorporate lifecycle philosophy into their development. Life Cycle Analysis (LCA) examines the overall environmental impact of a product, process or system, taking into account every step of its life - from the receipt of the raw materials to its manufacture, sale, use and final disposal / deposition into the environment. This is a wider approach to environmental management and decision support that aims to assess the impacts of energy use and materials processing including waste disposal on the environment and to assess the potential for environmental improvements combined with the rational use of raw materials and energy at each stage of a system's life cycle. Incorporating the LCA approach into sustainability assessment is necessary to produce reliable results (Finkbeiner et al., 2010). LCA reviews the environmental aspect of sustainability and follows specific implementation standards (ISO 14040). In the category "Life Cycle Assessment", two (2) assessment methods were included and analyzed:

1. Greenhouse Gas Inventory
2. Life Cycle Sustainability Analysis

5.1.5 National Accounting for Sustainability

This category includes methods that measure sustainability by adapting financial accounting practices to a wider set of key determinants of prosperity. Methods of this category go beyond the strict economic parameters of prosperity and evaluate the impact of environmental phenomena such as environmental degradation, sustainable use of resources and devaluation of physical capital to determine sustainability aspects. In their entirety, the methods of this category are applied at national level. In the category "national sustainability accounting", four (4) valuation methods were included and analyzed:

1. General Progress Indicator

2. Sustainable Economic Welfare
3. Sustainable National Income
4. Genuine Savings

In Table 5-1 there is a summary of the twenty-two (22) methods, which includes their basic characteristics.

Table 5-1: Brief description of methods by category.

	Method	Description
		1. Individual Indicators
1.1	Sustainable Development Indicators (SDIs)	The SDIs method is a pool of sustainable development indicators developed under the Driving Force-Pressure-State-Impact-Response (DPSIR) framework to support those who assess the effectiveness of policy towards sustainable development. The SDIs applied at local level (Crilly et al., 1999; Devuyst and Hens, 2000; Valentin and Spangenberg, 2000; McMahon, 2002; Eckerberg and Mineur, 2003; Holden, 2006; Scipioni et al. monitoring Local Agenda 21 (see LA 21). At regional level, fewer applications exist (Gahin et al., 2003, EC, 2004; Colho et al., 2006; Mickwitz et al., 2006; Wallis et al., 2007). The number of markers used each time by scholars varies (Mascarenhas et al., 2010).
1.2	Environmental Pressure Indicators (EPIs)	Environmental Pressure Indicators (EPIs) were developed by the Eurostat Statistical Office of the European Communities. EPIs consist of 60 indicators, six (6) for each of the ten policy fields under the Fifth Environmental Action Program (Lammers and Gilbert, 1999). The ten policy areas concern environmental pressures such as forest destruction, overfishing, tourist traffic and the landfill of waste. to assess and evaluate environmental sustainability. EPIs provide the ability to compare the current environmental conditions of EU Member States and assess trends in Member States as well as across the EU. Available data on EPIs reporting exist for 1999 and 2001 (European Commission and Eurostat, 1999, 2001).
1.3	United Nations Commission on Sustainable Development (UNCSD- 58)	All UNCSD-58 indicators are composed of fifty-eight (58) national indicators and are used by the United Nations Commission on Sustainable Development. This set of indicators was set up to monitor the course of the measures adopted in Rio de Janeiro for "wider and fuller social development". These indicators are related to four aspects of sustainability, economic, social, environmental and institutional (UNCSD, 2001). Available data on the UNCSD-58 reports are available for each Member State since 1994 (United Nations, 2002).
1.4	The Dashboard of Sustainability	The Dashboard of Sustainability (DS) method is a mathematical and graphical tool designed to integrate complex sustainability influences and support national decision-making by generating summary assessments. The tool

		evaluates indicators related to environmental protection, economic development and social promotion. The indicators are in line with the issues raised by Local Agenda 21, but they are not predetermined. Their design of indicators depends on the availability of the data. In order to adapt this tool locally, two changes to the basic methodology need to be made: measuring urban viability using ad hoc indicators and allowing benchmarking over time. Graphic and numerical results can help decision makers reach a plan for future sustainability, which will be understood and accepted by all stakeholders.
1.5	European Common Indicators (ECIs)	The ECIs method is an application of the SDIs method. The method was developed by the Ambiente Italia Institute (2003) for the European Commission and proposes ten (10) common (harmonized) indicators on local sustainability. The indicators have the same characteristics as SDIs.
		2. Composite Indicators
2.1	Environmental Sustainability Index (ESI)	The method was developed in 2001 under the auspices of the World Economic Forum (World Economic Forum) for 122 countries. ESI measures total progress towards environmental sustainability (WEF, 2001). ESI scores consist of a set of 22 sub-indices, each of which combines two to six variables. Overall, the method examines sixty-seven (67) variables to measure progress towards sustainability.
2.2	Fossil Fuel Sustainability Index (FFSI)	The method was developed to determine the most efficient management of fossil fuels for the energy system (Ediger et al., 2007). This study was conducted in sixty two (62) countries, taking into account the independence, lifespan and environmental constraints. Then, the results of these indicators are consolidated into an index for oil, gas and coal. For the development of the indicator, two approaches, equal weighting and analysis of key components were taken into account.
2.3	Carrying capacity (CC)	Carrying Capacity 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, definitions are found in the bibliography depending on the subject of the study. The more general definition given by Rees (1997) for the ecosystem's carrying capacity is "the maximum population of specific species that can be hosted by an environment without causing permanent damage to environmental productivity". The method measures markers and compares them with known limits. The indicators assess the pressures created by a population. The resulting conclusion concerns the ability to meet the needs of the particular population from the environment that hosts it.
		3. Material and Energy Flow Analysis
		3.1 Material Flow

3.1.1	Material Flow Analysis (MFA)	The MFA method is used to determine the balance of materials and energy of a system. This method is mostly applied at national level due to easy access to the required data and the existence of a methodological framework developed by Eurostat (2001). The tested system is analyzed by means of various indices that measure material flows in t and energy in joules. These indicators provide a global representation of anthropogenic ecological pressures as a positive correlation between material flows and environmental damage. MFA is a tool that evaluates the dematerialization of an economy (which allows the decoupling of social and economic prosperity from raw materials) and thus its evolution towards sustainability (Bringezu, 1997).
3.1.2	Substance Flow Analysis (SFA)	The SFA method (Bruner, 2012; Huang et al., 2012) aims at controlling the flow of substances (chemical elements and / or compounds) that have significant levels of concern regarding their impact on ecological and human health in their production and use . The method consists of the following basic steps: a) definition of the objectives and choice of appropriate control indicators; b) definition of the system under consideration; c) identification of the relevant flows and processes; d) mass balance; (f) presentation and analysis of the results. SFA can be used to evaluate important environmental sustainability parameters by quantifying flows of substances that affect the environmental performance of the system under consideration (Huang et al., 2012).
3.1.3	Physical input-output tables (PIOT)	The method studies the direct and indirect physical flows of a system, applying the principle of maintaining the mass. PIOT treats the environment as a source of raw materials and recipient of the residuals of the productive processes of an economy (Giljum and Hubacek, 2009). The results of the method are summarized (the sum of all materials), leading to the limited applicability of the method and the difficulty of separating materials with different environmental impacts (Hoekstra and van den Bergh, 2006). To improve this problem, it has been proposed to group materials into sub-categories such as biomass, fossil fuels and minerals (Eurostat, 2001).
3.1.4	Ecological network analysis (ENA)	The method is an application of input and output tables. An ENA is based on modeling a system that allows the connection between material flows and the structure of an ecosystem (Fath and Patten, 1999). The method is widely applied to natural ecosystems and rarely to social, and involves two steps: system modeling and analysis (Zhang et al., 2010).
3.1.5	Water Footprint (WF)	The WF method (Hoekstra et al., 2009) is based on the calculation of "the total volume of fresh water required to meet the immediate and / or indirect needs of the system under consideration". WF is usually comprised of three

		components (Hoekstra et al., 2011): a) Blue WF refers to the volume of surface and groundwater consumed, mainly by evaporation, in the production of a product or service; b) Green WF refers to the volume of water consumed by atmospheric precipitations (mainly rainwater) and c) Gray WF refers to the volume of water required to reduce the concentration of pollutants and to restore the quality of the water system to the desired levels.
	3.2 Energy Flow	
3.2.1	Emergy Analysis (EA)	The EA method (Brown and Ugliati, 2004) is used to calculate "the energy of a type that is transformed directly and indirectly to obtain a product or service." The energy required is expressed as the sum of the individual types of actions, expressed as a final form energy, usually solar energy (expressed in emjoules). For its calculation, it is necessary to know specific solar transform coefficients. The EA method is usually confused with the analysis of the energy input (EE) of a system that essentially consists exclusively of the thermal energy of the fuels required for system operation (Brown and Herendeen, 1996). In most cases it is followed by the calculation of relevant composite indicators (eg Environmental Loading Ratio (ELR), Emergy Yield Ratio (EYR), Emergy Investment Ratio (EIR), etc.) for better understanding and longitudinal analysis of the results Geng et al., 2010).
3.2.2	Extended Exergy Accounting	The EXA method (Rosen and Dincer, 2001) is based on the "calculation of the maximum equivalent mechanical work that can be extracted from a system when it tends to a thermodynamic equilibrium state based on a reference system". In other words, CSR is a measure of the thermodynamic "quality" contained in an energy carrier (Hammond, 2007). The application of the method allows for the finding and evaluation of flows that contain activity (and thus can be exploited further) or where it is completely lost (and therefore needs to be further analyzed) (Apaiah et al., 2006). The application of the method requires the definition of a reference system.
	3.3 Integrated	
3.3	Ecological Footprint (EF)	The ecological footprint (Wackernagel and Rees, 1996) expresses "the theoretical area (in global hectares) used by man-made technical systems to produce the resources to consume and to absorb waste generated (including CO2 emissions from energy consumption) "(Wackernagel et al., 1999). More specifically, the ecological footprint measures the amount of natural resources consumed by a person, a society or a country at a given time. The ecological footprint is calculated by adding the footprint of all inhabitants (Kitzes and Wackernagel, 2009) and converting them into corresponding equivalent hectares using conversion factors (Monfreda et al., 2004). Environmental sustainability is assessed by comparing the ecological

		footprint with bioactivity (the area that is ecologically productive in the study area). If the ecological footprint is less than bioactivity then the system is viable and can export its difference in the form of products or services (Stoeglehner and Narodoslawsky, 2008). Related Approaches: Eco-Index Methodology (Chambers et al., 2000), Sustainable Process Index (Kettl et al., 2011a), Energy Footprint (Global Footprint Network, 2009)
		4. Life Cycle Assesment
4.1	Greenhouse Gas Inventory	According to the IPCC (1996) guidelines, the parameters monitored to calculate the net emissions of anthropogenic activities are fuel use, uncontrolled fuel emissions, industrial processes, solvents, agricultural practices and waste management and disposal. The method is an accounting system that presents as a main result the comparison between CO2 equivalents and the absorption capacity of the ecosystems of a particular region. Greenhouse Gas Inventory - is in a position to introduce the problem of responsibility for anthropogenic greenhouse gas emissions (Bastianoni et al., 2004). The method was applied in a province of Italy to highlight the role of physical capital in the sustainability of the population in a given economic, industrial and urban infrastructure (Pulselli et al., 2008).
4.2	Life Cycle Sustainability Analysis (LCSA)	The overall Life Cycle Assessment (LCA) method is mostly applied to assess and evaluate product viability. However, Guinée et al., 2011 proposed a framework for future developments in LCA, the so-called Life Cycle Sustainability Analysis (LCSA). The framework consists, among other things, of broadening the purpose of product-related analysis to economic issues, including an intermediate level such as that of a municipality or a region. However, few examples of using the LCA method, either as such or in combination with other methods, exist in the regional literature (Loiseau et al., 2012).
		5. National Accounting for Sustainability
5.1	Genuine Progress Indicator (GPI)	The method was developed by the non-profit organization Redefining Progress in the mid-1990s (Cobb et al., 1995), linking the economic, social and environmental aspect of sustainability. GPI adapts national accounting practices to include a wider set of welfare factors, including reductions for military spending, environmental degradation and devaluation of physical capital. Method calculations have been applied in a number of countries.
5.2	Index of Sustainable Economic Welfare (ISEW)	The composite ISEW indicator was proposed by Daly and Cobb in 1989 and provides a deeper representation of the well-being of a society than GDP, since its definition also includes variables not included in conventional national accounting (such as social and environmental issues). Recently, there has been a growing interest in calculating this index and locally (Chelli et al.,

		2013). ISEW is defined as follows: ISEW = personal consumption + public non-defense spending - private defense expenditure + capital formation + domestic labor services; environmental degradation costs; devaluation of physical capital (Daly and Cobb, 1989).
5.3	Sustainable National Income (SNI)	The method was developed in the Netherlands (Huenting et al., 1993). The tool attempts to overcome rigorous economic parameters to determine prosperity by incorporating sustainable resource utilization measurements into national income calculations. The method does not directly involve social parameters. The result of the method is a composite indicator, which is derived from a comparison of national income that is estimated to be sustainable with conventional national income. The difference in these figures describes the country's dependence on the use of natural resources, which goes beyond sustainable use (Gerlagh et al., 2002).
5.4	Genuine Savings (GS)	The method was developed by Pearce and Atkinson in 1993 and identifies the viability of a national economy (Hamilton et al., 1997) based on Hicksian Income (Bohringer and Jochem, 2007). This indicator is more relevant to the World Bank (World Bank). The method calculates net changes across the range of assets that are important for growth: assets produced, natural resources, environmental quality, human resources and foreign assets (Singh et al., 2012). The Adjusted Net Savings index includes depletion of resources and degradation of the environment. In addition, it has expanded on technological change, human resources, exhaustible resource exports, resource discovery, and critical physical capital. More emphasis is placed on the economic and environmental component, but the tool also includes investment in education. The positive index value reflects a positive transition towards sustainability, while a negative value represents the opposite. The advantage of the method is the clear message that a country can take regarding its progress toward growth (Everett and Wilks, 1999).

Chapter 6 - Conclusions

The implementation of the methodological framework in two intervention areas is hard and extensive task because the project area combine two territories in Greece and Bulgaria with different natural and anthropogenic features and also with differnet level of natural protection. The implementation of the methodological frame work in project area 2 is even more complicated because it is composed of two parts with different anthropogenic loads. That part of the study area that is situated in Rila Natational Park possess high bio-capacity, but due to the It's high protection status the used of this territory for economical purposes opposite to the NP-EMATH is very limited and there are not permanent residents inside the park.

Over the past century, atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and hydrogenated hydrocarbons, i.e. greenhouse gases, have increased as a consequence of human activity. Greenhouse gases prevent the radiation of heat back to space and cause warming of the climate. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (AR4) (IPCC 2007)1, the atmospheric concentrations of CO_2 have increased by 35%, CH_4 concentrations have more than doubled and N_2O concentration has risen by 18%, compared with the pre-industrial era. Changing climate has effects on both human and natural systems (e.g. human settlements, human health, water and food resources, ecosystem and biodiversity). Some of the effects on environmental and socio-economic systems will be beneficial, some damaging. The larger changes and the rate of changes in climate, the more adverse effects will predominate. In the examine area IN Bulgaria the adverse impacts are related, for example, the winter tourism, increased floodings and droughts and the prevalence of pests and diseases. Positive impacts could be possible growth of productivity in agriculture and forestry and decreased need for heating energy. According to the "Fifth National Communication of Bulgaria on Climate Change"2 from the year 2010 the average temperature in the country could rise. Extreme weather events, such as storms, droughts and heavy rains, are likely to increase. According to the HadCM33 model significant summer warming in the Western Balkan countries were projected for 2080. Air temperatures during this time of the year are expected to increase between 5°C and 8°C over most of the countries in the peninsula. Summer precipitation is projected to decrease in the region. Acknowledging the importance of the climate change issue is the reason for building of GHG inventories for local governments. The results from the Questionnaires and analyses of the data collected have shown the low level of information that the local governments possess about the sources of GHG emitents.

According the results of this research the total carbon foot print of the project territories are **560 783,93 tCO_2e**. The carbon footprint of the project area 2 (PA2) are **335 418 tCO_2e** which is more than the carbon footprint od the project area 1 (PA1) – **2225 365,93 tCO_2e**. This imbalance in the carbon foot print results is due the larger number of the permanent leaving population in the Project area 2 and especially in the catchment area of Blagoevgradska Bistrica River. In the two project area the biggest source of carbon footprint is the electricity concumption with total emissions of **249 545,08 tCO_2**. Again the carbon foot print of PA1 is biggier (174 709.08 tCO2e) than the one of the PA2 (74 836). The second biggest source of GHG according this research are the emissions from road traffic which are **131 470tCO2.** The same as in the electricity consumption carbon footprint the internal structure of the road traffic carbon foot print is imbalanced because the one of the PA2 (72 670 tCO2) is bigger than the one of PA1 (58 800 tCO2e). One of the main reason for this imbalance is the present of more roads with international importance (E79) in PA2. Also substantial quantities of GHG are emitted by using carbon fuels for heating which produce **110 138 tCO2e** . In the project area 2 great source of GHG and their equivalent in CO2e is the solid waste disposal **28 476 CO2e** t/year and the domestic wastewater handling which is also a great source of GHG with the total emissions from wastewater in the project area 2 equals 9501 CO2e t/year. The sector of agriculture is also a contribute to the GHG emissions in PA 2 mainly due to entheric fermentation of the live stock. The Entheric emissions of CH4 for 2016 are **6149,64 t** CO2e/year. The main problem that was accounted during the implementation of the methodological frame work and the estimation of the Carboonfoot print was the absence of database about the electricity consumption and used fuel in the local communities, this data have been collected from local utilities providers. The data about the electricity consumption and the used fuels are associated only with the activities of the local authorities in the proeject area 2 are also represented in this study but they have relatively small impact on the amount of the carbon foot print.

Usually worldwide the sectors of electricity consumption's and road traffic are the biggest source of GHG, which turn out to be exactly the case in this research. Although the higher carbon foot print in project area 2 due to the local natural-geographic features, like predominantly mountainous terrain the last one possess relatively good developed absorption capacity which is result of the broad area covered by forests. The total area cover with forest in the area of interest are **26 977,1** ha. and these forest areas posses huge absorption capacity of **56 756, 23** T. CO2/year. Beside the great absorption capacity additional policy measures are highly needed to reduce the Carbon foot print in the project area especially on the territory of Blagoevgradska Bistritza River catchment area. The absorbtion capacity of Project area 1 is relatively small mainly due the smaller size of the areas cover by forests. The carbon footprint of Rila National Park opposite to the footprints of the NP-EMATH is close to zero deu to high level of protection of its territories that regards all industrial activities as illigal in the national park. Also the lack of permennet rezidents inside the Park Terrritory hleps to keep the carbon footprint close to zero.

Total Water Footprint for NP-EMATH, has been calculated equal to **$5{,}40\times10^{8}$ m^3/yr or 18.825 m^3/yr/rcapita**. Agriculture contributes with 99,4% to Total Water Footprint, while industry contributes with 0,2% and household with 0,4%. This is a reasonable result, as agriculture remains the most important economic activity in the area, while industry is limited. In the project area 2 the total water footprint is **249 685 329,1 m^3/yr.** Because the town of Blagoevgrad with population of 70 880 is situated in Blagoevgradska Bistritza Catchment area the last posses high water foot print of **244 659 480 m^3/yr** Also, substantial amounts of water are extracted from the catchment area for drinking, irrigation and other community services.

The water footprint of Rila National Park is **5 025 849,1** M^{3}, which is less than the footprint of Blagoevgradska Bistritza River catchment area due to the lack of permanent population and the small number of tourists that are accommodated in the park for more than one day. We have to take in the consideration that substantial amount of the water resources of the park are devoted for the local communities around the park territory.

The total ecological footprint of NP-EMATH was estimated to **181,324 Gha** as an absolute value, or **6.19 Gha per inhabitant.** The Bio-capacity of NP-EMATH rose to **187,528 Gha**. This result indicates the capacity of the area to cover its current consumer needs of its inhabitants. The total ecological foot print of project area 2 is **148 183.33 Gha,** but there is a huge imbalance in the internal structure of the EF because the main contributor is the catchement area of Blagoevgradska Bistritza River. The Ecological footprint of the Rila National Park is relatively small only **15503 Gha.** The total Bio-capacity of the project area 2 is **181 658,95 Gha.**

According to the results of the implementation of the methodological framework for the assessment of the carrying capacity developed by the project team, this indicator for project area 1 was estimated at **38,224** equivalent persons. This figure means **30,278** permanent residents (of which 24,045 adults and 6,233 minors) and 26,127 visitors (of which 19,595 adults and 6,532 minors). In other words, the Carrying Capacity of the protected area of NP-EMATH at that time (reference year 2013) is covered at **97%.**

When feeding combined data into the Methodology (for the whole Study Area 2 including the lands within the National Park and those from Blagoevgradska Bistritsa catchment area outside it), the result for the carrying capacity for project area 2 becomes **84.28%.** If interpreted on its own, it shows that the carrying capacity for the territory is quite high in consuming (thanks no doubt to the city of Blagoevgrad) but still not exhausted (thanks to the protected area of the National Park and its regimes and norms for anthropogenic activities).

Although the values of carring capacity in the both project areas are less than 100 % further political, social and economic measures have to be implementated in order to improved the carbon, water and ecological footprint of the project territory. This measures have to be extracted from modern methodologies as a Life-Cycle Assessment (LCA). This is the proper methodology for investigating the life-cycle impacts of industrial processes and will help to the local authorities to reach an environmental performance optimization. Such methodology provides a framework for estimating the environmental impact of products or processes from cradle to grave, that is, from raw material extraction and processing through manufacturing, distribution, retail, consumption, and product disposal which will help to be improved the footprints of the project areas. Further more using the LCA assessment methodology allows the management of protected areas to have a complex information about the use of various resources in their territorial scope. That information can be processed consistently toward the general optimization of the management of the protected territories. This also align with the policy of the European Commission that the best way to demonstrate the efficacy of the LCA approach is to apply it to various practical applications (European Commission 2003) in order to reach the ultimate goal: **SUSTAINABILITY**.

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ANNEX A - Capitalization of the results

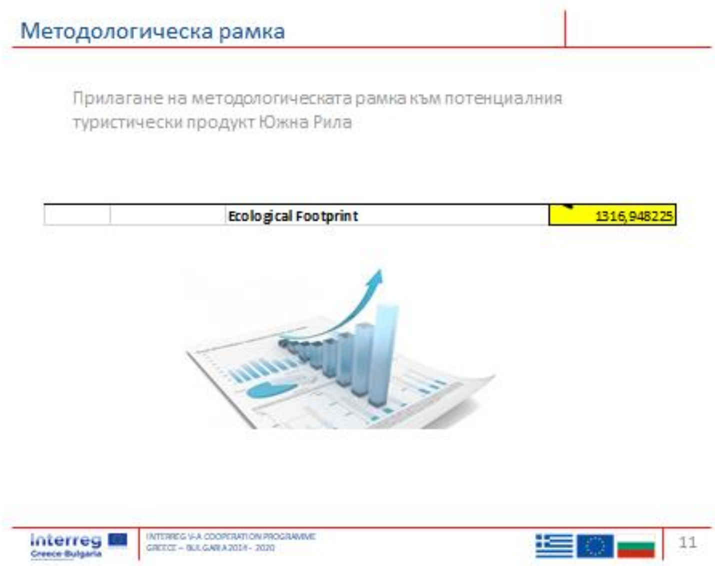
Regarding to implementation of WP.3/ D3.7.3 "Organization of two information meetings to present the results of the implementation of a methodological framework against to the potential tourism product "Destination South Rila" featuring a total of 30 participant with organized transport and catering" were held two information meetings.

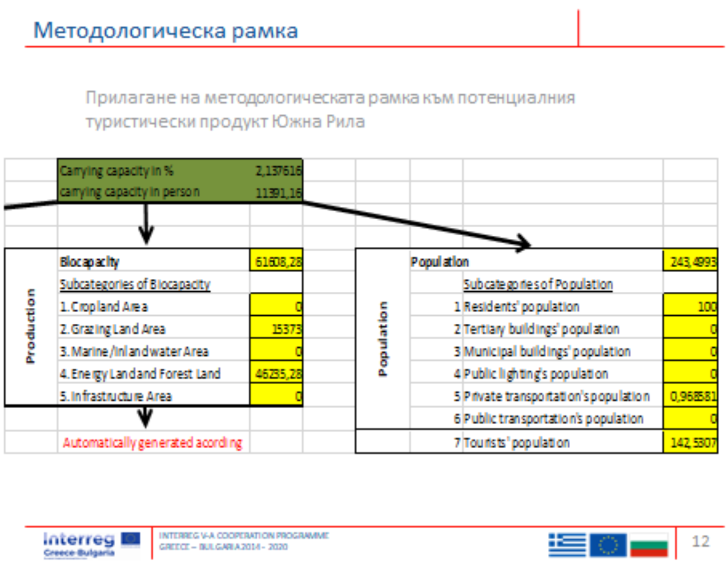
The first meeting was held in Bodrost locality, Blagoevgrad Municipality on 17th August 2018. To about 20 representatives of various public organizations and local businesses took part in the meeting. The program includes two presentations were presented to the participants. The first presentation on the topic: Potential tourism product "South Rila" - heterogeneous, complex, unique and changing ". Questions were discussed on the policies of the state institutions for the development of the individual regions and in particular on the "South Rila" potential tourist product.

The second presentation with topic „Presentation of the results from the implementation of the Methodological Framework to the potential tourist product "Destination South Rila" gave rise to a great interest among the participants.

Analysis and evaluation of the overall environmental performance (capacity, carbon and water footprint, climate change, eutrophication, ecotoxicity and acidification of soils, landuse and so on) as a comparison between two different areas of South Rila and Dupnitsa Park Section was submitted to the meeting.

Biocapacity	61608,28
Subcategories	Values in ha
Cropland Area	0
Grazing Land Area	15373
Marine/Inland water Area	0
Energy Land and Forest Land	25404
Infrastructure Area	0



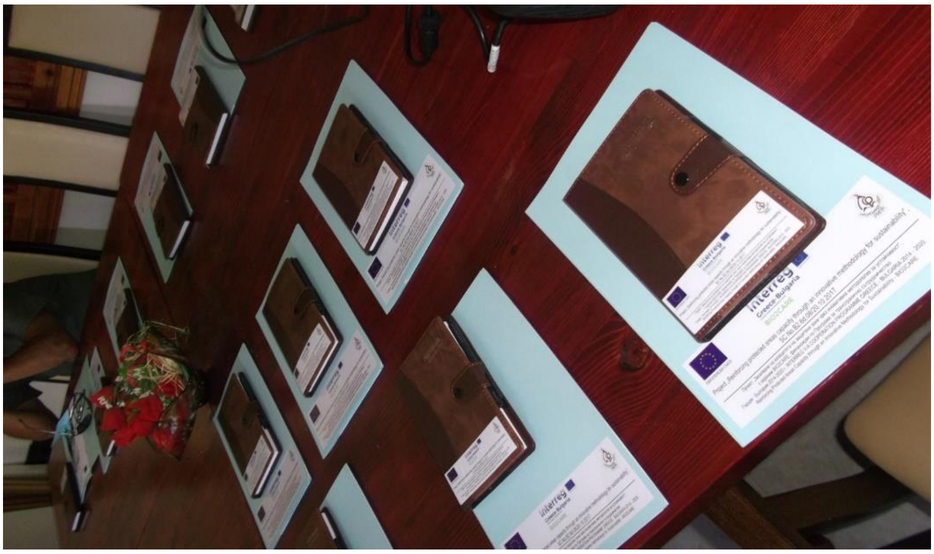


The participants in the information meeting received promotional materials containing the name of the project / English / Bulgarian /, the logos of the Project and the logo of the Rila National Park. The advertisements package includes cardboard folders format A 4/15 pcs./, advertising notebook / 15pcs./, chemical / 15 pcs./ and flaers in format 1/3 of A 4 - color, two-sided.

The second information meeting was held in Yakoruda municipality, Treshtenik locality on the 24th August 2018. To about 18 representatives of various public organizations and local businesses took part in the meeting.

The second presentation with topic „Presentation of the results from the implementation of the Methodological Framework to the potential tourist product "Destination South Rila" gave rise to a great interest among the participants.

Analysis and evaluation of the overall environmental performance (capacity, carbon and water footprint, climate change, eutrophication, ecotoxicity and acidification of soils, landuse and so on) as a comparison between two different areas of South Rila and Dupnitsa Park Section was submitted to the meeting. Participants also received promotional material on the project.



The territory of South Rila with its area and low anthropogenic load provides numerous opportunities for development of a sustainable tourist product. Due to the fact that in practice this part of Rila National Park is little known planning and development of potential tourism product "South Rila" can be placed on scientific and methodological foundations associated with determining the carrying capacity in South Rila. Applying this methodological framework would allow the desired sustainability of this potential tourism product to achieve a balance between the use of the economic and recreational resources of Southern Rila on the one hand and the conservation of natural ecosystems.

The application of the methodological framework to that part of the territory of South Rila, which is part of the National Park, showed that it was loaded with only 2.13% of its peak capacity. Also, the proposed methodology demonstrates that this territory has a huge bio-capacity equivalent to 61,608.21 global hectares and, at the same time, a very low environmental footprint, 1316 global hectares. These values of ecological footprint and biological capacity are the result of the low anthropogenic pressure and tourist popularity of the South Rila. This is well illustrated if the bio-capacity and ecological footprint of the South Rila and those of the Dupnitsa Park Section are compared. The latter, although having a bio-capacity equivalent to 13199 Gha , i. E. almost five times smaller than that of South Rila, the ecological footprint due to the increased tourist pressure equals 2940 global hectares, which is close to 1.5 more than the equivalent values for South Rila.

The increased value of the ecological footprint on the territory of the Dupnitsa Park Section is due to the high number of tourist visits around 49 000, which are the result of the good transport infrastructure (chair lift to the Seven Rila Lakes) and the presence of some of the most attractive and popular destinations for hiking. The increased human pressure is reflected in the calculation of the carrying capacity of the territory of the Dupnitsa Park Section as methodological framework indicates that the territory of the latter is charged with 22% of poems and ability.

Based on data released well illustrated not even utilization of natural resources and the distribution of anthropogenic pressure in different parts of the Rila National Park, which is well located otrazhennie and in varying degrees of utilization Taking their ability - 22% of Dupnitsa Park Section and 2,13% for the territory of South Rila.

In order to increase the efficiency of the use of the natural and recreational resources within Rila National Park without any negative impact on biodiversity conservation, it is necessary to promote and develop such regional tourism products as "the potential tourist product South Rila "The high bio-capacity that owns the territory of South Rila with an insignificant ecological footprint is a prerequisite for the successful development of the territory of the South Rila as an integrated tourist product.

Implementation of the Methodological framework within a potential tourist product "Destination South RILA"

Introduction

The Tourist industry is a complex sector that can influence the economic development of defined regions and even countries. The tourist industry in Bulgaria and especially in SW Bulgaria despite the fact that it is a source of numerous problems associated with the environmental preservation is a one of the main economic drivers behind the social and economic development of the region.

One of the main centers of the tourist industry in South-West Bulgaria is Rila National park. It is situated in the southwest part of the country, in Rila Mountain. The park has a total area of 81,046 hectares and is the largest of the three national parks in Bulgaria as well as one of the largest in Europe. The park managers aim to preserve and maintain the biological diversity, to protect the wild nature and provide opportunities for scientific and educational activities, development of tourism and ecological way of the population' slife. There are more than 100 peaks on the territory of the park, with an attitude of over 2000 meters; the highest peak in the country and on the Balkan Peninsula is among them - the Musala peak (2,925 meters high).

There are more than 120 permanent and 30 temporary glacial lakes in the high parts of Rila. The spring of some of the deepest and longest rivers on the Balkan Peninsula are here – Iskar, Maritsa and Mesta. The water supplies, which form within the boundaries of National Park Rila are the most important resources of pure drinking water for the nearby municipalities.

The park territory is covered by forest ecosystems such as spruce (Picea), fir (Abies), white pine (Pinus peuce) and dwarf pine (Pinus mugo). About 95% are natural, with an average age of 90years. The biodiversity of the park is extremely diverse. There are about 1,400 vascular plants, 105 relict and 57 endemic plant species, such as Rila primrose (Primula deorum), Pawlowski lady's mantle (Alchemilla pawlowskii) and Ornamental rhubarb (Rheum palmatum L.). The park is home to 282 moss species, 130 algaespeciesand233fungispecies. The mountain fauna is presented by 172 vertebrate species, 5 of which are fishes, 20 are reptiles and amphibians, 99 are birds and the mammals are 48. Here lives the largest chamois population in Bulgaria, the largest alpine European ground squirrel population, one of the four alpine newt populations and one of the two Bulgarian nesting sites of the pygmy owl (Glaucidium passerinum). The invertebrate fauna is unique. 2,934 species have been discovered up until the present moment.

Rila is one of the mountains, where tourism is well developed. The park offers a special zone, called Intensive Tourism Zone, which includes a network of paths and shelters, as well as accommodation options in the facilities, located in the park. There is a wide range of activities for tourists – horse riding, cycling, skiing on specified routes, camping, mountaineering, etc.

Two major European tourist routes pass through the area – E4 and E8. 17 tourist huts with about 1,500 beds were built on the park territory. Beside the vast territory and the great tourist potential that Rila National Park possess, the tourist visits inside the park are not even distributed on its territory. The most popular and exposed to tourist activities are the central and the North-West parts of the park as the area around the seven rila lakes is the most visited area inside the park with more than 40000 visits per year. Opposite to the Seven Rila lakes the South Rila Fig. 1, even though its vast territory is not a popular tourist destination. This imbalance in the used of the territory of the Rila National Park for tourist purposes is a great concern for the management body of the Park. Because of that the Park administration loud like to promote a South Rila as separate tourist product in order: first to limited the number of the visits around Seven Rila Lakes and second to improved the efficiency and to achieved more sustainable development of the tourist sector in Rila National Park.

One of the suitable methodology for sustainability that can be used to determine the maximum tourist potential of the South-Rila is the methodology for estimation of the Carrying capacity of this part of Rila National Park. To determine the carring capacity is used a energy driven approach, Or in other words how much energy in Gha this territiry can produce and how much energy can be consumed from the future tourists in that specific part of the park.

Fig.1. South Rila

CARRING CAPACITY ESTIMATION OF THE POTENTIAL TOURIST PRODUCT SOUTH RILA

The methodological approach for development of sustainable tourist product in South Rila includes the estimation of the Carring Capacity of the last, through new approach that combine the data from the holistic indicators for environmental sustainability as Carbon footprint, Water Footprint and Ecological Footrpint. In the proposed methodological approach the carring capacity is present as a ratio between the biocapacity of that territory measured in Gha and the Ecological Footprint which again is measured in Gha. The Ecological Footprint has been determined with a consumed based approach or with other words the Ecological Footprint is equal to the energy needed to produce all the goods that are consumed inside this territory of the Park. In this consumed based approach the Ecological Footprint is a directly connected with the number of the permanent residents or with the number of the tourist inside the park and actually when carring capacity is determine we can define that number of tourist that this territory can sustain.

Biocapacity of the South Rila

Because the bio capacity is a function of the energy that is produced from the main types of land cover a classification of these types is the first stage of bio capacity estimation. The main types of land cover for this specific methodology are: crop lands, Grazing lands, forest and energy lands and infrastructure lands. Majority of the South Rila territories are covered with forest (25 404 ha) and semi forest and gras lands (15373). Because of that the territory of South Rila possess a high bio capacity. This Bio capacity is equal to 61 608 Gha Table 1.

Table 1. Biocapacity of South Rila

Biocapacity	61608,28	
Subcategories	**Values in ha**	**Global Equivalent Factor (EqF)**
Cropland Area	0	2,2
Grazing Land Area	15373	0,5
Marine/Inland water Area	0	0,4
Energy Land and Forest Land	25404	1,4
Infrastructure Area	0	2,2

Yield Factor	**Values in Gha**
1,5	0
2	15373
0,8	0
1,3	46235,28
1,5	0

Ecological Footprint of South Rila

The ecological footprint is a logical function of the number of the population and the tourist and the consumed energy and goods. There are no permanent living population on the territory of South Rila, because of that only the number of tourist have to be considered in the process of ecological footprint estimation. The consumed good and energy per tourist are represent as a average values extracted from the European statistical service. After that they are multiply by the number of the tourist per year and transformed in Gha/t/y. The Ecological footprint of South Rila is 654,94 Gha.

Table 2. Ecological footprint of South Rila

7. Tourism					654,9466536
	Indicator code	Description	value	Gha/t/y	Gha
1. Agricultural products	Indicator EF1.1.7	Bread Consumption in t per year	8,064	0,307600	2,4804864
	Indicator EF1.2.7	Potatoes Consumption in t per year	15,372	0,096000	1,475712
	Indicator EF1.3.7	Sugar Consumption in t per year	1,008	0,335500	0,338184
	Indicator EF1.4.7	Cereals Consumption in t per year	4,032	0,667000	2,689344
	Indicator EF1.5.7	Flour Consumption in t per year	2,268	0,423000	0,959364
	Indicator EF1.7.7	Legumes Consumption in t per year	13,608	0,681300	9,2711304
	Indicator EF1.8.7	Fruits and Vegetables Consumption in t per year	135,828	0,743000	100,920204
	Indicator EF1.9.7	Beverage Consumption in t per year	45,108	2,110000	95,17788
	Indicator EF1.10.7	Tobacco Consumption in t per year	0,1044	1,140000	0,119016
	Indicator EF1.11.7	Rice consumption in t per year	25,2	0,573600	14,45472
	Indicator EF1.12.7	Vegetable oils Consumption in t per year	3,276	2,592000	8,491392
	Indicator code	Description	value	Gha/t/y	Gha
2 Livestock products	Indicator EF2.1.7	Pork meat Consumption in t per year	11,088	1,380000	15,30144
	Indicator EF2.2.7	Beef meat Consumption in t per year	10,332	14,650000	151,3638
	Indicator EF2.3.7	Sausages Consumption in t per year	5,04	1,380000	6,9552
	Indicator EF2.4.7	Chicken Consumption in t per year	8,064	0,690000	5,56416
	Indicator EF2.5.7	Egg Consumption in t per year	6,552	0,513000	3,361176
	Indicator EF2.6.7	Milk Consumption in t per year	81,9	0,185500	15,19245
	Indicator EF2.7.7	Cheese Consumption in t per year	5,04	0,151000	0,76104
	Indicator EF2.8.7	Butter Consumption in t per year	1,764	0,011700	0,0206388
	Indicator code	Description	value	Gha/t/y	Gha
3 Fishery & Aquaculture products	Indicator EF3.1.7	Fish Consumption in t per year	11,34	1,280000	14,5152
	Indicator EF3.2.7	Seafood Consumption in t per year	18,396	0,021400	0,3936744
	Indicator code	Description	value	Gha/t/y	Gha
5. CO2 emissions	Indicator EF5.1.7	Electricity Consumption in kWh per year	440640	0,000271	119,3870016
	Indicator EF5.2.7	Thermal Energy Consumption in kWh per year	922080	0,000093	85,75344

Carring capacity of South Rila

The carring capacity represent the connection or the ratio between the ecological footprint in Gha/t/y and the bio capacity of the research area. Because the ecological footprint, as it was stated before, has been connected with the number of the tourist, actually the carring capacity represent the number of people that this bio capacity can sustain for one year.

Due to the fact that South Rila is not a popular tourist destination and there is no permanent living population inside the territory of South Rila the last is using only 2,13 % of its carring capacity. In number of people it can sustain the energy that is needed (ecological footprint) for 11 391 permanently living people for one year.

Table 3. Carring capacity of South Rila

Production	**Biocapacity**	61608,28
	Subcategories of Biocapacity	
	1. Cropland Area	0
	2. Grazing Land Area	15373
	3. Marine/Inland water Area	0
	4. Energy Land and Forest Land	46235,28
	5. Infrastructure Area	0

Population	**Population**		243,4993
		Subcategories of Population	
	1	Residents' population	100
	2	Tertiary buildings' population	0
	3	Municipal buildings' population	0
	4	Public lighting's population	0
	5	Private transportation's population	0,968581
	6	Public transportation's population	0
	7	Tourists' population	142,5307

Ecological Footprint	1316,948225

Carrying capacity in %	2,137616
carrying capacity in person	11391,16

Conclusions

Because the territory of South Rila has very small anthropogenic load which has been distributed on a relatively large area this part of Rila National Park possess all the preconditions to become a popular tourist destination with well developed and sustain tourism industry. The development of this future tourist destination can be put on solid scientific and methodological foundations. One of the pillars of this methodological approach can be the estimation of the carring capacity of the South Rila. If the carring capacity is determined along with the planning and the development of the potential tourist product this will improved the final product and a balance between the economic use of the natural resources and the environmental protection can be biuld.

South Rila posses a huge bio capacity (61608, 21 ha), but the methodological framework shows that only 2,13% of the carring capacity of that territory is used at the moment. It has to be taken in consideration that the value of the carring capacity is so small because the territory of South Rila, due to the high protection status possess very low ecological footprint – 1316 Gha. If we make a comparison between the values of the EF and the BC of the most popular tourist spot in Rila National Park which is the Seven Rila Lakes and South Rila, the first one possess an EF of 2940 Gha which is one and a half times more than the one of the South Rila. Farther more this EF is distributed on a smaller territory which also has a three times smaller Biocapacity. This imbalance comes from the better tourist infrastructure around the Seven Rila Lakes and the existence of a tourist lift which allows more than 49 000 tourist/year to visit this area. The higher anthropogenic load in this part of Rila National Park is the reason behind the higher value of the carring capacity of this territory – 22%.

Based on this methodological approach a conclusion can be made that there is a huge imbalance in the distribution of the anthropogenic load along Rila National Park territory which very well can be demonstrate when a comperisson is made between the values of the carring capacity of the different parts of the National Park.

The higher Bio-capacity that the territory of South Rila possess is the needed precondition for development of successful and sustainable future tourist products. Because of that in order to improve the sustainable use of the natural resources in Rila National Park and to enhance the protection of the natural ecosystems the park administration should developed a regional tourist products and destinations such as "Potential tourist product South Rila".