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Examining the potential carbon footprint reduction by implementing circular economy practices in a protected area with anthropogenic activities

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Abstract

Protected areas play a crucial role for biodiversity preservation and ecosystem health. These areas have wide socioeconomic and cultural value due to their importance on said biodiversity conservation, as well as on people's livelihood, and nowadays, in helping mitigate and adapt to climate change. These values are often undermined due to extensive anthropogenic activities within the boundaries of protected areas. Recent studies have shown that globally a large percentage of protected areas have been highly degraded due to the impacts of human activities.

European Union with the approved Cross Border Cooperation programmes and their targets, admits that protected areas in the European region are under pressure and under various threats by the constantly increasing anthropogenic activities within, or in close proximity to the boundaries of the protected areas. In full compliance with Interreg's Greece-Bulgaria 2014 - 2020 priority objective to enhance the effectiveness of biodiversity protection initiatives, the project "Reinforcing protected areas capacity through an innovative methodology for sustainability (BIO2CARE)" was developed. BIO2CARE project aims at reinforcing the administrative capacity and effectiveness of Protected Areas Management Bodies, in benefit of biodiversity and local communities, through the implementation of an innovative and integrated approach. Eight (8) partners participate in the project, with the Laboratory of Environmental Management and Industrial Ecology from Democritus University of Thrace being the leading partner. BIO2CARE with its output results aims to reinforce the efficiency and effectiveness of Protected Areas Management Bodies. The main outputs include a methodological framework of assessing the environmental performance of the area, a high-tech monitoring system to monitor and mitigate the illegal activities such as lodging, hunting, sand-removal, etc. taking place within the boundaries of the protected area, as well as the implementation of symbiotic activities in order to promote a circular economy strategy.

In this study, the area under examination is the National Park of Eastern Macedonia and Thrace (NP-EMATH) in NE Greece. 43 villages and close to 29,000 people are located within the boundaries of the National Park. Furthermore, numerous anthropogenic activities take place, mostly in the agricultural sector as agricultural production is the main economic activity. There is also industrial activity focusing on processing the agricultural goods produced in the area, as well as touristic activities. Finally, in close proximity, a heavy industrial zone is located in the western boundaries of the NP-EMATH. A potential approach for the mitigation of the environmental impacts deriving of those anthropogenic activities is the implementation of Industrial Symbiosis practices, as part a circular economy strategy in the area. Industrial symbiosis, as a tool of Industrial Ecology, focuses on the exchange of by-products, materials, energy, and water, in order to achieve positive economic, environmental, and social results.

This paper aims to:

a) assess and quantify the existing situation of carbon footprint deriving from the current anthropogenic activity within the boundaries of NP-EMATH by implementing the Life Cycle Assessment (LCA) method,
b) identify and propose the potential implementation of symbiotic activities, based on successful examples from the literature, and taking into consideration the particular needs and characteristics of the area, and
c) examine the potential carbon footprint reduction by the implementation of the identified and proposed symbiotic activities, comparing the existing situation with the proposed symbiotic scenario utilizing again the method of Life Cycle Assessment.

The results of the first LCA study regarding the existing situation showcased that the Carbon Footprint within the boundaries of the protected area is up to 221 kt of CO2 eq. The main activities contributing to the carbon footprint are the electricity and heating oil consumption. Regarding the symbiotic case study, through an extensive literature review, and considering the specific characteristics of the area, sixteen (16) potential symbiotic activities were identified. These activities include CO_2 capture from the nearby industrial zone and reuse for greenhouse enrichment, development of a local Biomass Power Plant utilizing the available amount of biomass in the area, reuse of industrial wastewater for district heating, as well as the development of an agricultural based symbiotic network. The proposed activities can lead to an estimated reduction of 4,320 tonnes CO_2 and 87,250 MWh of oil for heating. Utilizing these results, the second LCA was conducted comparing the carbon footprint of the symbiotic scenario with the existing situation. The implementation of the symbiotic activities could potentially lead to a reduction of up to 36,3 kt of CO2 eq, which is approximately a reduction of 16,5%. It should be noted however, that this result is under re-calculation in order to represent a more realistic approach. By capturing and reusing further amounts of CO_2 from the adjacent industrial zone, the reduction could increase even further. It is also notable, that the implementation of circular economy practices could lead to economic and social benefits, by creating new job opportunities, strengthening the current agricultural production, and promoting a healthier lifestyle for the residents within the area.

Overall, following a circular economy strategy by implementing Industrial Symbiosis practices in the area, could have a positive impact on preserving the biodiversity and natural ecosystem of the protected area, while mitigating the environmental footprint from anthropogenic activities, and promoting a more harmonious long-term co-existence between natural capital and anthropogenic activities.

JEL classifications: O13, Q51, Q56, Q57

Keywords: circular economy; industrial symbiosis; protected areas; life cycle assessment

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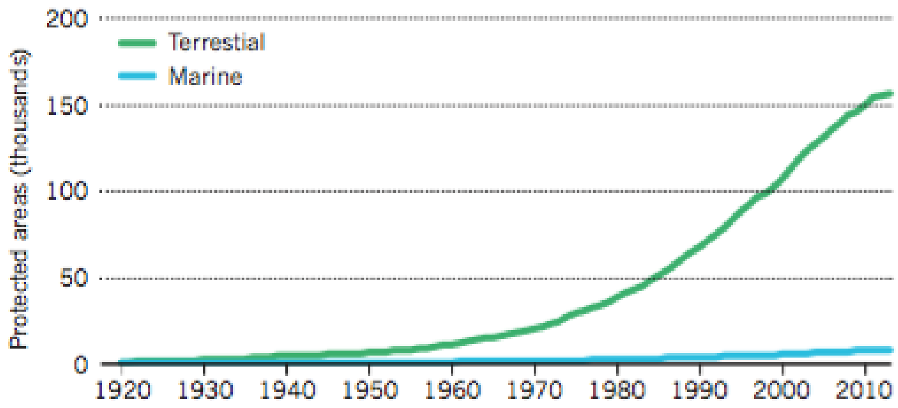
Presentation Structure

- Protected areas and anthropogenic activities
- BIO2CARE Project
- Study area
- Carbon Footprint of the existing situation
- Industrial Symbiosis case study
- Carbon Footprint of the symbiotic scenario
- Conclusions

Protected areas

- A protected area is a "clearly defined geographical space that is recognized as and dedicated to achieving the long-term conservation of nature – with its associated ecosystem services and cultural values".

- Worldwide there are more than 162,000 legally designated national protected areas, covering more than 28.4 million km^2.



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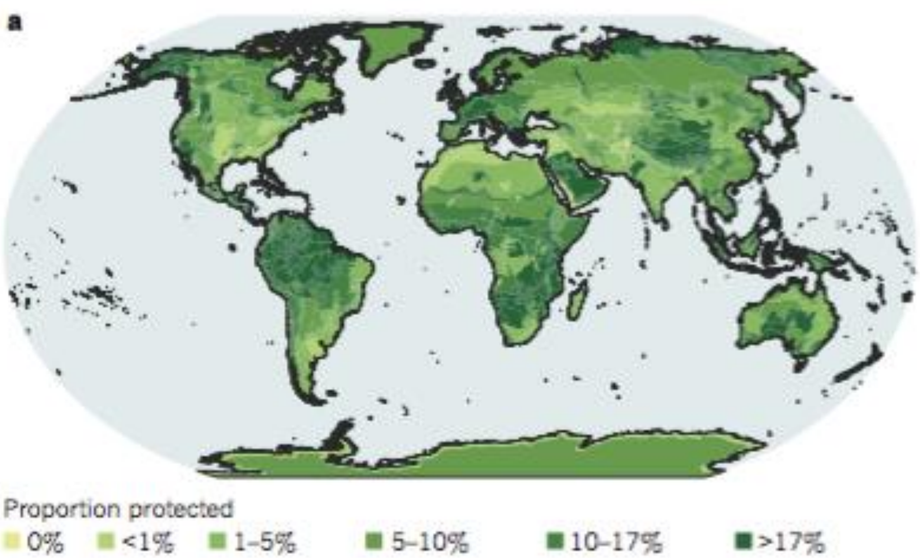
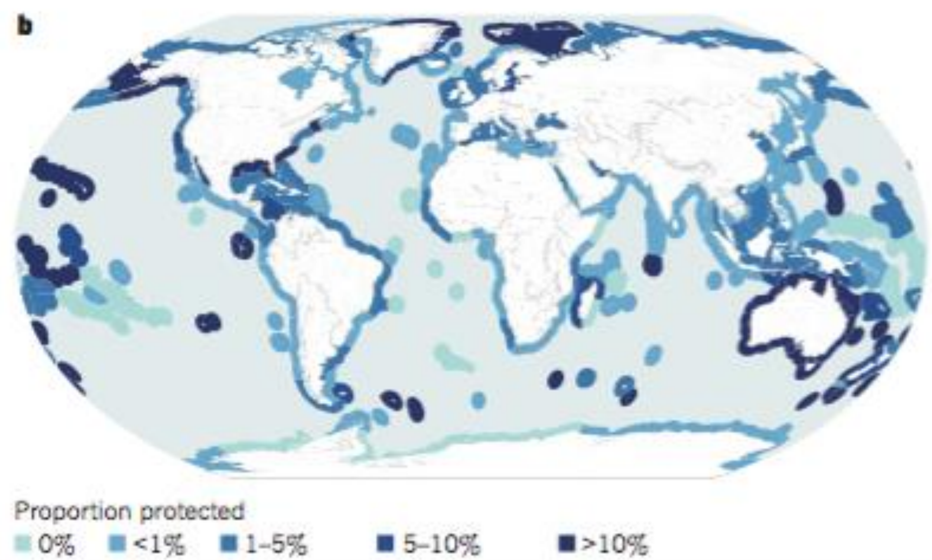
Protected areas

Terrestrial Protected Areas
155,584 in total
18.4 million km^2
Covering around 12% of the whole terrestrial land

Marine Protected Areas
7,318 total
10.1 million km^2
Covering around 3% of the word's marine environments





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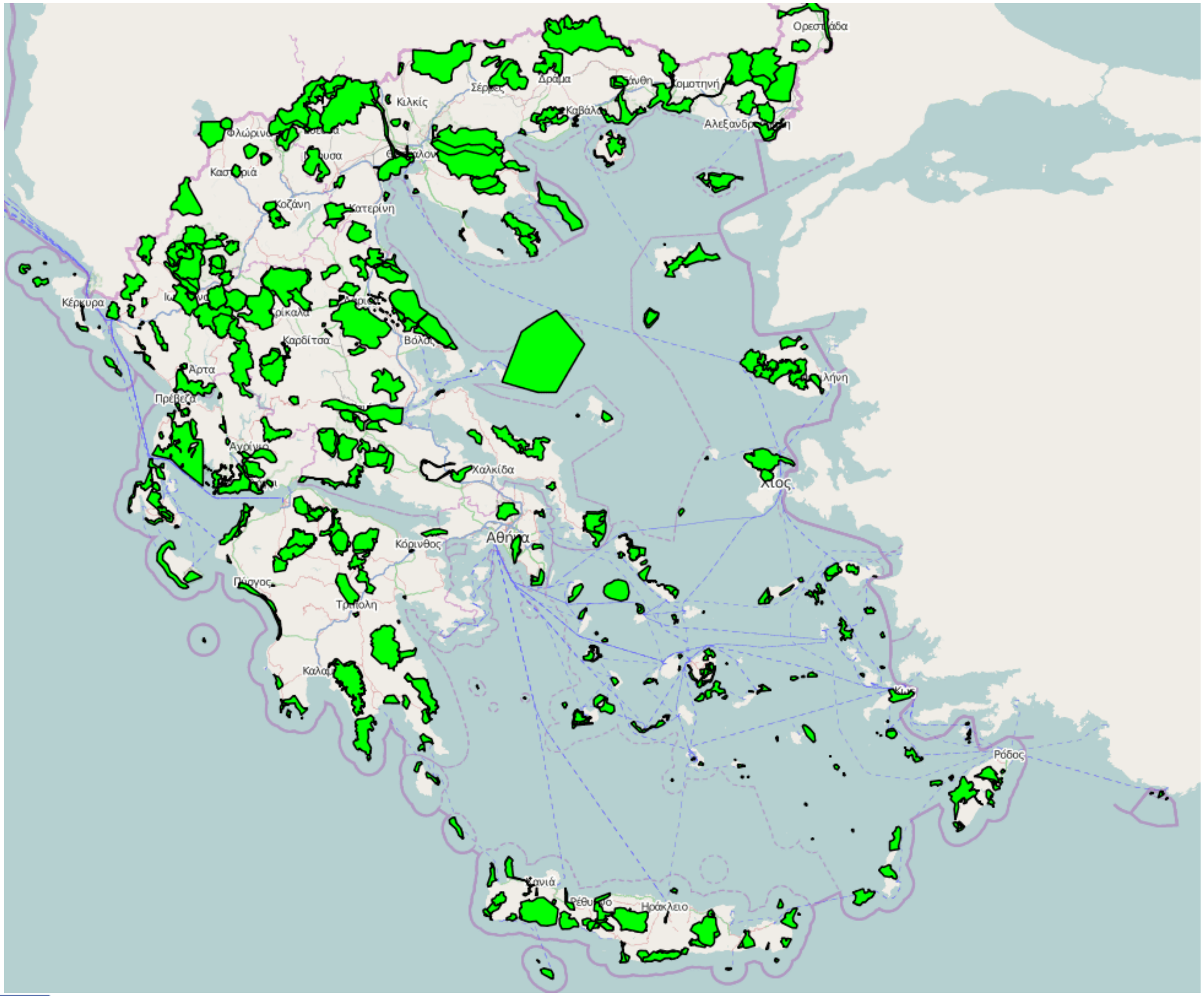
Protected areas in Greece

- Since 1937, Greece has started to recognize areas with special ecological interest and put them under protection.

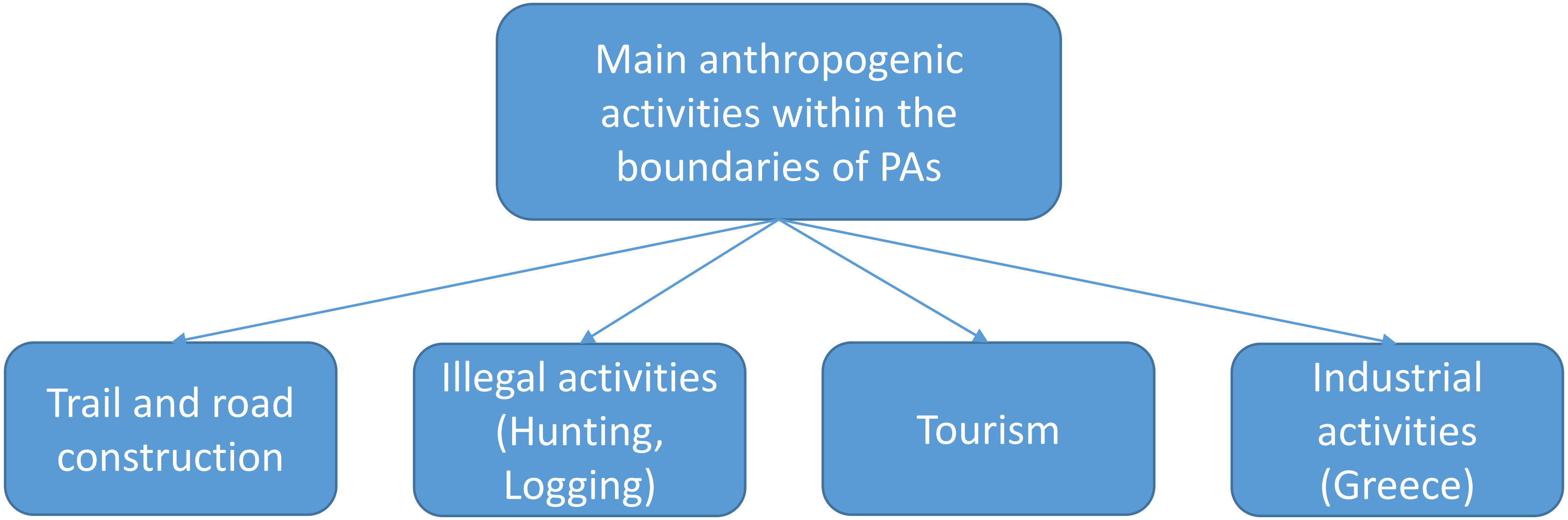
- Today, 234 NATURA 2000 sites have been designated across the country, covering a total of 18% of Greece's land area, or about 2,360,000 hectares, not including the purely marine areas.

Protected areas in Greece



Protected areas and anthropogenic activities

- Human activities can undermine the main goal of protected areas, which is to preserve biodiversity.
- Recent studies concluded that **32.8%** of the total protected areas are highly degraded due to anthropogenic activities.



The BIO2CARE project

Interreg Greece – Bulgaria 2014 – 2020

Priority Axis:
2. A Sustainable and Climate adaptable Cross-Border area

Thematic Objective:
06 – Preserving and protecting the environment and promoting resource efficiency

Investment Priority:
6d. Protecting and restoring biodiversity, soil protection and restoration and promoting ecosystem services including NATURA 2000

Specific Objective:
5. To enhance the effectiveness of biodiversity protection activities

The BIO2CARE project

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The BIO2CARE project

LB (PB1): Democritus University of Thrace

PB3: Municipality of Nestos

PB4: The Goulandris Natural History Museum/Greek Biotope Wetland Centre

PB5: National Confederation of Disabled People, Brunch of Northern Greece

PB6: Regional Inspectorate of Environment and Water – Blagoevrad

PB7: National Park Rila

PB8: South-West University Neofit Rilski

PB9: Pirin Tourism Forum

The BIO2CARE project

BIO2CARE Key objective

“To reinforce the administrative capacities and effectiveness of Protected Areas (PAs) Management Bodies….**in benefit of biodiversity and local communities**…through the **implementation of an innovative and integrated approach**”

How this objective will be achieved?

In full compliance with CBC GR-BG 2014-20 priority specific objective: “To enhance the effectiveness of biodiversity protection activities”

The BIO2CARE project

How this objective will be achieved? – Goals of the Project

- The BIO2CARE **decision making platform** will become a valuable tool for understanding aggravating activities and quantifying their impacts on biodiversity (e.g. measuring ecological footprint, carbon footprint and water footprint)

- The **monitoring systems/activities** will enhance the capability of Management Bodies to protect the areas of interest and mitigate illegal activities

- Small scale infrastructures like **pathways accessible by disabled people** will make PAs more attractive to new audience, while attracting new target groups for neighboring businesses

- Support entrepreneurship on surrounding areas of BIO2CARE by establishing the process of awarding an **ecolabel**, a quality scheme that will help local businesses to show a qualitative distinction, surpassing competitors

The BIO2CARE project

➢BIO2CARE applies an integrated approach responding to PAs entire environmental systems. It will deliver a wide range of differentiated **outputs**:

- **O.1**: One **set of studies** including a methodology, current situation analysis and SWOT analysis studies

- **O.2**: **Monitoring networks/equipment** which operate in two different levels: high-tech monitoring of fauna and flora and high-tech monitoring of illegal activities

- **O.3**: **Two (2) e-tools/software** for estimating the carrying capacity in the areas of interest (**BIO2CARE Calc**) and for assessing and proposing potential symbiotic activities (**BIO2CARE Symbiosis**) and **Two (2) smart applications** (OSX/Android) for facilitating and promoting green tourism (**BIO4TOURISM**)

Essential components of one integrated **Decision Support system (DSS)** per country, that could operate separately or jointly on CB area

The BIO2CARE project

➢BIO2CARE applies an integrated approach responding to PAs entire environmental systems. It will deliver a wide range of differentiated **outputs**:

- **O.4**: **Infrastructure/Pathways** for recreational purposes and bird watching for the handicapped and disabled
- **O.5**: Development and implementation of a **sustainability labeling scheme** including varying certification levels
- **O.6**: Two (2) **Training sessions** regarding the use of BIO2CARE Software and Two (2) **targeted workshops** regarding BIO2CARE labeling scheme

} **Will feedback DSS** (O.4–O.6)

- **O.7**: One (1) **Policy recommendation** report

Study area

- The protected area under study is the National Park of Eastern Macedonia and Thrace.

Study area

- The NP-EMATH area constitutes a geographical part of the Kavala, Xanthi, and Rodopi Regions and six of their municipalities: Nestos, Topeiros, Avdira, Iasmos, Komotini, and Maronia-Sapes.

- Forty-three (43) villages are located in the area, whereas close to 29,000 people (over 10,000 households) are living within the boundaries of NP-EMATH.

- The wetland complex of NP-EMATH is one of the most significant in Greece, including 1) the Nestos Delta, 2) the Lake Vistonida, 3) the lake Ismarida.

Study area – Anthropogenic activity

- Within the boundaries of NP-EMATH numerous anthropogenic activities take place, mostly in the agricultural sector as agricultural production is the main economic activity.

- There is also industrial activity focusing on processing the agricultural goods produced in the area, as well as touristic activities.

- Finally, in close proximity (5 – 10 km), a heavy industrial zone is located in the western boundaries of the NP-EMATH.

Carbon Footprint of the existing situation

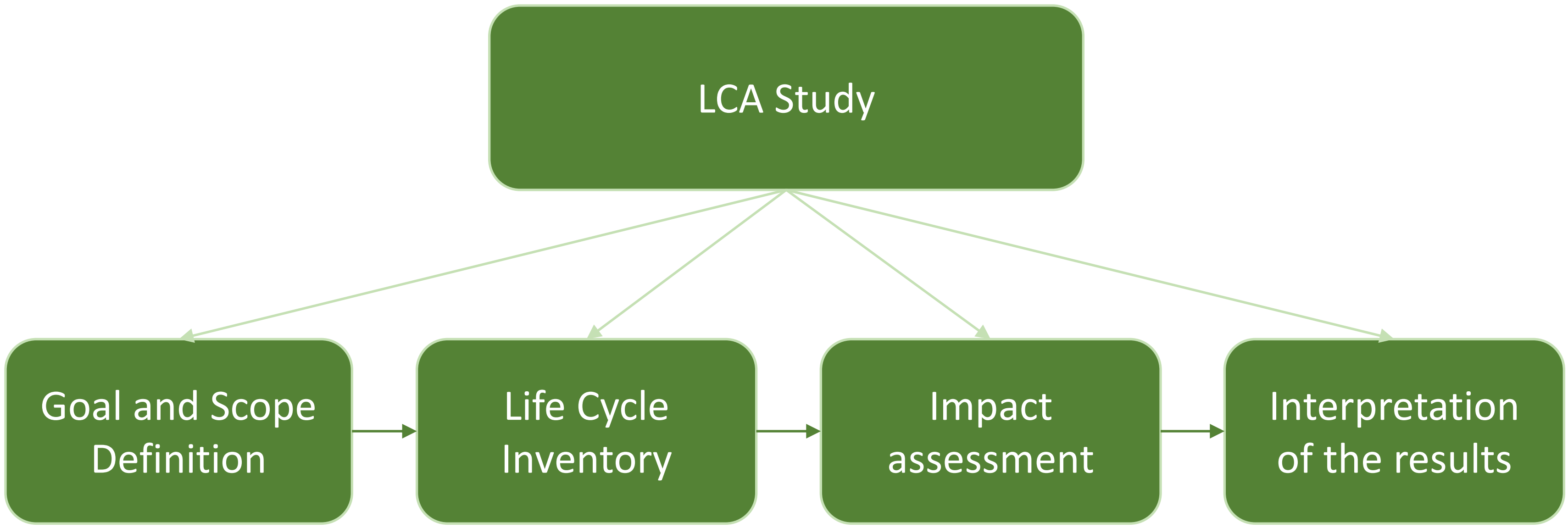
- **Carbon Footprint** is defined as the total Greenhouse Gas (GHG) emissions caused by an individual/a product/a process etc.

- In this study the **Life Cycle Assessment** method was utilized in order to evaluate the total carbon footprint within the boundaries of the study area.

- **Life-cycle assessment (LCA) is a methodology for assessing environmental impacts associated with all the stages of the life-cycle of a commercial product, process, or service.**

Carbon Footprint of the existing situation

- An LCA study is conducted following a 4 step approach.



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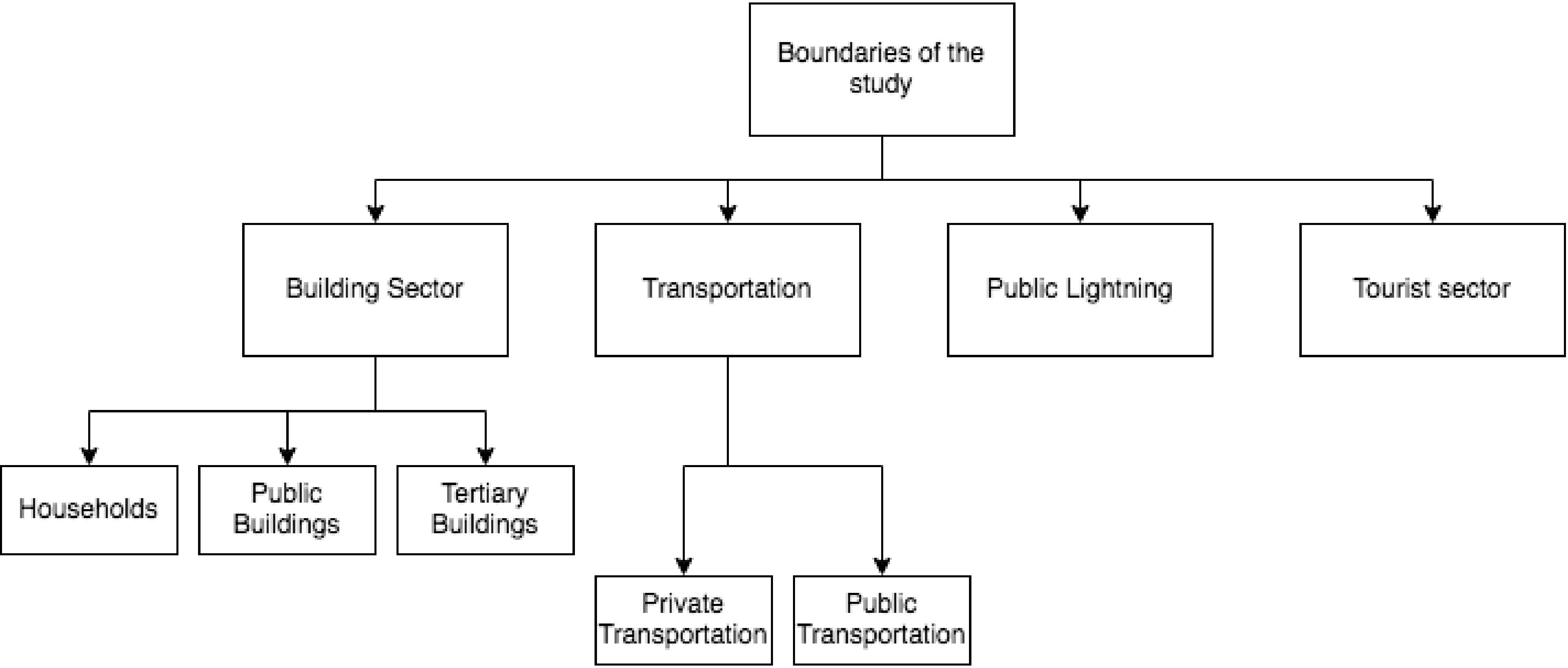
Carbon Footprint of the existing situation

- The boundaries of the study included:



Carbon Footprint of the existing situation

- Utilizing the LCA methodology the existing carbon footprint within the boundaries of NP-EMATH was calculated at: **$2{,}21 \times 10^{8}$ kgCO_2eq**

- The key processes contributing to the Carbon footprint of the area are presented below.

S/N	Process	Kg CO_2eq	Percentage (%)
1	Electricity consumption	$8{,}10 \times 10^{7}$	37
2	Heating oil	$7{,}01 \times 10^{7}$	32
3	Trucks	$3{,}74 \times 10^{7}$	17
4	Passenger cars (petrol)	$2{,}25 \times 10^{7}$	10
5	Passenger cars (diesel)	$4{,}48 \times 10^{6}$	2
6	Rest of the processes	-	2
	Total Carbon Footprint	$2{,}21 \times 10^{8}$	100

Industrial Symbiosis

- A potential approach for the mitigation of the environmental impacts deriving of those anthropogenic activities is the implementation of Industrial Symbiosis practices, as part a circular economy strategy in the area.

- **Industrial symbiosis**, as a tool of Industrial Ecology, focuses on the exchange of by-products, materials, energy, and water, in order to achieve positive economic, environmental, and social results.

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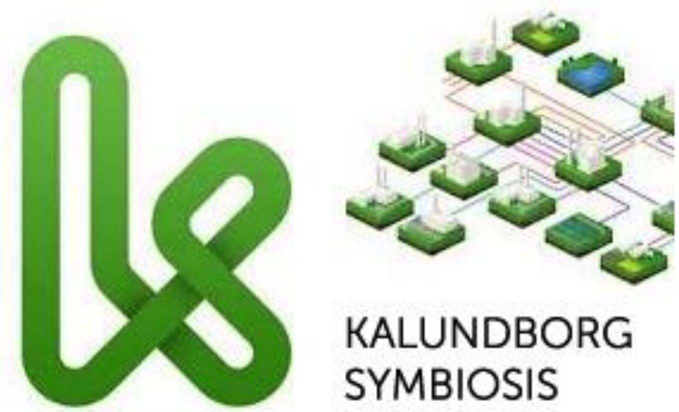
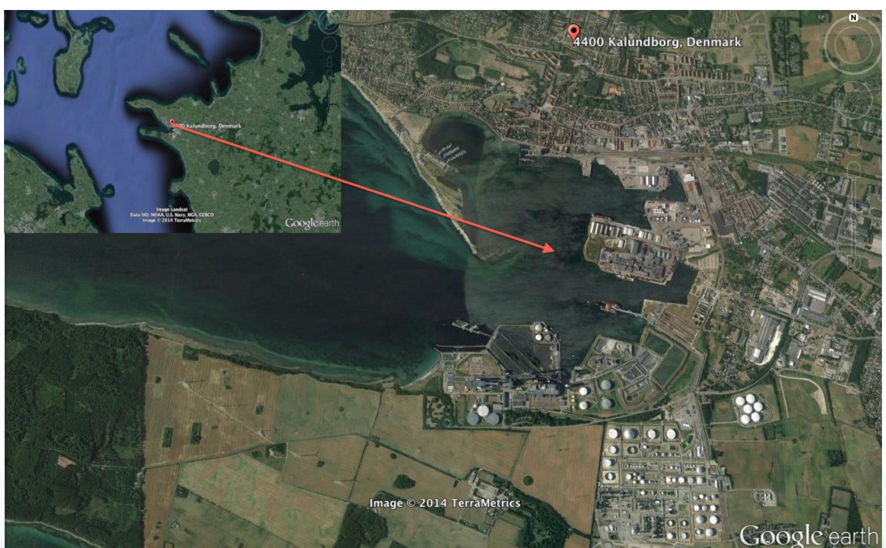
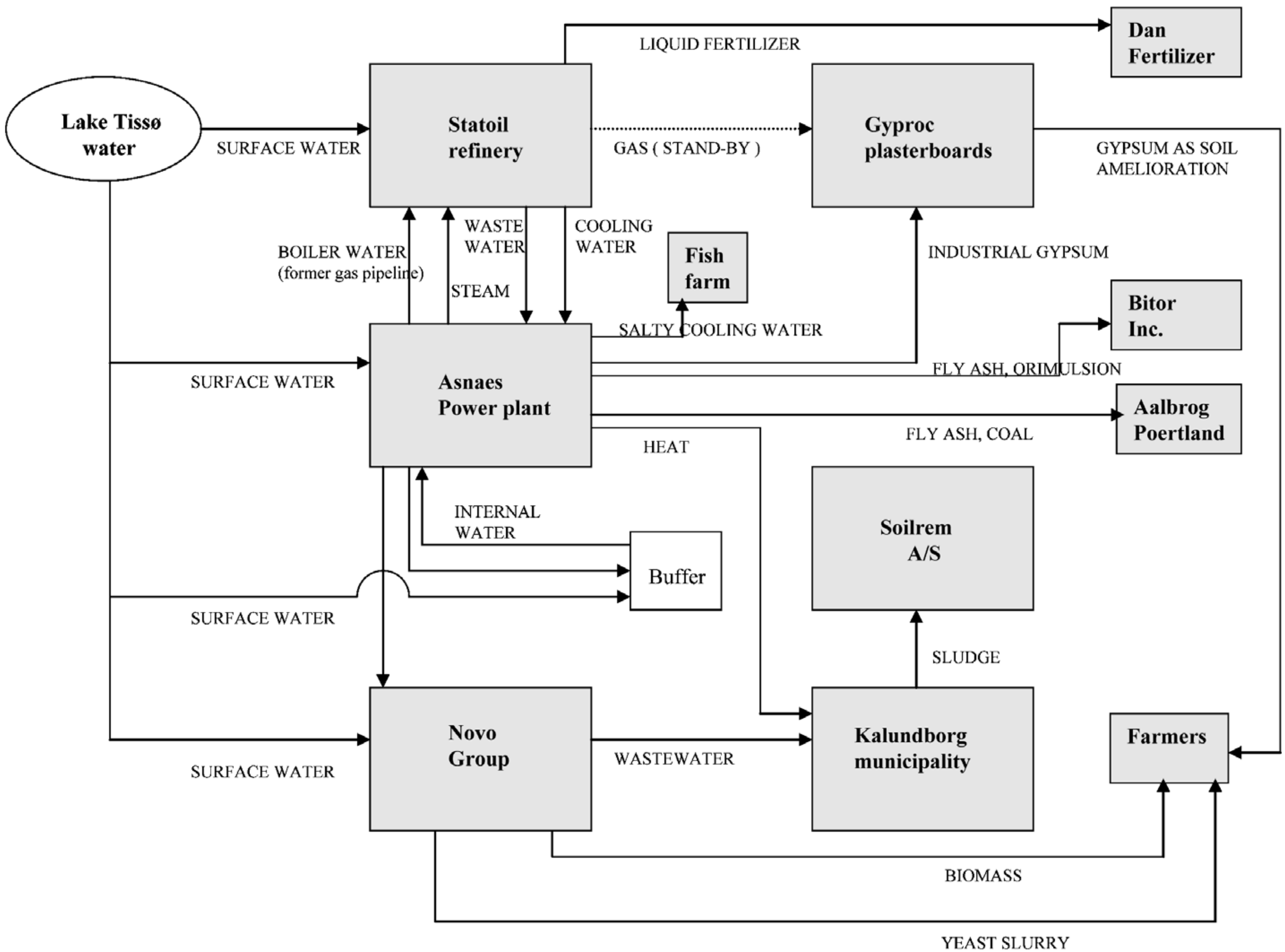
ΔΗΜΟΚΡΙΤΕΙΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΡΑΚΗΣ | DEMOCRITUS UNIVERSITY OF THRACE

Industrial Symbiosis

- An established example of Industrial Symbiosis is the case of Kalundborg in Denmark.
  - The first Eco-industrial Park
  - Cooperation between 13 companies
  - 30 symbiotic activities
  - Yearly financial benefits: 80.500.000 €





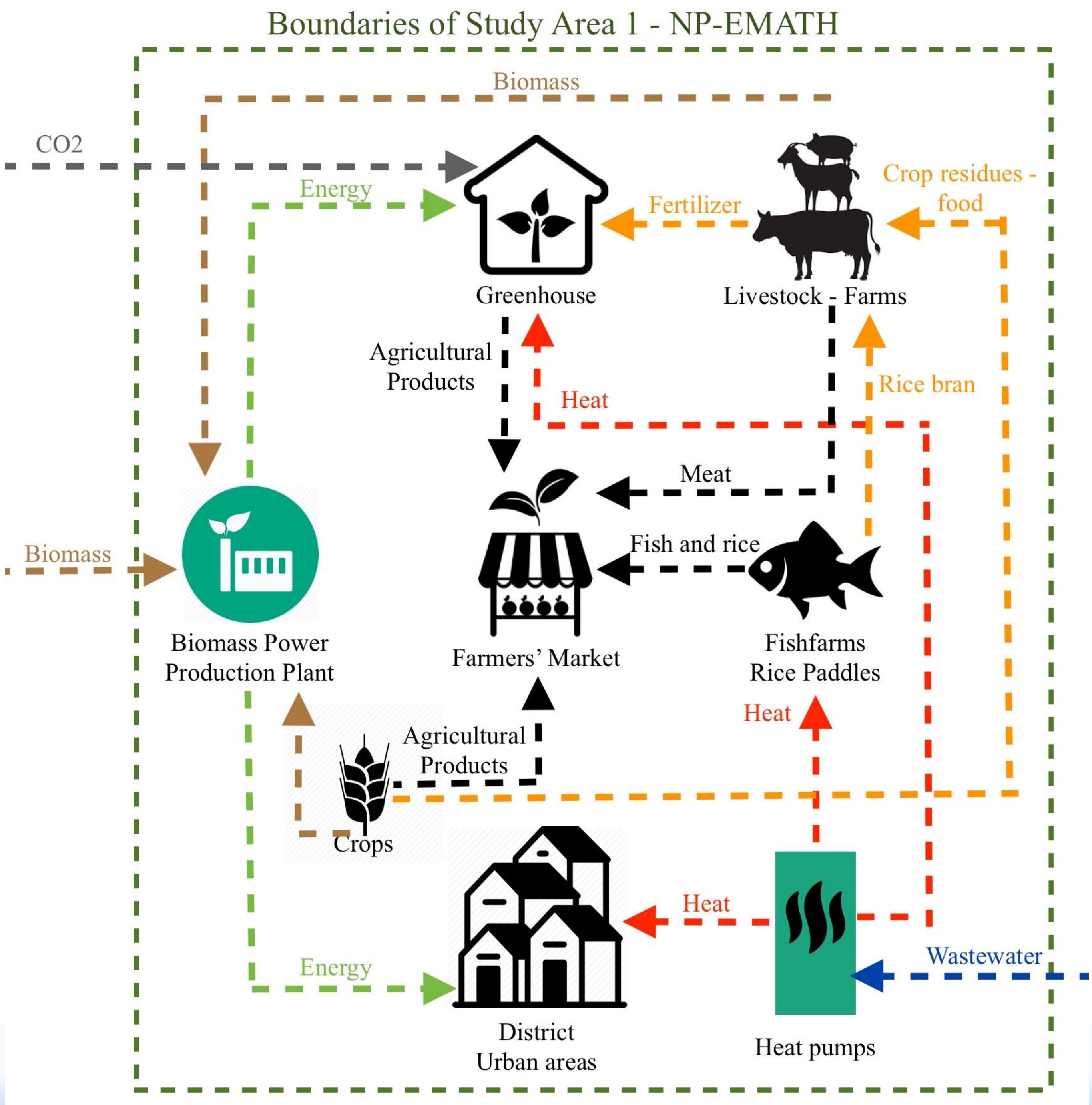

LIQUID FERTILIZER
Dan Fertilizer
Lake Tissø water
SURFACE WATER
Statoil refinery
GAS (STAND-BY)
Gyproc plasterboards
GYPSUM AS SOIL AMELIORATION
BOILER WATER
(former gas pipeline)
WASTE WATER
STEAM
COOLING WATER
Fish farm
INDUSTRIAL GYPSUM
Bitor Inc.
SALTY COOLING WATER
SURFACE WATER
Asnaes Power plant
FLY ASH, ORIMULSION
Aalbrog Poertland
FLY ASH, COAL
HEAT
INTERNAL WATER
Buffer
Soilrem A/S
SURFACE WATER
SLUDGE
Novo Group
WASTEWATER
Kalundborg municipality
Farmers
SURFACE WATER
BIOMASS
YEAST SLURRY

Benefits from the Kalundborg Industrial Symbiosis

Yearly results		
Reduction on natural resources consumption	**Quantities**	**Measurement unit**
Oil	19	kt
Coals	30	kt
Water	3.000.000	m^3
Emission reductions		
CO_2	275	kt
SO_2	25	kt
Waste reuse		
Flying ash	135	kt
Sulfur	2,8	kt
Phosphogypsum	80	kt

Industrial Symbiosis case study in NP-EMATH

- Considering the specific characteristics and needs of the area, as well as through an extensive literature review sixteen (16) potential symbiotic activities were identified.



Boundaries of Study Area 1 - NP-EMATH
Biomass
CO2
Energy
Greenhouse
Fertilizer
Crop residues -
food
Livestock - Farms
Agricultural
Products
Heat
Rice bran
Meat
Biomass
Fish and rice
Biomass Power
Production Plant
Farmers' Market
Fishfarms
Rice Paddles
Heat
Agricultural
Products
Crops
Heat
Wastewater
Energy
District
Urban areas
Heat pumps

Potential benefits from the implementation of symbiotic activities in the area

Proposed Symbiotic Activity		**Environmental Benefits**
CO_2 capture and reuse for the development of local Greenhouse		Reduction of 4.320 tonnes of CO_2
Development of a Biomass Power Production Plant		Reduction of 72.000 – 98.000 tons of oil
Industrial Wastewater for District Heating		Reduction of 86.400 MW of thermal energy from heating oil
Agricultural based symbiotic network	Development of fishfarms/rice puddles	Fertilizer reduction Land use
	Livestock residue utilization	Fertilizer Biomass
	Crop residues utilization	Food for livestock Biomass
	Development of a local farmers' market	Reduced transportation impacts

Carbon footprint of the symbiotic scenario

- After the identification of the 16 potential symbiotic activities, a new life cycle inventory was developed, implementing the data resulting from these symbiotic activities.

- The method of LCA was again utilized.

- The Carbon Footprint of the symbiotic scenario in the study area is **$1,89x10^8$ kgCO_2eq.**

- In comparison to the existing situation, we could potentially have a reduction of 36,3 kt of CO_2eq (16,5%) – This result is undercalculated in order to represent a more realistic approach.

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Conclusions (1)

- Aim of this study was:
  - Assess and quantify the existing situation of carbon footprint deriving from the current anthropogenic activity within the boundaries of NP-EMATH.
  - Identify and propose the potential implementation of symbiotic activities.
  - Examine the potential carbon footprint reduction by the implementation of the identified and proposed symbiotic activities.

- The carbon footprint of the existing situation was calculated at **$2{,}21 \times 10^8$ kgCO_2eq**, with electricity and heating oil consumption being the processes with the most contribution.

- In total 16 potential symbiotic activities were identified, based on literature review, and the characteristics and need of the area.

Conclusions (2)

- The proposed activities can lead to an estimated reduction of 4,320 tonnes CO2 and 87,250 MWh of oil for heating (among other significant results).

- The potential implementation of the identified symbiotic activities could lead to a reduction of up to **36,3 kt of CO_2eq (16,5%)** in the total carbon footprint of the area.

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