Online Symposium on Circular Economy and Sustainability

Greece 1-3 July, 2020

**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:

1. 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,
2. 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
3. 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 CO2 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 CO2 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 CO2 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