DEVELOPMENT OF A MODEL FOR THE IMPLEMENTATION OF THE CIRCULAR ECONOMY IN DESERT COASTAL REGIONS

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Background

Food production in desert regions is a challenge due to the restricted access to freshwater. A major challenge for the development of desert coastal regions is thus to minimize the cost of water desalination and maximize its utilisation for agriculture, industrial, commercial and residential use.

Objective

The goal of this study is to define a logical way to create a model of a circular economy that can fit in arid coastal regions and can be extrapolated to other places in the world.

Introduction

This study compares two different desert coastal regions on the American continent which have similar geographical characteristics. In both of these deserts, there are cities in which the access and management of freshwater represent an issue for their continuous growth and conceding water rights to the mining industry. The city of Antofagasta (Chile) with 432,000 inhabitants (2021) is located in the Atacama Desert (AD) and its main source of water is a desalination plant. The city of Hermosillo (Mexico) with 936,000 inhabitants (2020) located in the Sonoran Desert (SD), utilizes aquifers filled with water appropriated or transferred from other users as its main source of water due to a prolonged drought.

Deserts have singular environmental characteristics that distinguish them from other ecosystems. Some of these characteristics are the temperature, high solar radiation, lack of precipitation, and non-arable lands. A comparison of the main environmental characteristics is presented in **table 1**.

Table 1. Environmental characteristics of Atacama and Sonoran Deserts

Desert	Coastal area [km^2]	Solar radiation [kWh/m^{2}day]	Non-Arable land [ha]	Temperature [ºC]	Annual rainfall [mm]	Agricultural method	Water desalination [Ml/day]	Aqua farming
Atacama	1,600	7 – 7.5	1.05x10^7	-3.79 to 36	20 - 80	Hydroponic	Antofagasta 91.24	Scallops
Sonoran	3,400	7.8	3.6x10^7	-5 to 50	50 - 300	Irrigation	3 approved, 1 under construction	Shrimp

Model development

Circular economy models are based on closing the loop on product life-cycle, materials, and resources. Desertification, droughts, and water scarcity prevent compliance with the United Nation's Sustainable Development Goals since it leads to underdevelopment. Thus, a model for maximizing the usage of water in desert coastal regions must contain the following:

Solar energy source: Solar radiation is the most abundant energy source on earth. Solar cell systems offer three generations of technology with efficiency-cost trade-offs.

Water desalination: Water scarcity in desert places is a challenge for the inhabitants. However, AD and SD have the advantage of being next to the Pacific Ocean; therefore, water desalination plants play an essential role in this type of area.

Food production: Crop production with hydroponic systems in non-arable lands ensures food safety and requires 80 % less water than conventional farming. Irrigation water dosing with hydrogels has proven to save up to 50% in water consumption.

Microalgae culture: The availability of non-arable lands could make possible the production of biomass for the food industry, chemicals, pharmaceuticals, etc. in open raceways or flat panel photobioreactors.

Seaweed farming and processing: Large seaweed farms for food supply and biochemicals utilising seawater with natural nutrients or aquacultural waste.

Nutrient recovery from waste-water treatment streams and anaerobic digestion can be utilized for crop nutrition. Nitrogen (ammonia), phosphorus (phosphates), and, potassium (K-salts) can be recovered from anaerobic digestion.

Figure 1 describes a prototype of a circular economy model for desert coastal regions. The most abundant resources on earth are seawater and solar radiation, which are key in this type of ecosystem.

Seawater is desalinated and further utilized for food production (hydroponic and water dosing with hydrogels), biofuel production (microalgae), and biochemicals (seaweed). The wastes from these three processes are treated through anaerobic digestion, where the biogas is separated and the methane is burned in a combined heat and power unit (CHP) to produce energy. The CO_2 is used as feed for microalgae culture. Digestate and recovered nutrients are used for food production.

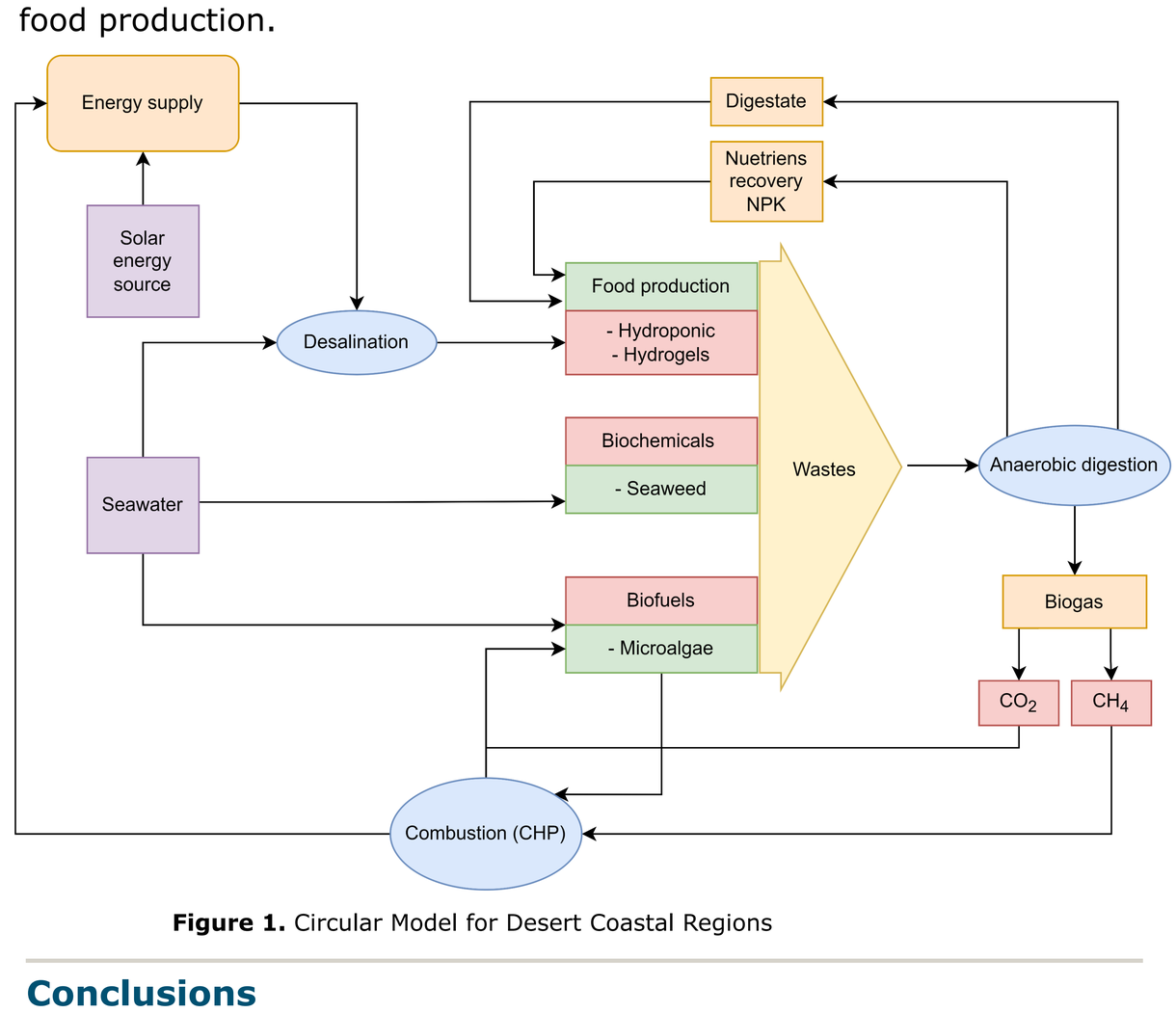

Figure 1. Circular Model for Desert Coastal Regions

Conclusions

- The integration of natural resources, sustainable energy, food production, and waste recovery methods with state-of-the-art technology can lead to a circular bioeconomy for desert coastal regions by means of the maximization of water utilisation.
- The use of water in terms of dosing and reutilisation is the key point of the circular economy in desert regions.
- Desert places present an advantageous opportunity for solar energy and the wise use of non-arable lands.

Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 860477 – AgRefine – H2020-MSCA-ITN-2019.

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