Lisbon School of Economics & Management
Universidade de Lisboa

MASTERS IN MANAGEMENT (MIM)

MASTERS FINAL WORK

DISSERTATION

THE BLUE ECONOMY AND THE POWER OF IMPACT INVESTING: A CASE STUDY OF SEAWEED FARMING

ARLETTE JULIE CONSTANZE SCHRAMM

MARCH - 2023

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ABSTRACT, KEYWORDS AND JEL CODES

The research focuses on the promotion of sustainable seaweed farming through impact investment. The thesis concludes that sustainable seaweed farming aligns with the blue economy (BE) notion, which seeks to transform economic development into sustainable growth while providing advantages for everyone. The cultivation of seaweed is a sustainable marine industry that adheres to the criteria of a BE. Nevertheless, the existing sector size prevents seaweed farming from compatibility with the BE and necessitates various solutions.

This thesis demonstrates that investing in sustainable seaweed farming has positive effects ranging from decarbonization to promoting social equity and community development. However, without funding, the industry will be exposed to a wide range of risk factors ranging from carbon dumping on high seas to the loss of ocean health caused by the introduction of invasive species. Furthermore, the seaweed business has the potential for exploitation and, due to inadequate laws and licencing, poses substantial marine problems for vital organisms.

Investments will counteract potential threats to the industry and result in lower production costs and reduced negative externalities. Impact investment contributes to the long-term sustainability of the seaweed farming sector by fostering economies of scale and industry expansion. Moreover, investing in sustainable seaweed production would contribute to the fulfilment of 12 of the 17 United Nations' Sustainable Development Goals (SDGs).

KEYWORDS: Seaweed Farming, Sustainable Development, Impact Investment; Blue finance; Green bonds; Ocean management; Sustainable finance; Sustainable investing; Ocean based financing

JEL CODES: Q01 – Sustainable Development, Q2 – Renewable Resources and Conservation, Q22 – Fishery; Aquaculture, Q25 – Water, Q26 – Recreational Aspects of Natural Resources

Glossary

BE – Blue Economy

HAB – Harmful algal bloom

IMP – Impact Management Project

IMO – International Maritime Organization

SDG – Sustainable Development Goal

SIDS – Small Island Developing State

UNCSD - United Nations Conference on Sustainable Development

UN - United Nations

UNEP – United Nations Environment Program

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1. INTRODUCTION

Oceans and seas make up over 70% of the Earth's surface, making them essential in the fight against climate change (United Nations, 2022a). Oceans also absorb carbon dioxide emissions and extra heat, producing 50% of the world's oxygen (United Nations, 2022a; Bari, 2017; McKinley, et al., 2019). However, human activities are putting oceans under pressure, leading to biodiversity loss and health degradation. The Blue Economy (BE) concept refers to the sustainable use and management of marine resources to promote economic growth and improve livelihoods and social well-being (UNEP, 2012). The concept aims to move away from a traditional model of marine resource extraction. A non-sustainable ocean economy causes the depletion of resources through human activities such as overfishing, oil and gas extraction and mining (UNEP, 2012). The BE is said to generate economic, social, and environmental benefits for everyone. The benefits are broad and can range from creating new industries and employment to supporting and developing new technologies, such as renewable energy. However, knowledge gaps in the BE remain challenging and influence investment decisions in several ways (Addamo, Calvo Santos, & Guillén, 2022). Due to the lack of standardization regarding reporting and measurement of the social and environmental impact of BE investments, the analysis and evaluation of investment opportunities remain challenging (Addamo, Calvo Santos, & Guillén, 2022). Knowledge gaps hinder the socio-economic valuation of oceans and reduce possible harmonization and enhancement of BE statistics (Addamo, Calvo Santos, & Guillén, 2022). As a repercussion, monitoring of efforts towards de-carbonising the industry can not be measured appropriately (Addamo, Calvo Santos, & Guillén, 2022). Policymakers face problems in developing effective strategies for the sector's growth (Addamo, Calvo Santos, & Guillén, 2022). Risk assessment in the industry is limited and, as a repercussion, affects the risk-return profile of investments (Addamo, Calvo Santos, & Guillén, 2022).

The thesis "The Blue Economy and the Power of Impact Investing: A Case Study of Seaweed farming" explores how impact investment can contribute to closing the knowledge and funding gaps within the BE through the case study of sustainable seaweed farming. The seaweed industry is relevant for the BE as it connects the idea of resource extraction and sustainable development, profiting everyone while simultaneously adding to environmental and social health and supporting the fulfilment of SDG 14, "Life Below Water" (appendix 1). The study seeks to investigate the potential of Impact Investing in financing and promoting sustainable seaweed farming to contribute to the UN's achievement and success of Sustainable Development Goals (SDG). The research question is: “How can Impact Investment promote sustainable seaweed farming?”.

1.1. Motivation

Marine resource depletion and ocean ecosystem degradation have become urgent worldwide environmental and economic challenges. The BE concept offers a solution to this issue by providing a framework for sustainable ocean development, promoting economic growth, social-well being, and environmental protection of critically endangered ecosystems. As an emerging industry, Seaweed farming has the potential to contribute to the BE as it provides sustainable food, animal feed, fuel and many other sources of products and services. However, while a sustainable seaweed industry offers various opportunities, it faces significant funding gaps and investment challenges. Impact Investing can be a promising solution to support the sustainable seaweed industry. Impact investing promotes the BE as it seeks social and environmental impact and generates financial returns for its investors. This thesis aims to investigate the potential of impact investing in closing the funding gap and evaluate the positive effects on the BE concept for stakeholders.

1.2. Scope and Limitations

The scope of the research focuses on seaweed farming as a potential contributor to the BE and sustainable ocean development while particularly highlighting it in the context of impact investing. The study includes a literature review, a case study, and interviews with experts in the field of impact investing, providing a comprehensive analysis of this topic. In addition, the study covers various aspects of sustainable seaweed farming, including environmental and social impact and economic feasibility.

The study is limited to the extent of seaweed farming in the context of the BE and impact investing and, therefore, does not cover any other aspects of ocean development or other financial models. The study builds on secondary data sources and expert opinions, which can be incomplete or biased. Furthermore, the study does not include a detailed examination of legal and regulatory frameworks or a comprehensive economic analysis affecting seaweed farming. Also, the research is limited to the status quo of the seaweed farming industry.

1.3. Outline

Introduction: This study will begin by discussing the concept of the BE, its development and its importance in the ocean-based industry. After a brief overview of the blue economy, the study will introduce the research questions and objectives. The methodology chapter will explain the research design used in this study, including the sample, data collection methods, and data analysis techniques. Lastly, the Introduction will include subchapters about the Scope and Limitations of the study.

The Blue Economy: The thesis continues with a literature review assessing available data and research of the BE and Impact Investment. The literature review is followed by an expert perspective of the BE and analysis of the research in this study. This chapter aims at giving a comprehensive overview of the Blue Economy as a whole.

A Case Study on Seaweed Farming: The study continues with a Case Study on Sustainable Seaweed farming, critically analysing the existing Seaweed farming research and how Impact Investing can be a tool in closing the funding gap in the sector. The analysis aims at assessing the environmental, social and economic benefits of seaweed farming and the applicability of impact investing to seaweed farming. Furthermore, this chapter focuses on the impact, investments in sustainable seaweed farming have on the fulfillment of the SDGs of the UN. Finally, this chapter will include a Conclusion of the Case Study.

Research and Contribution The last chapter of thesis focuses on contribution of this research to the Blue Economy field. Also, this chapter focuses on Limitations of research.

2. Methodology

The study aims to expand knowledge about the BE and examine the potential of seaweed farming adding to sustainable development as an investment opportunity in impact investing. A multi-faceted research approach is subject to this study, using a meta-analysis of existing BE and seaweed farming research and 13 expert interviews with key stakeholders in the impact investment field.

The Research Question aims to gain an understanding of the BE through a meta-analysis of 21 sources of research on the topic. The peer-reviewed reports and articles were included based on the criteria published between 2010 and 2022. The reports were studies that included definitions or discussions of the BE and are connected to the keywords “Blue Economy” and

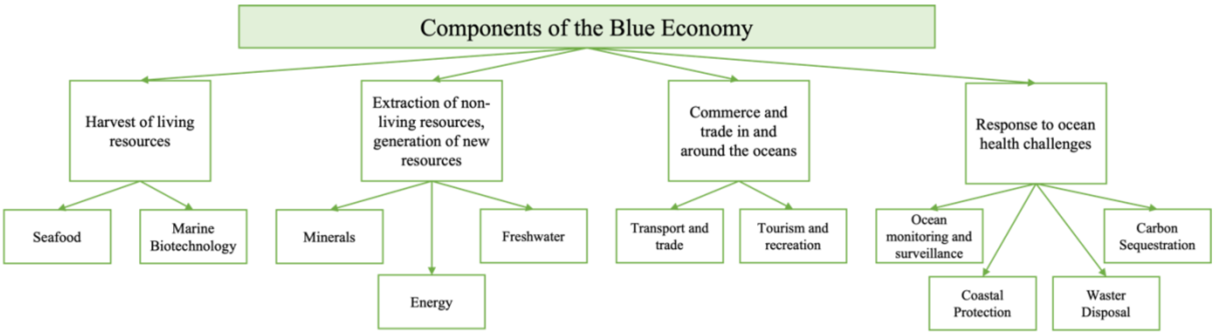
“Sustainable Development”. Studies not meeting the criteria were deemed irrelevant in answering the research question. The methodology used involved coding, leading to identifying six key themes. The major themes are the non-financial effects on economic growth, social and environmental advantages, the relationship to the UN's SDGs, and the financial consequences. The meta-analysis method’s strength lies in its capacity to synthesise data from numerous experts. As a result, it offers a thorough comprehension of a generally agreed definition of the BE. The study further acknowledges limitations, such as potential biases and differences in research methods among sources subject to the study. An expert interview with key stakeholders of the impact investing industry was included to understand the industry's future. The participants range from asset managers to pension funds and foundations. The data was collected through email or video conferencing and transcribed verbatim. Thematic analysis was then performed to identify key themes and patterns. Lastly, the responses were collected, and a future outlook was created. The Research Question further aims to understand the intersection between BE and seaweed farming. The commonly mentioned environmental, social and economic impacts of seaweed farming were analysed to accomplish this. A more detailed coding system was included in determining the impacts of investing in seaweed farming. As a result, eight positive impacts are identified for each category (environmental, social and economic) and eight potential risks and challenges to the industry's success. The meta-analysis is based on 25 research papers and the opinion of four seaweed companies. The inclusion criteria were peer-reviewed reports published in English between 2015 and 2022. The results were then applied to an Impact Metrics Model to determine the applicability of impact investing to seaweed farming and to analyse which impact contributes to what SDG target. Lastly, the results will be applied to the Impact Assessment Framework of the IMP to answer the questions: Who benefits, What is the outcome, How much impact does it have, What is the Market Gap, and How high is the risk?

3. The Blue Economy

The BE is a term used to describe an industry that is focused on the sustainable usage of marine resources to support economic growth, social well-being, and environmental protection (UNEP, 2012). In 2019 the BE generates a turnover of approximately EUR 667,2 billion in Europe alone, constituting a 94% increase since 2009 (Addamo, Calvo Santos, & Guillén, 2022; European Commission, 2018a). Employment in the BE has increased from 0,252 million jobs in 2009 to 4,45 million jobs in 2019 (Appendix 6) (Addamo, Calvo Santos, & Guillén, 2022;

European Commission, 2018a). As a concept, the BE is focusing on coastal and island countries with lower to middle-income levels, in which the ocean is a source of opportunity and represents a jurisdictional area, as well as on the high seas (World Bank Group, 2016). The BE can be subdivided into types of activities, ocean services, industries and drivers of growth. The four distinct types of activities are harvesting living resources, extraction of non-living resources and the generation of new resources, commerce and trade in and around oceans and responding to ocean health challenges directly linked to sustainable development (World Bank Group, 2016):

Figure 1 - Components of the Blue Economy



Source: Own illustration based on World Bank Group (2016)

The concept gained increasing attention in recent years as it connects global challenges of climate change, resource depletion and food security with growth drivers (Ki-Hoon Lee, 2020). The ocean service seafood, for example, is connected with the industries of fisheries and aquaculture, of which the main growth drivers are food security and demand for protein (World Bank Group, 2016). With its characteristics, the BE is often attributed to potential job creation and innovation, as new technologies give space for "Blue Economy innovation" (Cusack, et al., 2019; Pauli, 2010; Bari, 2017). Furthermore, the term BE often appears connected with supporting the United Nations' Sustainable Development Goals (SDGs) (Cusack, et al., 2019; Patil, et al., 2018; McKinley, et al., 2019), specifically SDG 14 "Life below Water" (Ki-Hoon Lee, 2020; Bari, 2017; Sumaila, Konar, & Hart , 2020b). The BE is rooted in various disciplines, such as politics, economics, and cultural studies, crossing ecology and planetary boundaries and, therefore, shaping a new urgency for the reassessment of the relationship between the environment and economy (Ki-Hoon Lee, 2020; Midlen, 2021; McKinley, et al., 2019).

3.1. ORIGINS AND EVOLUTION OF THE CONCEPT

The term BE originated at the United Nations Conference on Sustainable Development (UNCSD), Rio+20, held in Rio de Janeiro, Brazil, in June 2012 (UNEP, 2012). Whereas "ocean economy" describes the general realisation of the ocean as an economy, the concept of a BE (or sustainable ocean economy) describes the transitioning of the ocean economy into a concept combining economic growth and sustainable development (Sumaila, Konar, & Hart , 2020b). The BE has been defined in various ways by organisations; for example, the World Bank defines it as the "sustainable use of ocean resources for economic growth". The European Commission describes a BE as "all economic activities related to oceans, seas, and coasts" the Commonwealth of Nations views the BE as "an emerging concept that promotes responsible stewardship of the oceans" (United Nations, 2022a).

The need for a BE emerges from the history of ocean governance which can be traced back to the 17th Century when scholar and diplomat Hugh Grotius introduced the concept of "freedom of the seas" (Van Dyke, Zaelke, & Hewison, 1994). This concept, primarily developed within Western culture, posits that the oceans and their resources are subject to natural law and available for shared use (Van Dyke, Zaelke, & Hewison, 1994). However, after three centuries of unrestricted ocean harvesting, fish stocks worldwide have significantly declined, leading to a crisis (Midlen, 2021). Today oceans face challenges, such as ocean acidification, rising temperatures, and overfishing (Midlen, 2021).

In the early days of the 20th Century, the views of the world towards governing the oceans shifted (Van Dyke, Zaelke, & Hewison, 1994). The opening of the “nautilus” passage has led to the uncovering of resources with the potential to create wealth and benefits across the world (Dean, 1960). With it, claims for resources and open waters increased, simultaneously with the need for governance of the seas (Van Dyke, Zaelke, & Hewison, 1994).

1958 was the year of the first conference on the Law of the Sea, aiming to draft four international treaties through the United Nations (Van Dyke, Zaelke, & Hewison, 1994). The main idea being, to deal with international legal rights and duties about caring and taking of resources in the sea, beneath and within the airspace above (Dean, 1960). The United Nations Convention on the Law of the Sea (UNCLOS) was established in 1982 after lengthy negotiations to discuss numerous claims to territorial waters. The treaty included a number of provisions to address coastal state constraints, create territorial water rights, and ensure that the risk of water depletion was minimised (IILSS, 2023). As a result, the ocean is split into various boundaries that are each under a different jurisdiction (IILSS, 2023). Within these zones, a coastal state is given authority to conduct all fiscal and governmental activities, regulating all resources and polluting activities (IILSS, 2023). The areas exceeding the coastal state's waters are called the "High Sea" (IILSS, 2023). In 2023 a new historic agreement was signed, guaranteeing the safeguarding of marine life through placing 30% of the world's oceans as protected marine areas (UN, 2023).

The BE as a concept was first pioneered by Small Island Developing States (SIDS), which sought to bring attention to the high seas and differentiate it from the green economy (UNEP, 2012). The BE seeks to promote sustainable development for islands but also has broader implications for the world's future, given the need for international cooperation in waters beyond national jurisdiction (UNEP, 2012). Oceans are seen as "development spaces," seeking to shift away from traditional views of the oceans as places for free resource extraction and waste dumping (UNEP, 2012). Through this approach, the BE offers the potential to reinvest in sustainable human development while simultaneously reducing environmental risks and resource scarcity (UNEP, 2012; Cusack, et al., 2019; Corazon & Ebarvia, 2016; Choudhary, et al., 2021).

3.2. The Funding Gap

In 2019 the "BlueInvest" platform was published by the European Commission (Addamo, Calvo Santos, & Guillén, 2022). The platform aims at fostering EU financing for the BE through offering support to institutions that aim at promoting innovative thinking in the sector. According to the BlueInvest investment platform in 2022 over 300 companies are seeking financial support to promote their products and services (Addamo, Calvo Santos, & Guillén, 2022). Although financial government initiatives exist, the BE sector remains an industry facing significant gaps in funding (Addamo, Calvo Santos, & Guillén, 2022). Despite the efforts to fulfill the targets of SDG 14 "Life Below Water", only 25% of the funding goals of 2020 have been met by 2022 (World Economic Forum, 2022). According to the European Commission (2022), in 2019 EUR 6,1 billion are invested in tangible goods in the BE, generating an investment ratio of 3%. The failure to achieve the targets of SDG14 is the result of the low supply of securing and leveraging funding in the short-term (World Economic Forum, 2022).

Ocean degradation is an ongoing fast-moving process that urgently needs to be addressed. To effectively address this issue, an annual amount of approx. USD 174 billion is needed (Thompson, 2022). There needs to be more than the sole provision of governmental funding to close the funding gap in the BE (Sumaila, Konar, & Hart , 2020b). Rashi Sumaila, (2020b), Professor in Interdisciplinary Ocean and Fisheries Economics, states that the BE has been forecasted to have the potential to generate USD 3 trillion annually by 2030 (pre-pandemic forecast). According to Sumaila's (2020b) research, the total invested capital in the ocean economy in 2020 was as low as 1% of the ocean economy's total value. As of 2020, only USD 13 billion have been invested into the sustainable ocean economy over the previous ten years through philanthropy and official development assistance (Sumaila, Konar, & Hart , 2020b). Although the BE is a USD 1.5 trillion economy as of 2019, there remains a significant funding gap (Sumaila, Konar, & Hart , 2020b). The study by the Paulson Institute shows that stopping the continuous decline in total biodiversity by 2030 requires an amount equaling USD 722-967 billion for a minimum of 10 years (Baildon, et al., 2020). With USD 124-143 billion in financial flows into biodiversity globally, there is a global funding gap of an average of USD 598 billion to USD 824 billion annually. The precise number of the existing funding gap in marine biodiversity is unclear. However, it is assumed to be significant in achieving the goals of the SDGs of the UN and in mitigating climate change (Sumaila, Konar, & Hart , 2020b; Thompson, 2022; World Economic Forum, 2022). The creation of negative externalities supports further compounding of these issues. Around USD 22 billion of USD 35 billion that is invested into global marine fisheries annually are used to support harmful fishery subsidies (Sumaila, Konar, & Hart , 2020b). Therefore, there is a general need for possible plugs to close the finance gap, including exploring new financing mechanisms and tools (Thompson, 2022).

3.3. Impact Investing

Impact Investment is a financial investment strategy, sometimes referred to as an own asset class and the attempt of the leaders in finance and philanthropy to connect financial instruments to solving the world’s biggest challenges (Harji & Jackson, 2012; Schramm, 2023). Thus, Impact Investment describes the connection between the traditional view on finance and philanthropic objectives (Höchstädter & Scheck, 2014; GIIN, 2022; Schramm, 2023). The aim is to invest, and generate financial returns, while addressing environmental challenges and social well-being (Höchstädter & Scheck, 2014; GIIN, 2022; Schramm, 2023). The spectrum of impact can vary from addressing educational issues to fighting pollution to supporting biodiversity in ocean & coastal zones (IRIS+, 2022). Impact themes can be interconnected across distinct categories if the main objective is met; **positive impact**. Impact Investments are often project-specific, targeting a range of returns that can vary from below-market rates to above-market returns (Höchstädter & Scheck, 2014).

Impact Investment is a young asset class; the term first being used in 2007 at the meeting of the Rockefeller Foundation (Rockefeller Philanthropy Advisors, 2022). Despite its recent appearance, the impact investing market in 2020 is estimated to be USD 715 billion globally (ImpactDatabase, 2019). Various estimations of the European impact investing market size exist; the Eurosif states EUR 108.6 bn, EVPA EUR 6,5 bn and the GIIN EUR 11,8 bn (ImpactDatabase, 2019). The interest and engagement in impact investing continues to increase over time (ImpactDatabase, 2019).

Impact investing attracts a wide range of investors and institutions, such as traditional investors, philanthropic organisations, and development finance institutions:

Figure 2 – Impact Investing Sphere

Source: Own illustration based on (ImpactDatabase, 2019)

A detailed overview of the key players in impact investing is provided in Appendix 4. Asset Managers are significant players in impact investing and are directly related to philanthropic organisations, social impact funds, development finance institutions and family offices (ImpactDatabase, 2019). Asset managers and family offices often connect with philanthropic organisations to support impact investing initiatives in particularly underfunded areas (ImpactDatabase, 2019). Asset managers often interact with social impact funds to provide expertise for early-stage and growth-stage companies that work on critical social and environmental challenges (ImpactDatabase, 2019). Asset managers partner with development finance institutions to access capital and technical support to integrate into their impact investment initiatives (ImpactDatabase, 2019).

3.3.1. Tools for Investment

Impact Investing in the BE offers a range of different tools that have the potential to close the existing funding gap. Such tools include blue bonds, a sub-branch of green bonds, social impact bonds, marine protected area funds, crowdfunding, venture capital, and philanthropic capital (Thompson, 2022). All tools, their description, advantages and limitations can be summarised as follows:

Table 1 – Impact Investment Financing Tools

Impact Investment Tool	Description	Advantages	Limitations	Target Sectors / Examples
Blue Bonds	Bonds financing ocean conservation and sustainable ocean-based industries and practices	Targeted use of funds, public-private partnership, impact measurement, repayment based on performance, risk mitigation	Limited experience and market size, potential complexity in structuring and implementing projects	Ocean conservation, sustainable fishing, marine renewable energy, aquaculture
Green Bonds	Bonds financing projects aimed at mitigating or adapting to the impacts of climate change	Aligns private capital with public goals, well-established market, established impact reporting and verification standards	High minimum investment thresholds, limited availability for small and medium-sized enterprises	Renewable energy, energy efficiency, sustainable transportation, deforestation
Social Impact Bonds	Pay-for-success financing mechanism that aligns private capital with public goals	Aligns private capital with public goals, potential to attract private investment for public projects, risk sharing between public and private sectors	Complexity of structuring and implementing projects, uncertain financial returns, limited market size	Education, health, poverty alleviation, environmental conservation
Marine Protected Area Funds	Dedicated funds used to finance the creation, management, and monitoring of marine protected areas	Dedicated funding source for marine protected areas, risk sharing between public and private sectors, potential to attract private investment for public projects	Limited market size, complexity of structuring and implementing projects	Marine protected areas, ocean conservation
Crowdfunding	Platforms that raise small amounts of capital from a large number of people	Access to large pool of capital, easy to launch and promote projects, low minimum investment threshold	Difficulty in attracting large amounts of capital, limited due diligence and verification of impact	Renewable energy, sustainable agriculture, conservation, social enterprises
Venture Capital	Capital provided to startups for growth and expansion	Access to large amounts of capital, potential for high financial returns, support for innovation and growth	High risk, limited focus on environmental and social impact	Clean technology, sustainable agriculture, conservation
Philanthropic Capital	Grants and charitable donations	Flexibility in use of funds, no repayment required, support for innovation and growth	Limited funding source, limited ability to leverage additional capital, limited focus on environmental and social impact	Conservation, environmental education, scientific research

Source: Own Illustration based on (Thompson, 2022)

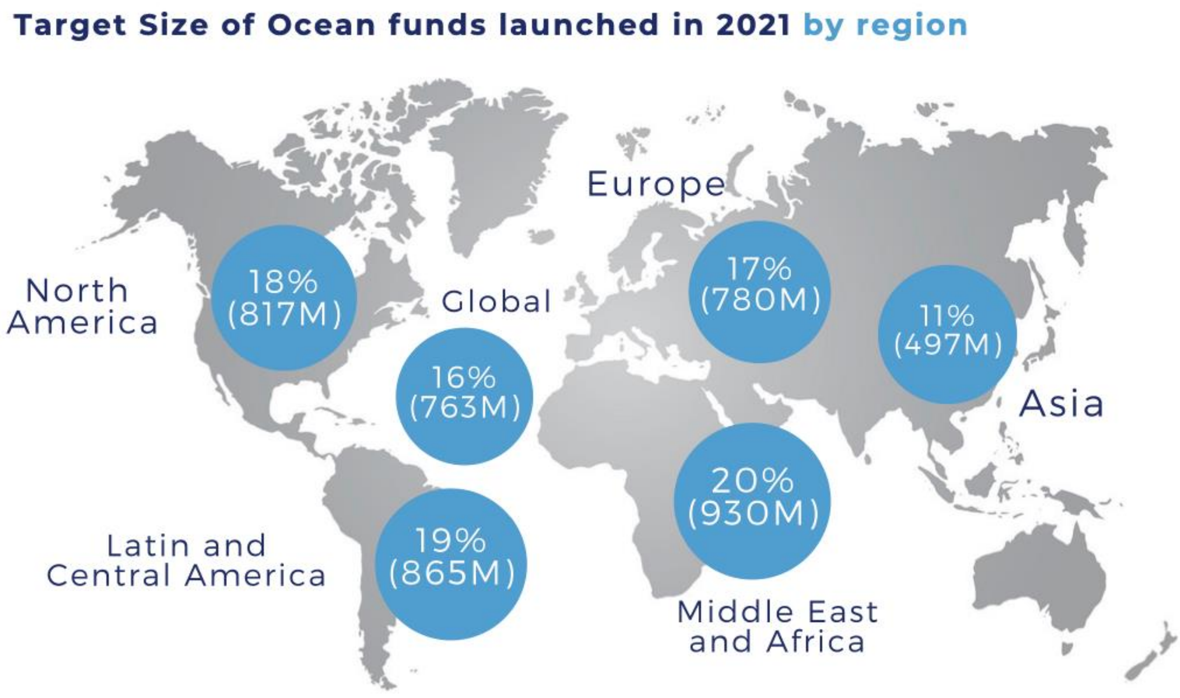
Mainly blue bonds were designed to finance sustainable ocean economies and conservation projects (Thompson, 2022). Commonly, blue bonds are strongly aligned with the SDGs of the UN, specifically SDG 14 (Thompson, 2022). A blue bond is a debt instrument a government or development bank issued. Alternatively, a blue bond can also be raised funds from investors in the blue economy sphere (Thompson, 2022).

Given the size and the pressing need for private investment in sustainable ocean-based industries and conservation initiatives within the BE, the industry offers significant potential for impact investment (Thompson, 2022). Impact investing in the BE simultaneously provides attractive financial returns for investors while delivering positive social and environmental impact (Ocean Panel, 2021). To effectively leverage impact investing in the BE, there is a general need for well-structured investment vehicles, proper measurement and transparent reporting, and collaboration between stakeholders (Phenix Capital, 2021). Aligning impact investing with the needs of the BE may support the growth of sustainable ocean-based industries and turn impact investing into a critical force in addressing the ocean's pressing challenges (Phenix Capital, 2021).

3.3.2. Ocean Impact Investment Funds

The Impact Database of Phenix Capital (2021) shows that at the end of 2021, a total of EUR 6 bn in capital has been committed towards ocean funds since 2015. The most significant contributor in 2021 to ocean financing is the Middle East and Africa, with 930 million EUR invested:

Figure 3 – Target Size of Ocean funds launched in 2021 by region



Source: (Phenix Capital, 2021)

As of 2022, 221 funds, of which 196 funds were established in Europe, with a total of 37,604 million EUR, are targeting the BE (Phenix Capital, 2021). As stated by the High-Level Panel for a Sustainable Ocean Economy-commissioned research (2021), every USD invested in an ocean-themed fund can generate a minimum of 5 USD in sustainable impact by 2050. Simultaneously investments in ocean-based climate actions can potentially cut 21% of annual greenhouse gas emissions by 2050 (Ocean Panel, 2021). Therefore, ocean-based funds are a critical tool in targeting the SDGs of the UN.

The strategy behind impact investing ocean-based funds is to target innovations that promote the achievement of SDG 14, "Life below Water", as stated by the Co-Managing Directors of the SWEN Blue Ocean Fund (Phenix Capital, 2021). While Impact Investing combines traditional financial strategies with philanthropic objectives, systemic impact and competitive market returns are simultaneously important in potential portfolio companies (Phenix Capital, 2021). The three main targets of an ocean-based impact investing fund are innovations that tackle overfishing, ocean pollution, and climate change (Phenix Capital, 2021).

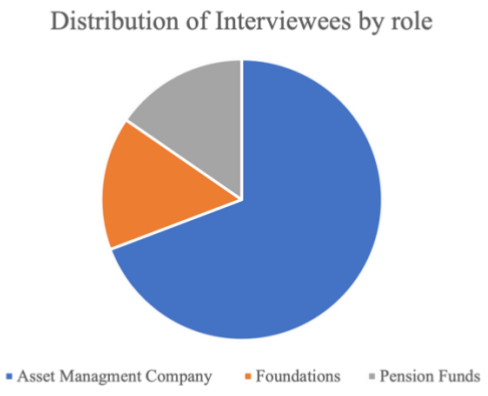
3.4. An Expert Perspective on the Blue Economy

The Impact Database is an attempt in summarizing all Impact Investment related institutions of Europe (ImpactDatabase, 2019). From the total of 452 entities, 72 (16%) connect themselves to SDG 14 and are divided into different categories as presented in Appendix 3. The 72 institutions can be subdivided into 16 categories ranging from Networks to asset management companies (see Appendix 3).

An expert interview with 13 key stakeholders[1] in the impact investing market was conducted. Nine stakeholders are Asset Managers, two are Foundations, and two are Pension funds:

Figure 4 – Distribution of Interviewees by role

[1] Due to the private nature of the impact investment industry, interviews were conducted anonymously for this research by request of the interviewee



Source: Own illustration

All interviewees connect themselves to SDG 14, "Life below Water"; five have or plan to directly invest in investment opportunities related to SDG 14. The remaining 8 institutions are only indirectly connected to SDG 14. All interviewees have stated that their primary focus and driver as impact investors is to support and finance sustainable businesses that generate financial returns and create positive social and environmental impacts.

8 of the interviewees were familiar with the concept of a BE. The BE is generally seen as a potential investment opportunity within the realm of impact investing; however, at this point not being sufficiently explored. All 8 interviewees that know about the BE concept believe that it presents a significant opportunity for investment due to its growth potential and positive impact on ocean conservation, sustainable development, and job creation, particularly in SIDS.

The interviewees were further questioned about their views on the future growth and evolution of the BE, specifically within the context of impact investing. The common understanding is that the BE has the potential to be a significant player in the impact investing industry, given its focus on sustainable and responsible development and management of ocean-based industries and resources. 3 interviewees stated that they have invested in the aquaculture sector. At the same time, two were open to exploring it as a potential investment area.

Finally, the interviewees were questioned about their perspectives on the risks and constraints that the BE faces, such as the scarcity of data and information about the scope and potential of the sector as well as the limited experience with investing. To address these issues and advance sustainable development, the experts emphasised the need for more collaboration and cooperation among important parties.

The comments on the BE are generally hopeful and supportive, underlining its potential for development and sustainability as well as its favourable effects on coastal towns and the ocean. To realise the industry's full potential, however, a number of issues related to it must be resolved. Although there are numerous viewpoints about the BE, there is still a lack of data in this sector, making it difficult to estimate its impact.Most impact investors of the survey have increased their efforts to assess impact properly; however, it remains a somewhat unregulated industry.

3.5. The Transition of an Ocean Economy to a Blue Economy

The findings of the meta-analysis on the BE (Appendix 1) show that the BE concept is an approach to align the ocean economy, based on its conventional methods, with sustainability. On an environmental level, the BE is connected to de-carbonisation, restoration and ecological engineering of marine areas and coastal zones, environmental risk reduction and an ecosystem-based approach to oceans. The social benefits of the BE transition are connected to food security for all people, increased health and well-being initiatives, and the creation of social equity. A BE aims to turn economic growth into sustainable growth by contributing to sustainable investment opportunities and innovative sustainable projects through technological advances. As such the BE promotes social and environmental health and creates long-term sustainable employment. The positive environmental impacts, social benefits and economic feasibility of a BE are essential in reaching the SDGs of the UN by 2030 and 2050. Despite the risks and challenges , sustainable seaweed farming presents a large amount of benefits if it receives adequate funding and research.

4. Case Study: Sustainable Seaweed Farming

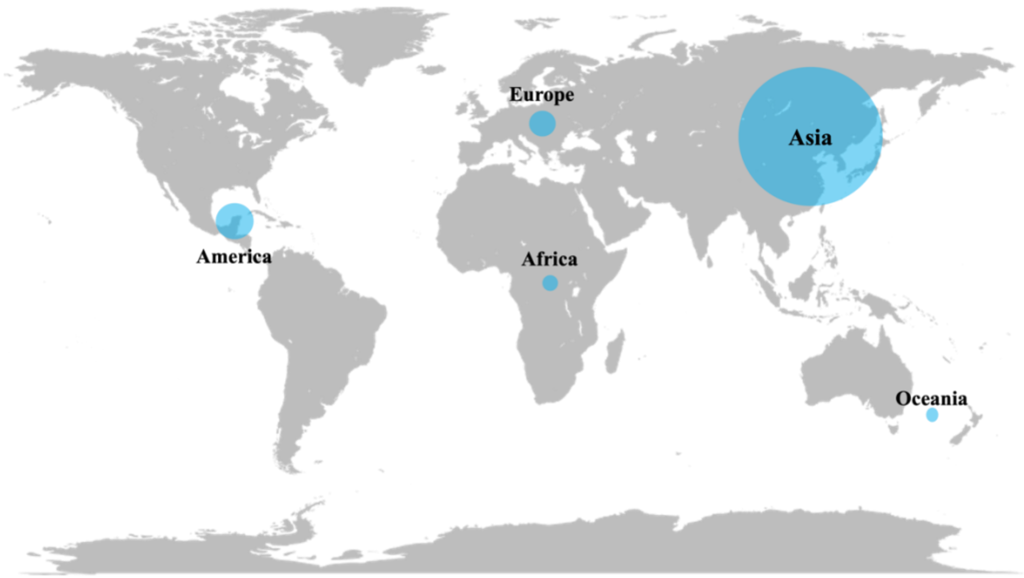
Seaweed is the common term for several species of algae, divided into three main species; red, green and brown algae (National Ocean Service, 2021). The algae appear in various water bodies, such as rivers, lakes and oceans. Seaweeds grow best when the water temperature is between 10 to 20°C, making a plant susceptible to various environments (van Hal, Huijgen, & Lopez-Contreras, 2014). Seaweed is a "bonafide misnomer", a weed that spreads in a way that can harm the habitat it grows in. Simultaneously, fixed and free-floating seaweeds provide essential food and habitat sources to a vast number of marine creatures (National Ocean Service, 2021). The consumption of seaweed as a source of food and medicine for humans goes back to ancient times, around 1500 years, when the Japanese incorporated the seaweed "nori" into what is known today as the "sushi roll" (Jagtap & Meena, 2022; National Ocean Service, 2021). Due to its biodiversity, 145 species are used in food production worldwide, whereas 110 species are cultivated to be used in gelling agent production (Jagtap & Meena, 2022).

Seaweed farming is seen as a growing market (FAO, 2021) and profitable industry with ecological and economic significance, having the potential to create "blue" employment and being a cost-effective source for food and agriculture, pharmaceuticals, cosmetics, and energy (Jagtap & Meena, 2022; Amosu, Robertson-Andersson, Maneveldt, Anderson, & Bolton, 2013). Besides its commercial use cases, Seaweeds also provide several environmental and social benefits (Sultana, 2022).

4.1. Global Seaweed Market

The global Seaweed industry is dominated by the Asian market, covering 97% of total Seaweed production, followed by America representing 1,36%, Europe at 0,8% and Africa and Oceania below 0,5% of global Seaweed production (FAO, 2021):

Figure 5 - Global Seaweed Production



Source: Own illustration based on (FAO, 2021)

Asia Pacific constitutes the largest market share for seaweed, driven by the exceptionally high demand for seaweed-based supplements and its far-spread usage within foods. There has been a constant increase in seaweed production from 1950 to 2019 (FAO, 2021). Asian production grew by 133% on average every ten years since 1950, American production by 23%, European by 5%, Africa by 60% and Oceania by 235% (FAO, 2021). In 2022 the global market value of the Seaweed Industry was estimated to range between USD 7.5 to USD 8 billion (Seaweed Solutions, 2022; imarc Group, 2022). The Seaweed Industry is forecasted to grow by an average CAGR of 9.5% from 2020 until 2028 (Seaweed Solutions, 2022; imarc Group, 2022). A study by Mintel (2016) found that the product range of seaweed-induced foods and drinks increased by 147% in Europe from 2011 to 2015. Similar observations of a increasing demand for seaweed in 2022 was observed by the European Commission (2022). The demand for Seaweed in Europe as of 2023 continues to grow, as can be seen in the revised data of the import value of Seaweed in Europe (Appendix 5), driving market growth further (Statista, 2023).

The market for seaweed can be segmented into different types (red, green and brown algae), its application (food, pharmaceuticals, energy, and cosmetics), and region (Asia Pacific, North America, Europe, South America, and Middle East & Africa) (imarc Group, 2022). However, the largest and fastest-growing industry segment is food, as the demand for seaweed-based food and supplements continues to grow (Statista, 2023).

The biggest challenges the growth of the global seaweed market faces are its limited awareness, high production costs, and regulatory restrictions (imarc Group, 2022). On the contrary, the demand for sustainable and natural products increases, along with growing health and wellness trends providing significant opportunities for the industry. A decrease in the import value of Seaweed in Europe can be observed from 2019 to 2020, when imports decreased by 9% (Statista, 2023). In 2021 imports exceeded pre-pandemic levels and rose by 28% (Statista, 2023). Further demand-boosting factors within Europe are the European commission's proposal to implement 23 actions that create opportunities for the algae industry, as seaweed products are expected to reach EUR 9 billion in 2030 (European Commission, 2022). As a result, an increase in the import value of seaweed can is observable in Europe, with an average increase in the import value of 5% from 2012 to 2021 (Statista, 2023).

4.2. An Environmental Perspective of Seaweed Farming

Seaweed farming is declared to be one of the least environmentally damaging forms of aquaculture and agriculture (Jagtap & Meena, 2022). Seaweed farming has the potential to mitigate climate change through its various characteristics. Seaweed has de-carbonising properties, e.g. seaweed absorbs carbon from the atmosphere through captivation and storage of emissions (Jagtap & Meena, 2022; Fröhlich, Afflerbach, Frazier, & Halpern, 2019).

According to the Seaweed company, one ton of seaweed can absorb 120kg of CO2 emissions, 2kg of nitrogen (N2O) and 0,2kg of phosphorus (The Seaweed Company, 2022). The seaweed population in world waters is estimated to store 175 million tons of carbon dioxide in 2022 (Marine Conservation Society, 2022).

Seaweed aquaculture is further known to support buffering eutrophication in hypoxic and acidic waters (Fröhlich, Afflerbach, Frazier, & Halpern, 2019). Seaweeds are used in natural oxygenation cycles and waste purification. In addition to being a crucial source of protein, algae can also be utilised in substitute of conventional goods like plastic and animal feed. Since seaweed grows quickly and can be picked frequently throughout the year, it is seen as a renewable source of food (van Hal, Huijgen, & Lopez-Contreras, 2014). As a bioresource in marine aquaculture, algae is not competing with terrestrial crops and does not require fertilisers, pesticides, land and freshwater. Approximately 48 million km^2 of oceans provide the necessities for seaweed aquaculture (Fröhlich, Afflerbach, Frazier, & Halpern, 2019). Besides its commercial use cases, seaweed also provides homes and food security to many marine organisms and support the restoration of ocean and coastal zones (Sultana, 2022). The recycling of nutrients allows seaweed to generate biomass yields with increased protein contents (Sultana, 2022). Biomass can be used to improve soil and plant health on land and increase the quality of animal nutrition (Sultana, 2022).

4.3. A Socio-Economic Perspective of Seaweed Farming

Seaweed farming is said to have various socio-economic impacts on all stakeholders. Stakeholders vary from rural communities to consumers, producers and industries, being directly affected, while seaweed farming indirectly affect all kinds of communities on a global level.

4.3.1. Worldwide

The population of the world is predicted to surpass 8.5 billion by 2030 and to continue growing to 9.7 billion by 2050 (OECD, 2016). 98% of global food supplies come from agriculture on land, although 70% of the world’s surface consists of oceans and coastal areas. With an increase in people, the inelastic demand for food increases simultaneously. Due to their nutritional characteristics, seaweeds provide an important alternative source for food security. Seaweeds are an alternative protein to meat and fish products as they are nutritionally rich (Steenbergen, Marlessy , & Holle, 2017). Furthermore, sustainable seaweed farming increases water quality in coastal zones where it is sustainably grown and adds to general health and well-being (Steenbergen, Marlessy , & Holle, 2017).

4.3.2. Community Development

Seaweed farming is often addressed as being socially beneficial, specifically for rural communities (Steenbergen, Marlessy , & Holle, 2017). Women empowerment is an important topic when it comes to seaweed farming, as the seaweed industry is a largely female-led industry and often gendered work (Steenbergen, Marlessy , & Holle, 2017). Whereas men tend to work in the fishing industry commonly, women are often left with the work in seaweed farms, being directly interconnected with SDG 5 (Jagtap & Meena, 2022). The role of women in seaweed farming raises their status within communities and significantly reduces inequalities between men and women (Sultana, 2022). Through women contributing to their household economies, women impact community development (Duarte, Bruhn , & Krause-Jensen, 2023). As a global development variable, women's empowerment leads to increased gender equity in rural communities (Malhotra & Schuler, 2002). Another example is the social inclusion of indigenous people, as seaweed farming is prevalent in coastal areas and adds to community development (Jagtap & Meena, 2022). Direct involvement in either aquaculture or the consumption of locally-grown seaweeds will eventually lead to increased connectedness to the environment, teaching about simple laws of demand and supply and sustainability (Sultana, 2022). The seaweed industry offers a range of new skill sets and employment pathways, particularly in regional areas (Farghali, Mohamed, Osman, & Rooney, 2022). By creating rural and urban jobs in the seaweed industry and supply chains, the livelihoods of local coastal communities can become more diverse (Farghali, Mohamed, Osman, & Rooney, 2022). According to the OECD (2016), the industrial and marine aquaculture compound annual growth rate between 2010 and 2030 is 5,69%, leading to a change in the industry's total growth from 303% from 2010 to 2030 and an increase in employment of 152%.

Aquaculture may lead to new tourism experiences and boost coastal economies (Thau Lym Yong, Thien, & Rup, 2022). The regulation and support of services enhanced by aquaculture will benefit ecotourism and recreation of coastal waters (Thau Lym Yong, Thien, & Rup, 2022). The environmentally beneficial characteristics of seaweed farming make other industries, such as aquaculture and agriculture, more sustainable. Seaweed species are generally fast-growing organisms and offer regular harvesting opportunities and create new market opportunities (Araujo, Morais, Cotas, & Garcia-Poza, 2022). With increasing economically sustainable growth attributes, there is an increasing need for reasonable supportive regulations, such as ensuring water safety controls to guarantee safe seaweed cultivation (Araujo, Morais, Cotas, & Garcia-Poza, 2022).

4.3.3. Consumers / Producers / Industries

Algae has the potential to prevent individuals from various diseases, as it can be used in a large variety of medications and will support overall well-being (Jagtap & Meena, 2022). In terms of industries, seaweeds can potentially add to sustainable development in other industries. One example is the support of fisheries through seaweed farms, as algae provide an essential food source for various ocean organisms leading to fish aggregation in the long term (Araujo, Morais, Cotas, & Garcia-Poza, 2022). Furthermore, seaweeds can be used in products such as animal feed and fertilisers as an alternative raw material for agriculture and the livestock industry (Araujo, Morais, Cotas, & Garcia-Poza, 2022). Seaweeds represent an organic, healthy, nutritious raw material and can act as biomass (Araujo, Morais, Cotas, & Garcia-Poza, 2022).

Seaweeds have the potential to be low in production costs. Yet, the biological yield of seaweed and the distance between the farm and the shoreline have a significant impact on production costs (Kite-Powell, et al., 2022). Whereas seaweed farmed in temperate climates is thought to cost between $250 and $300 per dry tonne, seaweed grown in tropical regions is predicted to cost between $200 and $250 per dry tonne (Kite-Powell, et al., 2022). Only in situations where there is less than a 50km distance between the farm and the shoreline can production costs of USD 100 per dry tonne be reached (Kite-Powell, et al., 2022). Therefore, the price per tonne of seaweed varies as it depends on the scale of farming. With mostly small-scale farms operating around Europe, ph control methods and organic acid are commonly used to kill epiphytes and competing organisms and reduce the risk of harmful algal bloom (HAB).

Mainly (technological) innovations are essential to boost all positive, sustainable economic attributes of seaweed farming. While simultaneously, there is an increased need for safe infrastructure, benefiting local communities through higher accessibility to other communities (Araujo, Morais, Cotas, & Garcia-Poza, 2022).

4.4. Seaweed Farming and SDGs: Risks and Challenges

The seaweed industry is rapidly growing with the potential for environmental, social and economic benefits. However, the industry faces various internal and external risks. Risks appear in all three main sectors, varying from environmental threats and future shocks caused by rising temperatures, pandemics and recessions to social acceptance or legal limitations (Fröhlich, Afflerbach, Frazier, & Halpern, 2019).

Seaweed farming operations typically involve the usage of longlines and ropes, posing a hazard to marine mammals such as dolphins and whales (The Seaweed Company, 2022). Marine mammal entanglement has been well documented in the literature and needs to be mitigated in the future using the implementation of best practices for gear design (Campbell , Macleod, & Sahlm, 2019; Ferdous & Yusof, 2022).

Another important risk is the introduction of non-native species through seaweed farming (Spillias, Cottrell, & Kelly, 2022). Not only can invasive species outcompete native seaweeds, but they also alter ecosystem dynamics and reduce biodiversity (Spillias, Cottrell, & Kelly, 2022; Bjerregaard, Valderrama, Radulovich, Diana, & Capron, 2016; Zhang, Liao, Huang, & Yaoy, 2022). Invasive species can range from poisonous algae to cholera and countless plants or animals that enter harbour waters and disrupt the ecological balance of coastal ecosystems and other waters (Zhang, Liao, Huang, & Yaoy, 2022; Golberg, et al., 2021). The productivity of seaweed farms can be reduced by introducing such species, leading to financial losses for farmers (Ross, Tarbuck, & Macreadie, 2022; Araujo, Morais, Cotas, & Garcia-Poza, 2022). Monitoring programs and strict regulations are needed to prevent the spread of harmful algal bloom (HAB) (Jagtap & Meena, 2022).

The costs associated with seaweed farming are highly dependent on various economic factors. Specifically, the scale of farming correlates with the cost-effectiveness of farming operations (Fröhlich, Afflerbach, Frazier, & Halpern, 2019). Growth in the sector will increase productivity and support economies of scale (Fröhlich, Afflerbach, Frazier, & Halpern, 2019; Gallagher, Shelamoff, & Layton, 2022). When introducing non-endemic species of seaweed into ecosystems, there is a high need for ph control methods and organic acid control, which are costly but necessary to kill epiphytes and competing organisms (Gallagher, Shelamoff, & Layton, 2022; Jones, et al., 2022; Ross, Tarbuck, & Macreadie, 2022). Other economic factors can be costs of seeds, equipment costs and labour, often intertwined with other risks (marine mammal entanglement as an example). All factors influence the long-term financial viability of seaweed farmers and impact coastal economies (Ross, Tarbuck, & Macreadie, 2022).

The accessibility of technologies and tools for seaweed farming is another risk factor. Seaweed farming, being a new industry, has less access to (sustainable) technologies and tools as they are still under development (Zhang, Liao, Huang, & Yaoy, 2022). More research and development are needed to improve the accessibility and affordability of seaweed farming technologies (Zhang, Liao, Huang, & Yaoy, 2022; Farghali, Mohamed, Osman, & Rooney, 2022).

The world is facing several repercussions as of 2023 due to previous events, such as the 2021 supply chain crisis that emerged from the covid-19 pandemic (J.P. Morgan, 2022) and global warming, causing rising sea levels, which will remain to be an issue in the future (National Geographic, 2022). Furthermore, further future shocks and threats are risks that the seaweed industry will have to face, such as air pollution and contaminated nutrients entering world waters, invasive species that disrupt ecological balances on marine life, pesticides in agriculture ending up in the ocean and oil spills discharged by water-sewage treatment plants (National Geographic, 2022).

The potential of seaweed to cause public health threats is a substantial risk to consider and caused by, for example, invasive species causing HAB (Araujo, Morais, Cotas, & Garcia-Poza, 2022). In addition, usually triggered by the rapid growth of certain seaweeds, certain types of harmful algae can occur simultaneously with seaweeds and release harmful toxic compounds (Araujo, Morais, Cotas, & Garcia-Poza, 2022; Bjerregaard, Valderrama, Radulovich, Diana, & Capron, 2016).

Seaweed farming operations require permits and are subject to various regulations. Harvesting seaweeds from natural habitats are particularly dangerous from an ecological point of view. Uncontrolled wild harvesting is a hazard for ecosystems as it can destroy them (Hasselström & Thomas, 2022). Therefore, obtaining and maintaining necessary permits and licenses and complying with regulations can be challenging and increase production (Koksvik & Myskja, 2022; Hasselström & Thomas, 2022). Furthermore, implementing such regulations is an additional cost for already poor local authorities, while there is a need for risk management of economic and social impacts (Araujo, Morais, Cotas, & Garcia-Poza, 2022). While it is unlikely for a small farm to have significant negative externalities, vast farms or a high frequency of farms arranged next to each other have the potential to have noticeable effects (Araujo, Morais, Cotas, & Garcia-Poza, 2022). Furthermore, weak and poorly designed policies lead to poor management of resources, such as the proper distribution of financial support initiatives from government budgets (Behera, Vadodariya, Veeragurunathan, & Sigamani, 2022).

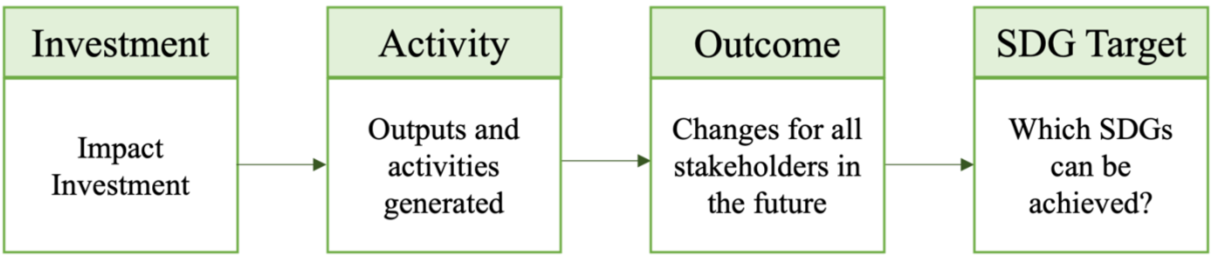
Many risks are directly associated with knowledge gaps; for example, as of 2023, it is not clear what ecological implications deep-sea biomass dumping for carbon sequestration has in the future (Fröhlich, Afflerbach, Frazier, & Halpern, 2019; Spillias, Cottrell, & Kelly, 2022). It is unknown if the nutrients absorbed by seaweeds are contaminated with heavy metals, killing marine plants and shellfish and producing oxygen depletion (Fröhlich, Afflerbach, Frazier, & Halpern, 2019). It is further unknown how climate change, causing storms, typhoons, ocean warming, and earthquakes, will affect seaweed farming (Spillias, Cottrell, & Kelly, 2022; Ricart, 2022; Gallagher, Shelamoff, & Layton, 2022).

4.5. Determining Impact Metrics of Seaweed Farming and their Influence on SDGs

The study will present and critically evaluate the research question's empirical findings: "How can Impact Investment promote sustainable seaweed farming?”. This section will build on the literature review and data collected to provide a comprehensive analysis of the current state of the sustainable seaweed farming industry and its applicability to a BE. The section will further evaluate the effectiveness of impact investing as an investment tool in promoting environmental, social and economic positive impact in the sustainable seaweed industry from a qualitative point of view.

The meta-analysis on seaweed farming has shown that long and short-term funding in the industry is necessary to guarantee it being sustainable in the long-term. Funding will add to the maintenance of genetic diversity in wild stocks of seaweeds; incentivise biosecurity practices, foster worldwide carbon capturing, safeguards food sources and reduces climate destruction. Impact investment, a financial strategy combining positive impact with financial returns, is a powerful tool to grow the seaweed industry as a sustainable practice under the BE. An impact metrics model is being applied to the industry to align impact investment and seaweed farming:

Figure 6 – Impact Metrics Model



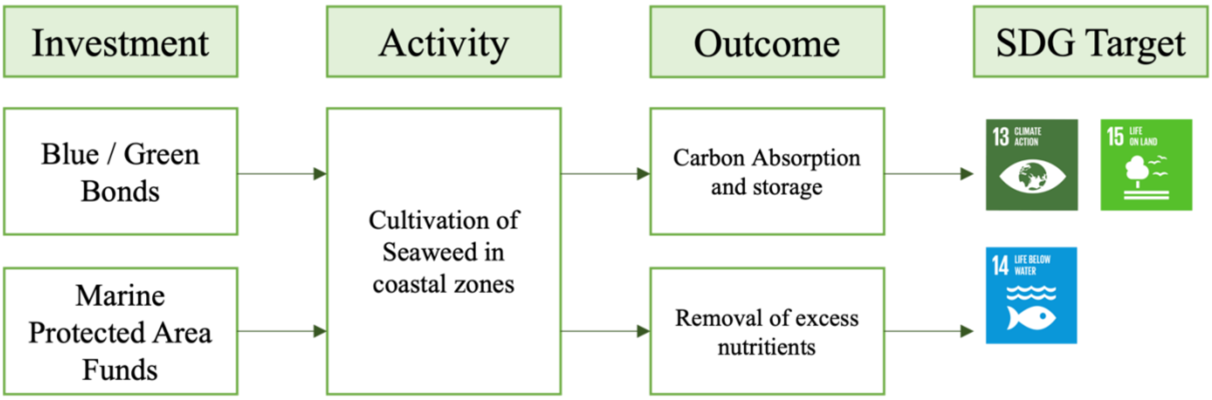
Source: Own Illustration based on (IRIS+, 2022)

The meta-analysis of 25 research publications on seaweed farming and four sustainable seaweed businesses revealed a strong correlation between seaweed farming and favourable social, economic, and environmental effects (see Appendix 2).

4.5.1. Assessment of Environmental Impact

The meta-analysis on beneficial environmental impacts suggests that seaweed farming has many potential benefits and positive impacts. The most prominent impact is the replacement of traditional non-renewable resources, as identified by 79% of studies. Additionally, 79% of studies mention the removal of excess nutrients through seaweed cultivation (79%) and its carbon sequestration characteristics (79%) as beneficial impacts for the environment. The outcome of investing in the seaweed industry will lead to the cultivation of seaweed in coastal zones and result in the outcome of carbon absorption and storage, which in turn will promote the achievement of the SDG targets 13, 14 and 15 (figure 7). In particular, blue and green bonds, as well as Marine Protected Area Funds, can be valuable tools in financing the cultivation of seaweeds in coastal zones:

Figure 7 - Environmental Impact



Source: Own Illustration

If one tonne of seaweed can absorb 120kg of CO_2 emissions in 2020, cultivated seaweed would be capable of absorbing 0,012190% of total global carbon emissions:

Table 2 – CO2 Emissions Absorption in comparison to global Seaweed Production

CO2 emissions	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**
Production Value Seaweed	550.810,00	1.321.330,00	2.206.140,00	4.102.920,00	5.531.800,00	11.798.930,00	21.240.430,00	35.817.361,00
Global CO2 emissions in bn tons	6,00	9,39	14,90	19,50	22,76	24,45	33,36	35,26
% of CO2 emissions absorbed through Seaweed	0,001102%	0,001689%	0,001777%	0,002525%	0,002917%	0,005563%	0,007640%	0,012190%

Source: own illustration based on (FAO, 2021; Seaweed Solutions, 2022)

The potential absorption through seaweed of nitrogen (N2O) and phosphorus is presented in the following table:

Table 3 – Nitrogen and Phosphorus Absorption in comparison to global Seaweed Production

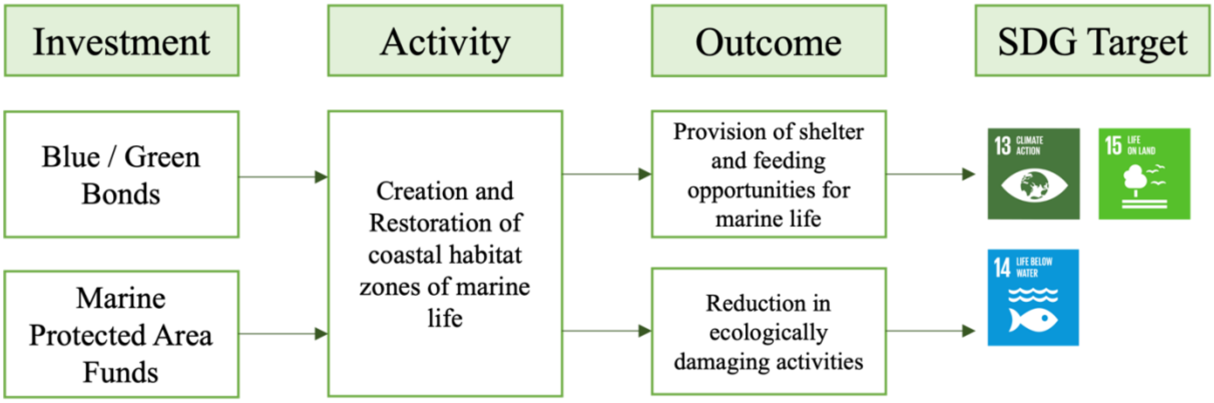
Year	1950	1960	1970	1980	1990	2000	2010	2020
Production Value Seaweed	550.810,00	1.321.330,00	2.206.140,00	4.102.920,00	5.531.800,00	11.798.930,00	21.240.430,00	35.817.361,00
Absorption of Nitrogen	1.101,62	2.642,66	4.412,28	8.205,84	11.063,60	23.597,86	42.480,86	71.634,72
Absorption of phosphorus	110,16	264,27	441,23	820,58	1.106,36	2.359,79	4.248,09	7.163,47

Source: own illustration based on (FAO, 2021; Seaweed Solutions, 2022)

However, 14% of investigated research states that carbon sequestration is not yet fully understood. 14% of studies state that either seaweed does not possess its de-carbonising properties as presented by many research in the field, the carbon sequestration effects are not sufficiently analysed or biased, or de-carbonising is only possible at large-scale production. In the industry’s current state within the cultivation process it produces as much CO2 emissions as it finally absorpes.

62% of analysed studies mention the potential of seaweed cultivation adding to the restoration of coastal and ocean zones as a positive environmental impact. This may result in the provision of shelter and feeding opportunities to marine life and simultaneously reduces the frequency of ecologically damaging activities:

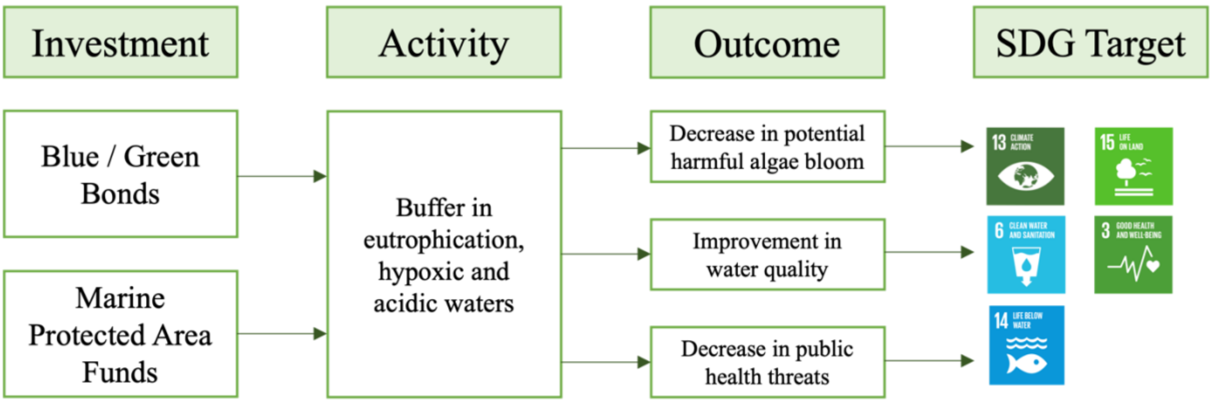
Figure 8 - Environmental Impact Restoration of coastal Habitat



Source: Own Illustration

Additionally, 52% of studies state that seaweed farming is a naturally occurring buffer for eutrophication in hypoxic and acidic waters. The flow of funds towards the cultivation of seaweed will buffer eutrophication and simultaneously decreases the risk of invasive species. Buffering acidic waters improve the overall water quality and decrease public health threats, benefiting not only SDG 14 but also 13, 15, 6 and 3:

Figure 9 - Environmental Impact Buffer in Eutrophication



Source: Own Illustration

3% argue that seaweed farming does not buffer eutrophication but instead increases its frequency. This suggests that more research is required to understand the potential impacts of seaweed farming on eutrophication.

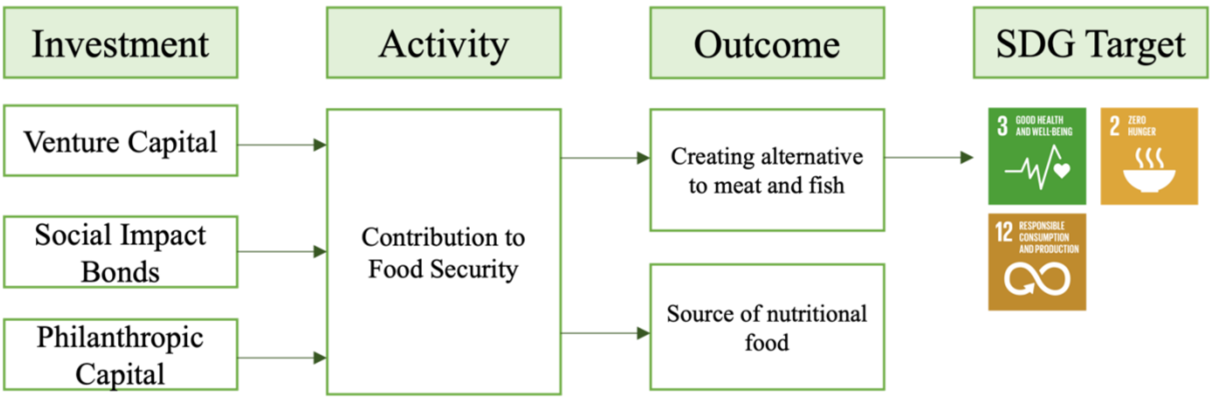
The preservation of species richness and resilience of ecosystems where seaweed is cultivated was mentioned in 45% of studies. Additionally, 38% of research highlights the biodiversity of seaweed, a plant with many species that can grow in different environments, making it a versatile plant. However, 3% argue that seaweed is not biodiverse due to current challenges such as poor growth environments, immature breeding, and a lack of technology. This finding suggests that seaweed farming is in need of more research to understand the potential impacts of seaweed farming on biodiversity.

Finally, 28% of studies highlight seaweed's preservative and chemical-free properties, as the algae does not require fertilisers or freshwater to grow. The study suggests that seaweed farming has the potential as an environmentally sustainable method adding to sustainable food production.

4.5.2. Assessment of Socio-Economic Impact

On a social impact level, sustainable seaweed farming has a range of potential benefits according to the meta-analysis. The most commonly highlighted social impact is the industry’s contribution to food security, mentioned by 97% of studies, with no studies arguing against. Furthermore, in 45% of studies, seaweed as a source of alternative protein is mentioned, highlighting its nutritional benefits as a food source. Which in turn supports the achievement of SDG targets 2, 3 and 12, as shown in figure 10:

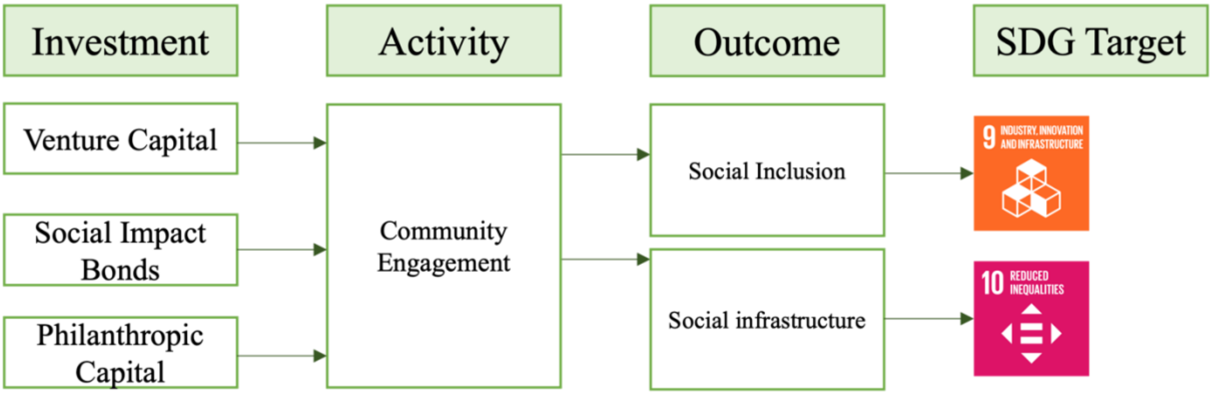
Figure 10 – Social Impact Contribution to Food Security



Source: Own Illustration

The factor "health & well-being" is mentioned by 72% of studies. Sustainable seaweed farming positively impacts health and well-being of individuals consuming it. In addition, 55% of studies cover social inclusion and 41% mention seaweed farming as being a factor that fosters community development and, therefore, pointing out it's potential in promoting social cohesion and community building:

Figure 11 – Social Impact Community Development

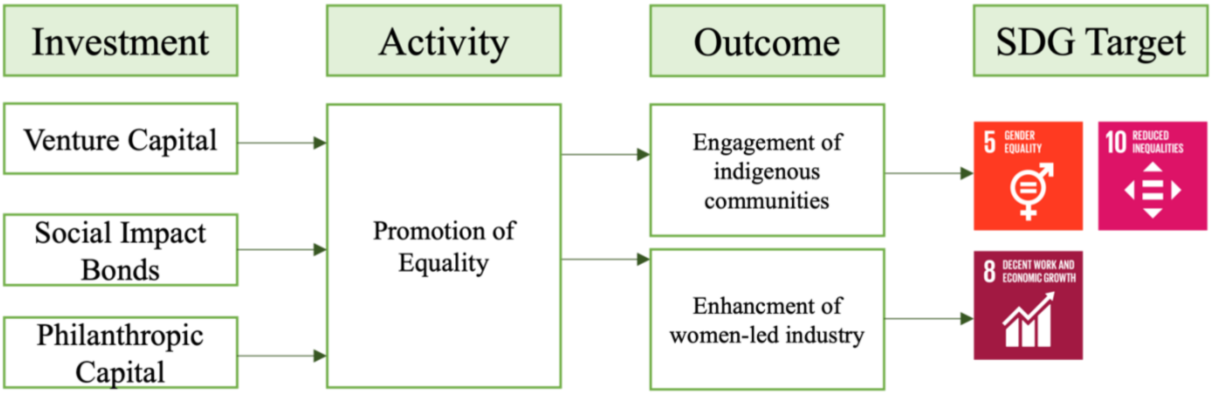


Source: Own Illustration

21% of studies mention seaweed farming in the context of the involvement of smaller groups, such as indigenous people, and that it promotes the inclusion of indigenous people in marine issues. However, 3% state that the increase in seaweed production demands an increase in technology investment to develop high-quality seaweed species and processing products. The increase in technology investment may be a burden to low-income areas.

Finally, 14% of studies mention that the enhancement of women's equality is the least often mentioned social impact of seaweed farming, however, its importance is highlighted in literature. The increase in gender equality through the involvement of women in community work is highlighted, however, requires more research:

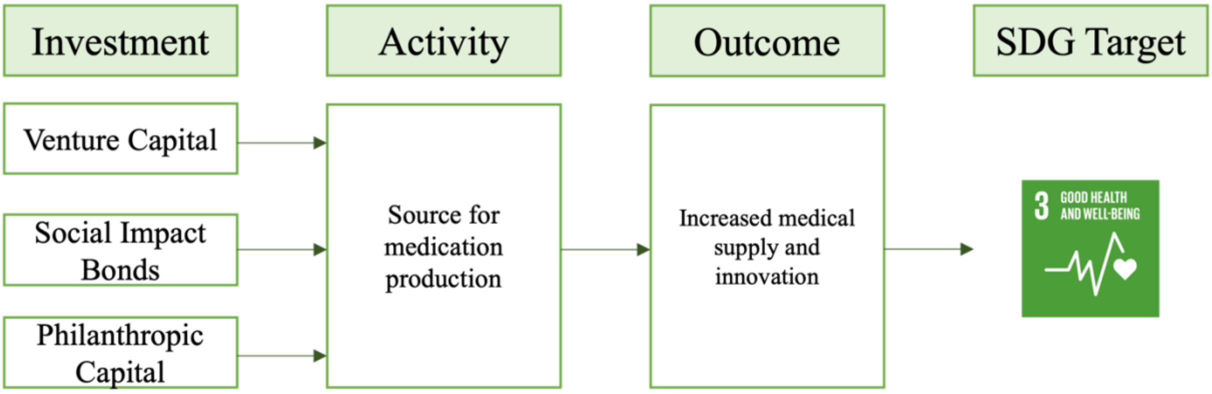
Figure 12 – Social Impact Promotion of Gender Equality



Source: Own Illustration

With an investment in the sustainable seaweed industry, the cultivation of seaweed will lead to an alternative source of medication and result in increased medical supply and innovation. Through financing medication production using seaweeds SDG 3 is targeted:

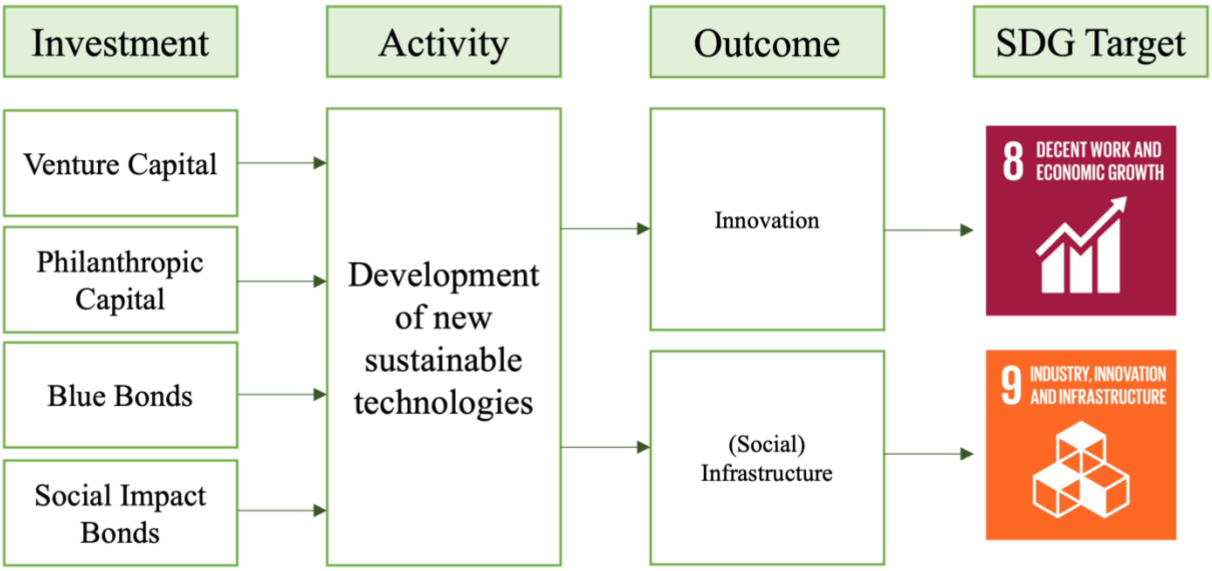
Figure 13 – Social Impact Contribution to Social Health and Well-being



Source: Own Illustration

The findings of the analysis on economic impacts created through seaweed farming highlight seven key findings. The most commonly mentioned economic impact is that seaweed farming operations generate new industries (55%) and make other industries more sustainable, which was identified by 72% of studies. By creating products such as bio-fertilisers and bioplastics, seaweed farming adds to sustainable economic growth and development. Additionally, 45% of studies mention the development of an international blue carbon market; however, 3% argue against that. New industries also include the potential to supplement animal feed and improve the soil for terrestrial crops, as mentioned by 59% of studies:

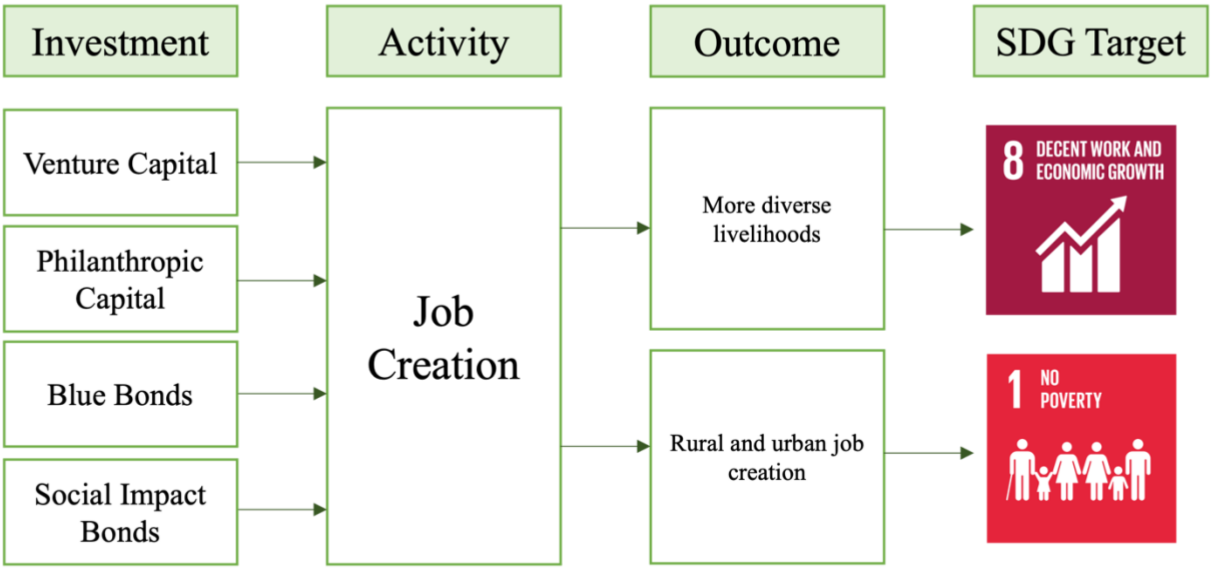
Figure 14 – Economic Impact Innovation and New Technologies



Source: Own Illustration

Another important economic impact is the creation of jobs, leading simultaneously to the creation of more diverse livelihoods for coastal communities:

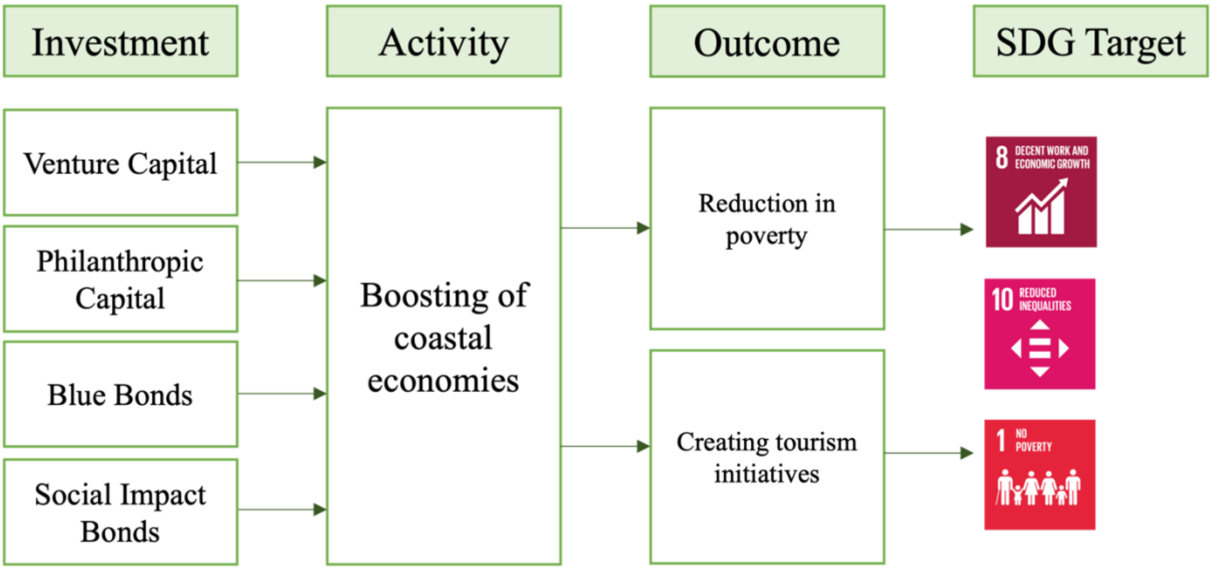
Figure 15 – Economic Impact Job Creation



Source: Own Illustration

48% of studies associate seaweed farming with fostering the bio-economic transition. 41% of studies mention the potential of seaweed cultivation to boost innovation as more funds are invested in sustainable technologies and infrastructure. Furthermore, 38% of studies highlight the potential of seaweed farming to boost local communities in coastal economies:

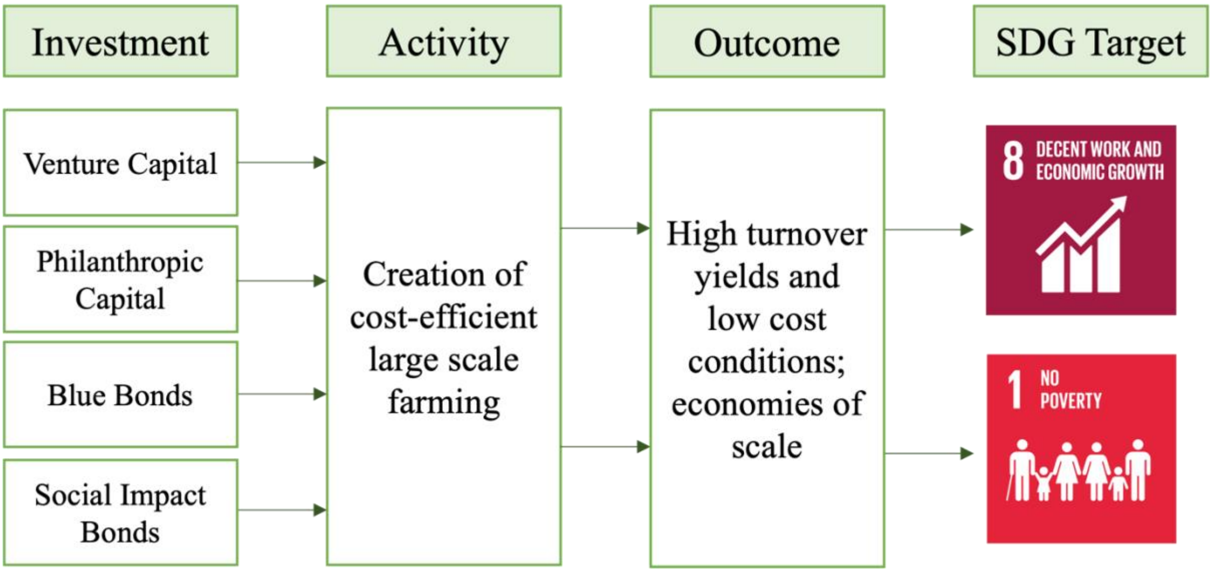
Figure 16 – Economic Impact Boosting Rural Communities



Source: Own Illustration

7% of studies argue that climate change increases the general costs of seaweed breeding management, equipment maintenance and growth environmental management and offsets the cost-efficiency of seaweed farming. Therefore, the impact of climate change on seaweed farming is an impact necessary to be assessed. Whereas an upscale in investments will reduce production costs, turning aquaculture into a cost-efficient and sustainable alternative for agriculture. With the growth in the seaweed farming sector, productivity and innovation may increase simultaneously and lead to a reduction in the price per tonne of seaweed:

Figure 17 – Economic Impact Creation of Economies of Scale



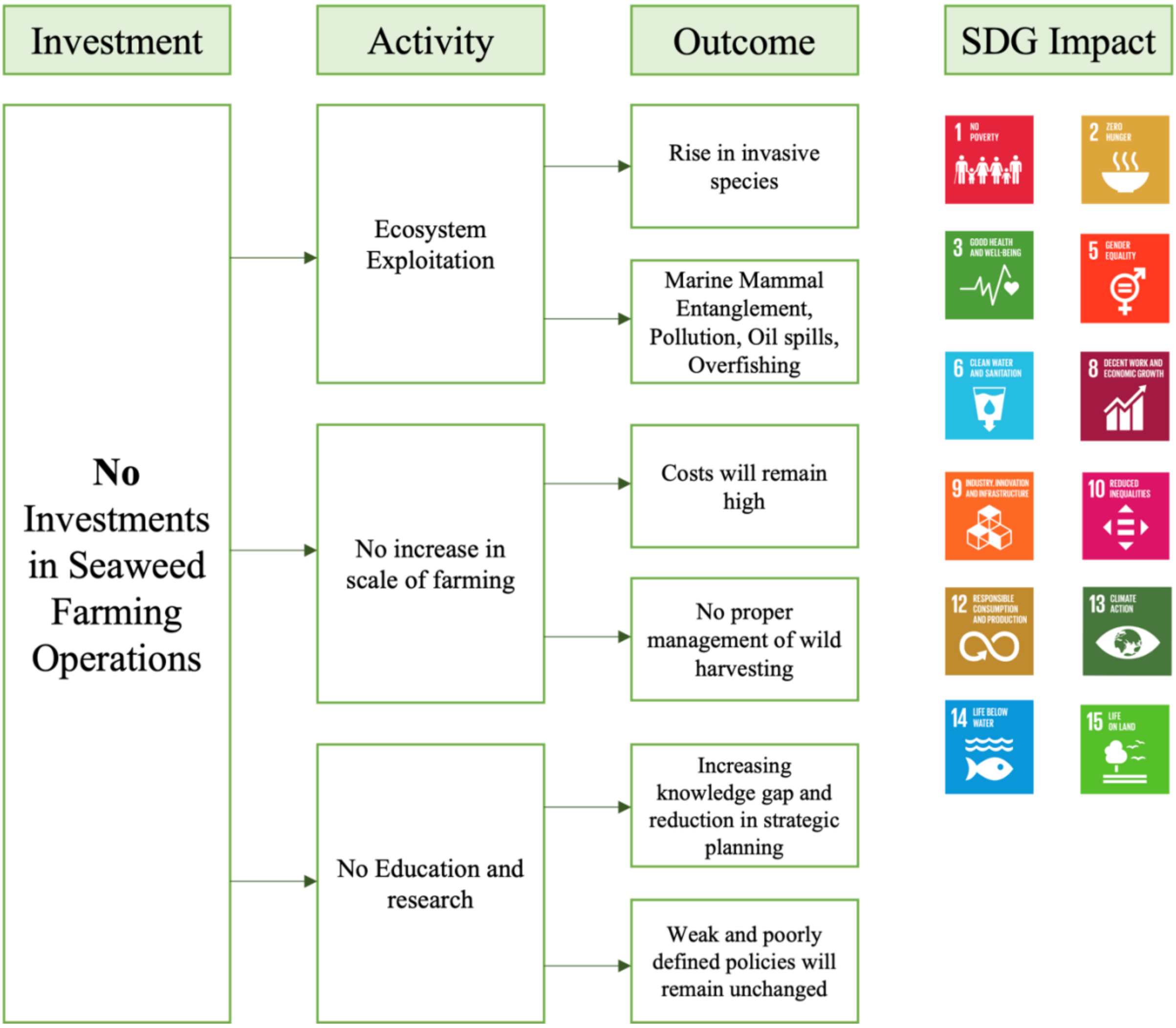
Source: Own Illustration

As presented in figure 17, an investment in seaweed farming will lead to four main activities as summarised by the study; Creation of jobs, Creation of large-scale farming, development of new sustainable sectors and increased sustainable economic growth in coastal economies, as well as worldwide.

4.5.3. Assessment of Risks and Challenges

The analysis has revealed several risks and challenges affecting the seaweed industry today or a potential in becoming a risk in the future. All risks and challenges that the seaweed industry faces will or are negatively affecting the essential beneficial characteristics of a BE and the fulfilment of SDGs:

Figure 18 – Risks and Challenges Environment, Social and Economic



Source: Own Illustration

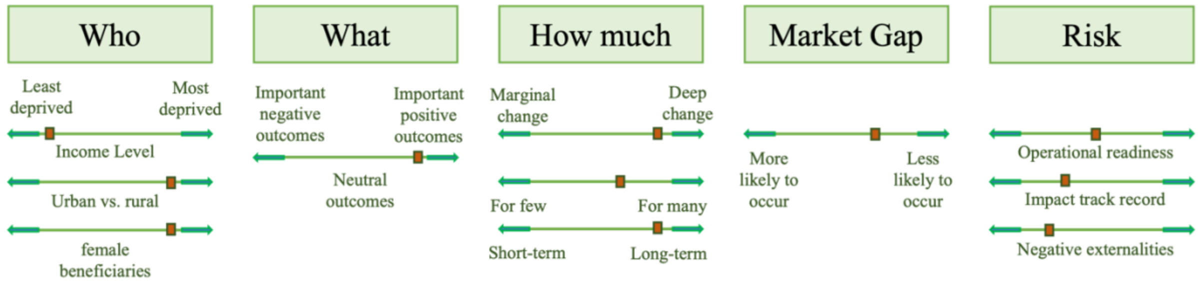
The most commonly associated risks with seaweed farming are future shocks such as climate-induced threats, marine heatwaves and disruption of supply chains (62%). The environmental risk of invasive species entering marine ecosystems where seaweed is cultivated was mentioned by 52%, equal to the "high costs of farming", where costs are assumed to depend on economic factors. Weak and poorly defined policies were mentioned by 45% of studies, being a current and future risk for seaweed farming. The absence of knowledge and lack of strategic planning was mentioned by 41%, as well as the accessibility of technologies and tools, due to the lack of long-term financial viability. 34% of studies mentioned the risk of public health threats from cultivating seaweed. Lastly, 14% argued that marine mammal entanglement could be a potential threat, particularly if the scale of farming increases over time, while 3% argued that seaweed farming contributes to marine life health through innovations.

4.6. EVALUATION OF THE IMPACT METRICS MODEL

The Meta-analysis (Appendix 1) on clarifying the term "Blue Economy" has shown that the BE aims to combine economic growth with sustainable development, creating "sustainable growth". The BE concept is based on developing sustainable marine practices with economic factors such as building technological advances, creating space for innovation and creating "blue" employment. In addition, the BE aims at providing social and environmental benefits such as meeting the increased future food demands of a growing population, supporting well-being and human health, and, therefore, is an opportunity for the creation of social equity and inclusion. With its attributes the BE aligns with the concept of sustainable seaweed farming. Through an increase in the scale of seaweed farming there is more room for innovation and sustainable development. The environmental benefits of the BE are the development of techniques and concepts that provide de-carbonisation and restore and ecologically engineer ecosystems to reduce environmental risks in the future. Seaweed cultivation can signficantly add to de-carbonisation and restoration of marine protected areas. With its intentions, the BE is directly connected with SDGs, particularly SDG 14, of the UN. Seaweed farming, as stated by this study, is directly supporting the targeted SDGs. The BE requires stakeholder engagement and international cooperation as it reshapes the conventional relationship between marine biology and the economy. Through seaweed farming, the well-being of coastal communities and the general public can be enhanced, resulting in increased social equity. Summarised, Seaweed farming is a industry applicable to the concept of the BE.

The Impact Assessment framework is a tool of the IMP to include impact assessment within a impact investors due diligence for assessing investment opportunities. The framework, as in Figure 19, asks several questions to answer Who, What, How much impact, the Market Gap and possible risks and challenges of an investment. When applying the results of the study to the Framework, the questions addressed can be answered as the following:

Figure 19 - IMP 5 Dimension Application to Seaweed Farming



Source: Own Illustration based on IMP

The study analyses that the sustainable seaweed farming sector tends to profit least deprived communities in terms of their income levels, through supporting sustainable growth of SIDS. Female beneficiary in the seaweed industry is deemed to be high, adding to gender equality. Seaweed farming creates a wide range of positive, important outcomes on an environmental and social level. Without an investment in seaweed farming the benefits and impacts could not be achieved, supporting the additionality characteristic of impact investment.

Through impact investment a deep change in the sustainability of seaweed farming is achieved. Without investments in the industry, it is likely that the industry will become unsustainable over time. The neglection of activities such as ph control or testing of acidity levels in the water will harm sensitive marine ecosystems. Changes in the sector are expected to have a long-term impact, since the industry's expansion will eventually benefit elements such as fish aggregation, economies of scale, and technical advancements.

As the global population continues to increase, the need for seaweed will grow.The risks of an investment in seaweed farming are based on the industries operational readiness which was seen as medium high. Seaweed farming on a small scale is unprofitable and costly, therefore, growth in the sector is required to increase its operational readiness. The impact track record and knowledge on the industry is low as there is only a limited amount of data, particularly of quantitative nature, available. Also, potential risks are negative externalities such as climate change or recessions.

5. Conclusion

Sustainable seaweed farming and the concept of the BE have many characteristics in common. Both approaches are aiming to turn economic growth into sustainable growth. The high seas are seen as development spaces that serve the purpose of generating benefits for all. Therefore, sustainable seaweed farming is a suitable marine practice aligning with the goals of a BE. A review of existing literature on seaweed farming shows that increasing the scale of seaweed farming is crucial to guarantee that the industry aligns with the characteristics of a BE. The analysis of both, the concept of a BE and the concept of sustainable seaweed farming were analysed in detail to understand and illustrate the BE and the seaweeds industry’s suitability under the BE. The seaweed farming industry is an industry with immense potential to become more profitable every year, supporting the key undertakings of a BE in terms of sustainable growth. Through the algae's versatile characteristics, Seaweeds can be used in various ways, ranging from human food sources to animal feed to important substances in medicine. The different characteristics of sustainable seaweed farming closely align with the assumptions of a BE as presented in Appendix 2. However, due to various reasons, such as the industry's current size as of 2023, the suitability of seaweed farming matching the BE approach are challenged. Factors such as the scale of sustainable farming are influential when matching the concept to the industry. Small-scale farming, for example, involves the necessity of executing ph control and the usage of acids to control epiphytes and competing organism populations. Although seaweed farming does not require freshwater and pesticides, as is used in traditional agriculture, seaweed populations must be observed appropriately. To guarantee that the seaweed industry closely aligns with the definitions of a BE, as presented in Appendix 1 and 2, a range of measures are necessary.

The main objective of Impact Investing is not only to generate financial returns for investors but to generate positive impact, which may happen in several areas and can be related to positive societal or environmental outcomes or both. Through applying the concept of seaweed farming to the Impact Metrics Model, it can be concluded that it generates positive impact ranging from improving social equity to de-carbonisation. Investing in seaweed farming will result in a broad range of positive impacts and will affect sustainable development positively. According to the underlying research of the study, an impact investment in seaweed farming is likely to have up to USD 5 of positive impact following each USD invested. Through a broad market trend analysis, it can be concluded that the seaweed industry is a promising and profitable industry. Mainly through the upscaling of the industry, e.g. more funds going towards it, it is likely that financial return will increase simultaneously. While investment in seaweed farming increases sustainability in many other industries, it also promotes more sustainable practices that reduce exposure costs.

Further, an investment in seaweed farming will result in industry growth and promote economies of scale. Seaweed is a potential alternative for various products, such as medication, animal feed, renewable chemicals and food. Through upscaling funding in the industry, the costs for production and the impact of negative externalities can be reduced. Therefore, Impact Investment is a helpful tool in making seaweed farming sustainable in the long-term. Simulatenously investing in sustainable seaweed cultivation will positively affect the achievement of the SDGs of the UN.

However, seaweed farming remains a scarcely researched industry with many potential threats needing to be addressed. While the industry's potential is promising, research suggests that activities such as carbon dumping on the high seas need to be sufficiently investigated. Furthermore, there is the potential for all kinds of communities to destroy essential ecosystems in coastal zones and the high seas. The seaweed industry has a high potential for exploitation and causes significant maritime issues for essential organisms through insufficient regulations and licensing. Particularly in the High Seas, where regulations need to be specified sufficiently, responsibility needs to be clearly stated. A further risk to consider, is the threat of impact investment firms not properly analysing impact. Through the author's experience in the direct conversation with impact investment firms, it can be stated that impact investors need to be sufficiently regulated. Often impact is only assumed but not quantified. Quantification in the impact investment industry is a critical knowledge gap, mainly because more available data is needed.

5.1. Research and Contribution

This thesis contributes to the BE, further analysis of the SDGs of the UN and Impact Investment research, providing an in-depth analysis of the BE concept while focusing on the role of seaweed farming in sustainable ocean development. The goal of the thesis is to contribute to the United Nations SDGs, specifically SDG 14 “Life Below Water”. The thesis analyses the current state of the sustainable seaweed industry and identifies challenges and opportunities in the sector. Furthermore, the research explores the potential of impact investment to close the existing funding gap in the sustainable seaweed industry by evaluating the effectiveness of promoting positive environmental, social and economic impact. The thesis provides insights and recommendations for various stakeholders, such as policymakers, investors and entrepreneurs, aiming to accelerate industry growth. The study contributes to the literature on BE, impact investing and sustainable seaweed farming in the context of SDGs. The importance of innovative financing models to promote sustainable development in the ocean economy is highlighted. Additionally, the research provides essential insights and recommendations to stakeholders to accelerate the industry growth of the BE to contribute to the fulfillment of the underlying targets of the SDGs.

5.2. Limitations of Research

The study of seaweed farming as a potential impact investment presents several limitations, primarily related to data availability, privacy concerns, and the nascent stage of the industry.

One major limitation is the lack of available data. Both industries, seaweed farming and impact investment, are areas scarcely researched. Both industries are relatively new, in need for data from long-term studies. It remains a challenge to assess the impact investment industry and to gather information about the financial, environmental and social impact of projects. The lack of data makes it challenging to evaluate an investment's potential as there are no comparables.

Several government funds are going towards the BE sector. However, using such funds primarily drives sectors of the ocean economy that do not support or even negatively affect the BE. The industry is not only in need of increased government spending towards sustainable development but also private investments from businesses. However, due to the privacy of general funding activity, it is difficult to properly evaluate risk and return profiles The funding gap results in less information available, as research is missing funding, and as a result, there is only a small concentrated group of experts on the topic.

Privacy concerns are another limitation. Many impact investment projects are not publicly disclosed, resulting in decreased transparency about the industry. The lack of transparency makes it difficult to gather information on specific projects and evaluate the performance of possible investment opportunities. Additionally, many impact investors may hesitate to share information on their investments, as they are concerned about competition or confidentiality and their fiduciary duty towards their investors.

Finally, the environmental and social impact and costs are generally difficult to quantify and measure. Impact and costs may vary depending on the location, type of seaweed, and farming methods applied. The lack of consistency in data collection and measurement, results in substantial limitations for research and understanding of the industry. Therefore, drawing meaningful conclusions about the overall impact of seaweed farming investments is challenging.

6. APPENDICES

"Appendix 1- Meta-analysis on the Definition of the BE"

Environment	*De-Carbonization*	*Sustainability*	*Restoration / Ecological Engineering*	*Environmental risk reduction*	*Ecoystem-based-Approach*
Total	52%	100%	71%	67%	67%
SDG	*Connection to SDGs*	*SDG 14 "Life below Water"*	*SDG 3 "Good Health & Well-Being"*	*SDG 8 "Decent Work & Economic Growth"*	*Other SDGS*
Total	43%	29%	10%	10%	5%
Economic	*Innovation*	*Technological advances*	*Employment / Job Creation*	*Growth*	
Total	81%	90%	90%	90%	
Social	*Food Security*	*Well-being*	*Social Equity*		
Total	76%	76%	76%		
Financial	*Investment Opportunity*	*Funding Gap*			
Total	62%	14%			

Relevance:	- 100 to 76% to be considered very relevant
	- 75 to 51% to be considered relevant
	- 50 to 26% to be considered less relevant
	- 25 to 1% to be considered not very relevant

Appendix 2

Environmental Impact	CO2e Mitigation / de-carbonizer		Ocean **Regenaration /** contribution to marine ecosystems / **Restoration** of coastal and ocean zones		**Removal** of excess nutrients (nitrogen, phosphorus) / Waste **purification**		**Replacement** of traditional non-renewable resources (example Bioplastics, Biofuel, Biomass)		**Preservative and chemical free;** no use for fertilizers and freshwater		**Buffer** in eutrophication, hypoxic and acidic waters		**Preservation** of species richness and resilience of ecosystem		**Biodiverse** plant; many species suitable for all kinds of environments	
Total (Positive- / Negative Impact)	79%	14%	62%	0%	79%	0%	79%	0%	28%	0%	52%	3%	45%	0%	38%	3%
Social Impact	Community Development		Contribution to Food Security		Health & Well-being creation		Social Inclusion		Source of alternative protein		Involvement of smaller groups (Indigenous example)		Enhancing women equality		Promotion of indigenous participation in marine issues	
Total (Positive- / Negative Impact)	41%	0%	97%	0%	72%	0%	55%	0%	45%	0%	21%	0%	14%	0%	21%	3%
Economic Impact	Effect on other Industries more sustainable (such as agriculture and aquaculture)		Creation of Jobs / provision of diverse livelihoods		Boosting local communities; coastal economies		Cost-effective Animal Feed and Soil supplement		Promotion of international blue carbon market development		Creation of new industries (such as Seaweed biofertilizers, source of renewable energy)		Innovation boosting through supporting technologies (sustainably) and infrastructure		Addition to bioeconomy transition	
Total (Positive- / Negative Impact)	72%	0%	59%	0%	38%	0%	59%	7%	45%	3%	55%	0%	41%	0%	48%	0%
Risks	EnvRisk: Marine Mammal Entanglement		EnvRisk: Invasive Species		Costs of farming high (depending on economic factors)		Accessibility of technologies and tools / long-term financial viability		Future Shocks (marine heatwaves, climate-induced threats)/ Disruption of Supply Chains; food security)		Public Health Threat		Absence of Knowledge and Strategic Planning		weak and poorly defined policies	
Total (Positive- / Negative Impact)	14%	3%	52%	0%	52%	0%	41%	0%	62%	0%	34%	0%	41%	0%	45%	0%

Appendix 3

Impact Investment Market	
Category	Count
Academic Institution	5
Accelerator	9
Asset Manager	122
Business Angel	3
Consultant / Advisor	69
Deal platform	13
Development Finance Institution	6
Ethical Bank	14
Foundation	75
Intermediary Service Provider	54
Multi Family Office	2
Network	52
Pension Fund	7
Private Bank	2
Shareholder Engagement Organization	4
Single Family Office	11
State entity	4

Source: (ImpactDatabase, 2019)

Appendix 4

Key Players in Impact Investing	Description	Examples
Family Offices and High-Net-Worth Individuals	Individuals and offices that often have resources and investment experience to support impact investment initiatives and provide funding to early-stage companies and organizations.	-
Social Impact Funds	Dedicated investment vehicles that focus on generating positive social and environmental impact.	Acumen, BlueOrchard
Development Finance Institutions	Institutions that provide financial and technical assistance to support sustainable development projects and impact investment initiatives.	International Finance Corporation (IFC), European Investment Bank (EIB), African Development Bank (AfDB)
Philanthropic Organizations	Organizations that use their resources and expertise to support impact investing initiatives and catalyze investment in underfunded areas.	Rockefeller Foundation, Bill & Melinda Gates Foundation
Asset Managers	Large players that manage investment funds that focus on generating financial returns and positive social and environmental impact.	BlackRock, TPG, The Rise Fund

Own illustration based on (ImpactDatabase, 2019)

Appendix 5 – Import Value of Seaweeds and Other Algae for Human Consumption in Europe

Import value of seaweeds and other algae for human consumption in Europe										
Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Import value in thousands of euros	86.109,00 €	70.872,00 €	78.014,00 €	79.251,00 €	70.728,00 €	87.648,00 €	94.049,00 €	109.586,00 €	99.326,00 €	126.641,00 €
Growth annually		-18%	10%	2%	-11%	24%	7%	17%	-9%	28%

Appendix 6 - Overview EU Blue Economy Sector

Overview EU Blue Economy Sector					
Year	2009	2016	2017	2018	2019
Turnover (in billion)	40,7664	566,2	658	650	667,2
Employment (in million)	0,252	3,5	4	4,5	4,45
Net Investment ratio	18%	29%	24%	4%	3%
Net investment in tangible goods (in billic	6,2	22,2	14,9	6,4	6,1

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