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SUSTAINABLE BUSINESS MODEL INNOVATION AND PERSPECTIVE OF USING MICROALGAE TO PRODUCE BIOFUEL: A SYSTEMATIC LITERATURE REVIEW

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Abstract: The dependence on fossil oil has led to the search for alternative renewable energy resources, such as biomass, which has climbed to the top of the list of renewable energy solutions. It is not possible to separate these energy issues from environmental and sustainability concerns. Developing sustainable practices is essential for the continued expansion of countries' and the world's energy resources. The capacity to transition into new market models rapidly and efficiently is a critical source of sustained competitive advantage and leverage for increasing biofuel microalgae production sustainability. Given the issue's importance, the causes of failure are mostly unknown, and there is only a limited thorough description of the sustainable business model innovation process in the literature. This study conducts a comprehensive review of the literature on the idea and technique of sustainable innovation in the microalgae business model. Multiple process phases of sustainable business model creation are described with a thorough list of major difficulties and obstacles connected with each step of the process. This study also looks into how management tools may be transformed into a process system and some insights into the process's operational setup and performance variables.

Keywords: Sustainability, biofuels, sustainable business model innovation, microalgae cultivation, harvesting and dewatering and Life Cycle Assessment (LCA).

Introduction

The beginning of the modern revolution brought about the quick rise and growth of oil, natural gas, and coal companies. The exploitation and use of fossil fuels has contributed to significant improvements in the economic growth and quality of life over the past century, but has been at the cost of environmental destruction and ecological goods and services depletion (EGS) and may affect the planet's capacity to support future generations (Vrublova, 2020). Besides, the increasing global use of limited fossil resources, fuelled by accelerated high rates of population growth and economic development, has been described as the key contributor to growing greenhouse gas and carbon dioxide levels and the related anthropogenic climate-induced destabilisation (Neupane, 2019), contributing to increased market volatility and the danger in the supply of fossil fuel and oil resources. Overall, growing concerns about alternative energy and stability, oil supply instability and market volatility, as well as global warming have led nations worldwide to embrace green energy systems and environmentally friendly technology (Rodionova *et al.,* 2017). Global warming is known as the 21st century's most critical environmental issue. An increasing body of evidence suggests that rising greenhouse gas emissions caused by human activity are causing dangerous and long-term greenhouse effects (Change, 2014; Hess *et al.,* 2020). The immediate impacts of global climate change include increased occurrence of rising temperatures and rising global average climate and sea levels. In contrast, future higher-order consequences include the degradation of habitats, extinction of organisms, permanent loss of biodiversity, increased frequency of food and waterborne diseases, extensive loss of life, political crisis, as well as threatened food security and environmental conservation (Mahmud *et al.,* 2020; Pachauri *et al.,* 2014).

Moreover, concerns about sustainability and the environment have stimulated interest in creating and using renewable alternative forms of energy. In order to overcome global warming created by fossil fuels, biofuels have become an essential alternative fuel. The development and use of biofuels contribute to carbon neutrality and sulphur's atmospheric conversion (Chisti, 2008a; Shuvo *et al.,* 2020). First-generation biofuels are produced from terrestrial crops, such as sugarcane or maize, for ethanol production and from plant oils, such as palm oil, soybeans, and rapeseed, to produce biodiesel (Moshood *et al.,* 2021). Second-generation biofuels contain lignocellulosic biofuels from non–food crops and waste biomass. The second-generation feedstock outcomes comprise lignocellulosic ethanol, bio-oil, and hydrotreating oil *(Jaiswal et al.,* 2020; Silva *et al.,* 2014; Sims *et al.,* 2010). First and second-generation feedstock cannot achieve biofuel generation objectives due to inadequate amount of biomass feedstock, food competition, land conditions, raised matters of water regulation, and the potential of increase in greenhouse gas (GHG) emissions (Salama *et al.,* 2017; Sims *et al.,* 2010). These interests have stimulated awareness in the production of biofuels from rapidly growing natural biomass that can produce a massive capacity to sustainable fuel for renewable transport and reducing GHG emissions. Microalgae biomass is an attractive carbon resource related to traditional terrestrial biofuel feedstock for third-generation biofuels (Aly & El Barmelgy, 2020; Jaiswal *et al.,* 2020; Posten & Schaub, 2009; Suemanotham, 2014).

As a result, innovation is essential in enforcing the social and environmental goals of an organisation by combining technology with effective environmental, social, and economic strategies (Geissdoerfer *et al.,* 2017; Lüdeke-Freund & Dembek, 2017). Innovation-based business models can enhance industrial, social, and environmental efficiency through companies engaging in a sustainable business model (Adomako *et al.,* 2019; Evans, Vladimirova *et al.,* 2017; Zhang *et al.,* 2020). In two situations, the market capitalisation of firms with innovative business models and sustainable development goals, the importance of a sustainable business model's innovation becomes apparent. According to Hunter *et al.* (2018), all technology companies with a creative business model are the five firms with the largest market capitalisation. However, 10 years ago, all the companies were conglomerates focused on conventional business models such, as banks or oil and gas firms (PwC, 2013). The Sustainable Development Goals (SDGs) reflect the degree to which the political, public and private sectors have focused on sustainability issues (Geissdoerfer, 2019b; Lagarde, 2019). More than 4,000 collective commitments and collaborations that directly contribute to the 17 targets have been identified by the United Nations (United Nations, 2019). The company model's strategic value of creativity comes with high failure rates (Hochberg *et al.,* 2007). Although data are stills scarce, new firms' failure rates could exceed 90% (Patel, 2015).

Therefore, there is little information for professionals, and the causes of these industrial problems remain largely underexplored in literature. Microalgae, the most recent feedstock used for biofuels, have been recommended in a large number of studies in solving challenges that have plagued biofuels, notably in terms of food distribution and resource allocation. The debate involving microalgae biofuels has been driven by research and engineering fields. At the same time, this facilitates the examination of improvements in production technologies, a more thorough economic assessment and a sustainable business model innovation is required to determine the need for policy action and the resulting ramifications, especially in the presence of externalities, by pursuing a sustainable business model innovation of biofuel microalgae production and use. The findings of this study can be used to reassess the approach to this new transportation fuel technology.

Methodology

Literature Search

One potential method of implementing systematic review of text data is illustrated by the methodology presented in this study. Numerous distinct phases are defined in the planning and exploration of sustainable business model innovation for microalgae biofuel. A review was carried out first of all. The literature scanning allowed the authors to determine the analytical structures used to process and analyse the data. Using an aggregator database like Scopus (scopus.com), Web of Science and Google Scholar, articles within the research framework were found and extracted. The predominant keywords used were "sustainability", "biofuels", "sustainable business model innovation", "microalgae cultivation", "harvesting" and "dewatering" and "life-cycle assessment" (LCA).

This study proposed and validated the methodological concepts produced by academic and literary contributions. In one scenario, the characteristics of the interest parameters are to be determined by descriptive analysis. This study shows what changes will benefit sustainable business model innovation in enhancing the efficiency of the microalgae biofuel, increase competitiveness, recognise potential technologies, identify business risk and encourage investments in technology. We adopted the recommendations by Tranfield *et al.* (2003), Rousseau *et al.* (2008), Watson (2015) and Durach *et al.* (2017) for this systematic literature review to: (1) identify current publications; (2) pick and measure their findings; (3) evaluate and synthesise the evidence; (4) comment on the outcomes; and (5) suggest a strategic plan. The specific steps of a detailed and comprehensive systematic review are being used as follows:

Lu and Liu (2014) have previously operationalised the overall structural research approach suggested. The study problems must be dealt with unambiguously at the start of the systematic analysis, as a specified procedure in Stage 1 appears to classify a topic or analytical problems (Khan *et al.,* 2003). In order to meet the demands of the review, the keywords of the research had to be established. Many keyword patterns in the sample are essential for the review area of science to be assured. Step 2 requires detailed and exact analyses of the respective publications and archives according to data sources (Khan *et al.,* 2003; Moshood *et al.,* 2020).

An appropriate field of research should also be known and chosen to access various related sources and information. Step 3 involves using keywords in descriptions, scopes, and keywords for research of a given area. This analysis's keyword is encoded, included in the known, and then picked from publishers and journals lists. Research should be valid, without language constraint, and open to modifications from research questions if required. Ke *et al.* (2009) and Lu and Liu (2014) proposed using a minimum parameter analysis to maintain compatibility.

Step 4 also requires the quality evaluation of the analysis to guarantee accuracy in methodology. The paper received for analyses and refinements must also be limited to the preference of attributes for an accurate assessment. The conditions of some records from the previous search query must be cleaned up. Naturally, the previous Step 3 search would offer a wide variety of mainstream questions and articles. Therefore, a detailed review of the articles' contents is required (Moshood *et al.,* 2020). The compilation of the evidence is used in Step 5. Based on the articles mostly related to areas of concern, the systematic review will be pursued here to describe and integrate the strong polished publications. Consequently, a field and meaning or form are supplied to extract the material (Lu & Liu, 2014). The reports are usually analysed and summed up by the analysis's parameters, existence, and conclusions.

Each stage of the evaluation phase is then organised around the sections of Processes, Findings, and Discussion, allowing the reader to understand further how the data are evaluated and follow the process's implications and the resulting data (Dohale *et al.,* 2020; Moshood *et al.,* 2020). The papers identified were screened, filtered, and validated for inclusion in the analysis through an iterative selection method following the outlined systematic literature review procedure, as seen in Figure 1.

The 276 papers were identified (discovered via database searches, 276 articles), screened (after duplication were removed, 134 articles remained), assessed for eligibility (after abstract review, 123 articles remained), and verified for inclusion (post-full-text review, 117 articles were utilised). The complete contents of the outstanding papers were checked in the context of the study issues for the final judgement regarding microalgae biofuels production and algae fuel production and other areas under examination. Duplicates have been excluded as part of this process, and the eligibility of the papers were verified through abstracts. The 117 articles were reviewed and validated as legitimate according to this study's systematic literature review procedure.

The Processing of Algae to Biofuels

The processing of microalgae to biofuels comprises four primary stages, which are harvesting, lipid upgrading, cultivation, and lipid removal (Silva *et al.,* 2014). Algae's dewatering is an example of the usual energy-intensive methods that can be circumvented by operating with wet biomass. With this respect, hydrothermal systems are an economical and environmental harmless choice when related to conventional means of lipid removal using organic solutions (Teymouri, 2017).

Microalgae Cultivation

Two major approaches are included in the cultivation methods for the development of microalgae biomass: the open-pond methods, including the use of round or square containers,

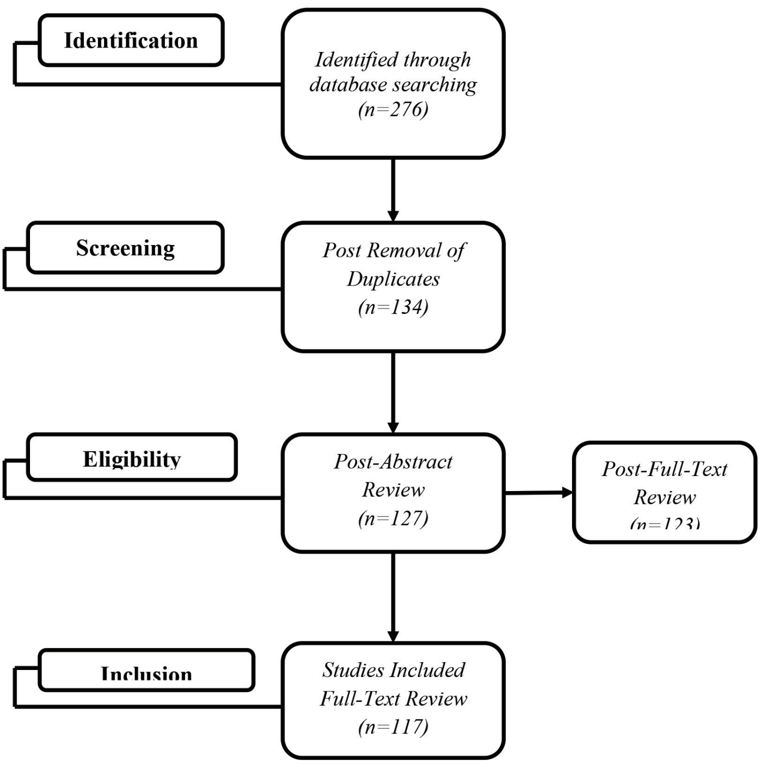

Figure 1: Literature review methodology

with shallow and paddlewheel agitated raceways as shown in Figure 2, and closed-pond methods (Photobioreactors, PBR), such as flat and tubular plates, as shown in Figure 3. The earliest and most natural approaches for growing microalgae are the open-pond methods, and there is a sound financial structure in this approach (Singh & Gu, 2010; Suparmaniam *et al.,* 2019). Techniques such as raceway ponds are simple to build, usually limited to constructing and running expensively, and have a higher processing potential than closed methods. Open ponds have a certain pattern and capacity, but a raceway pond is the most widely used style (Chew *et al.,* 2018). Typically, open ponds are constructed of oval-shaped recirculation channels, which are closed loops, typically deep-toned between 0.2 and 0.5 m, with mixing and circulation necessary for continuous algae growth and fertility. Usually, paddlewheels are used for combining open pond techniques. While these approaches are the most widely used at the developmental level, the procedures also present critical technological difficulties. Open ponds are susceptible to evaporation, environmental conditions, and lack of water, lighting temperature and unwanted variety of bacteria pollution controls (Chew *et al.,* 2018; de Souza Leite *et al.,* 2019; Jorquera *et al.,* 2010; Suemanotham, 2014).

Another alternative for the cultivation of microalgae is to use photobioreactors, or closed systems. Various shades, patterns, and forms exist, such as bubble column reactors or plate reactors, and tubular reactors. Closed bio-reactors have several benefits and can manage growing requirements, growth parameters (pH, sunlight, temperature, mixing, oxygen level, nutrients and carbon dioxide) and limit outside pollution and dehydration (Aron *et al.,* 2020). This method makes microalgae growth easy to manage, improves productivity, and guarantees a high yield (Chisti, 2008b). Some designs use

Figure 2: The open-pond system of microalgae cultivation
Sources: making-biodiesel-books.com

Figure 3: Closed ponds system of microalgae cultivation
Sources: www.superfoodevolution.com

direct light, while for continuous development, some use artificial light. The disadvantages of closed bioreactors are that it is much more expensive to set up than open ponds and require advanced control and monitoring systems (Abomohra & Almutairi, 2020; Michael R. Buehner, Peter M. Young, Bryan Willson, David Rausen, Rich Schoonover, Guy Babbitt, 2009).

In hybrid systems, both open ponds and closed ponds or photobioreactors are used to improve yields and fertility and cost-effective cultivation. The contingents are compiled in Table 1.

The main emission of greenhouse gases and the effects of fossil fuel flames is carbon dioxide. Thus, the approach of lowering carbon dioxide (CO_2) emissions seems to reduce fossil fuels or increase CO_2 sequestration. One of the advantages of using microalgae for biofuel production is that CO_2 from multiple bases, including atmospheric carbon dioxide, CO_2 emissions from manufacturing processes and power plants, and CO_2 from soluble carbonate can be withheld and imprisoned (Cullinane & Rochelle, 2004; Xiaogang *et al.,* 2020). Microalgae, therefore, have the ability by photosynthesis to repair CO_2 effectively. Flue gases that can be obtained from manufacturing processes or power plants often generate a rich supply of CO_2 to produce microalgae. Depending on the origin, the use of CO_2 in flue gases ranges from 12% to 20% (Hosseini *et al.,* 2018; Wang *et al.,* 2008). The ponds are supplied with CO_2 from the manufacturing of flue gases in different ways, such as vaccination and the

Table 1: Assessment of open and closed systems

Parameters	Open Systems	Closed Systems
Land required	High	Low
Temperature	Highly variable	Required cooling
$C0_2$ transfer rate	Poor	Excellent
$C0_2$ loss	High	Low
O_2 concentration	Low due to continuous spontaneous outgassing	Exchange device
Light utilisation efficiency	Poor	High
Temperature control	None	Excellent
Controlling of growth conditions	Very difficult	Easy
Shear	Low	High
Mixing efficiency	Poor	Excellent
Cleaning	None	Required due to wall growth and dirt
Contamination control	Difficult	Easy
Contamination risk	High	Low
Species control	Difficult	Easy
Biomass quality	Variable	Reproducible
Biomass productivity	Low	High
Population (algae cell) density	Low	High
Capital cost	High	Very high
Operating cost	Lower	Higher
Harvesting cost	High	Lower
Harvesting efficiency	Low	High

use of chemical absorption (monoethanolamide, MEA). Nutrients are an essential element for the growth of microalgae. Phosphorus (P), nitrogen (N) and silicon (Si) make up the carbohydrates, as well as iron (Fe). Many algae require a soluble source of nitrogen, such as urea, nitrate and ammonium. Phosphorus is necessary for smaller numbers, and more than the normal requirement amounts must be given (Suparmaniam *et al.,* 2019). The sum of nutrients depends on the conditions of microalgae production. Recycling drainage nutrients, such as rural, urban and manufacturing sources, will dramatically reduce nutrient expansion by almost 55%and significantly reduce process costs (Banerjee & Ramaswamy, 2017; Suemanotham, 2014; Yang *et al.,* 2011).

Microalgae Harvesting and Dewatering

The application of biomass in the cultivation methods of microalgae is typically at a scale of 1-5 g/L. Cells of microalgae are usually tiny, usually between 2 microns and 20 microns (mm). Typically, microalgae have a high water content, around 80% to 90%. Therefore, dewatering and harvesting steps need to eliminate the vast quantities of water used and improve the consistency of microalgae biomass (Fasaei *et al.,* 2018). Energy loss and expenses for dewatering and harvesting biomass are vital and they need to be correctly addressed. Microalgae harvesting, including bulk harvesting or primary harvesting, may be classified in a two-step manner. This is essential to organise the biomass of microalgae from the bulk by discontinuing the application of flocculation, sedimentation of gravity, and flotation.

In terms of thickening or secondary dewatering, with the use of filtration, centrifugation or other processes, the idea is to reduce the slurry. This generally requires more power than bulk harvesting or primary harvesting (Brennan & Owende, 2010; Zhang, Yao, Maleki, Liao & Lin, 2019). A one- or two-step harvesting process achieves the desired concentration of microalgae. The primary harvesting stage consists of 2% to 7% of the total suspended solids (TSS) microalgae slurry and a secondary harvesting step to produce 15% to 25% of the total suspended solids microalgae paste. The frequent harvesting and renewal processes are air-flotation, gravitational sedimentation, screening and filtration, flocculation, electrophoresis and centrifugation techniques. The correct harvesting system implementation depends on the microalgae characteristics, such as density, size, and the number of targets produced (Din *et al.,* 2020; Musa *et al.,* 2019; Suemanotham, 2014).

Microalgae Extraction

The microalgae biomass needs to be drained to eliminate huge water content and enhance the frequency to 80%–90% (w/w) before lipid removal. Various techniques have been applied to remove the water content in microalgae, including solar drum drying, cross-flow drying, drying, spray drying, and freeze drying (Brennan & Owende, 2010; Lee *et al.,* 2020). Regular drying (wind or solar) is the most affordable and most straightforward choice, but it is not an adequate approach and takes up a lot of time (Lee *et al.,* 2020). The other problem with the conventional drying method is that it is energy-intensive and expensive. Hence, the adoption of the drying process should depend on the class of algae, the range of procedures, and certain coveted products (Enamala *et al.,* 2018; Suemanotham, 2014). In order to maximise the pure energy of fuels and the impact of the outcome, it is vital to establish a balance between drying capacity and cost effectiveness. Microalgae cell division trails drying and cell division techniques are applied to reopen the cells and increase the solvent's perception to improve the lipid yield. In order to obtain intracellular outputs of microalgae, such as starch for biodiesel, oil and ethanol production, cell division is usually required. Some cell division methods are high-pressure homogeniser, grain plants (ceramic beads or agitation with glass), autoclave, microwave, freezing and osmotic shock (Amaro *et al.,* 2011). Microalgae oil removal techniques, such as water extraction, supercritical fluid extraction (SFE), mechanical removal, and ultrasound procedures, are available (Demirbas & Demirbas, 2011). The energy requirements, possible environmental toxicity, and chemical solvent safety issues with proper oil removal need to be explored (Buchmann *et al.,* 2019).

Sustainability Working Definition

On this basis, the word "sustainable" is characterised as a balanced and structural alignment of economic, social, environmental, and inter-generational success in this research to preserve the holistic, adaptive and flexible essence of sustainability. Instead of simply defining shared priorities, sustainability opens up the scope for a range of demands, such as what can be established and maintained for how long and to whom (Acero & Savaget, 2014; Reed & Abernethy, 2018). It has facilitated debate on how to enhance intragenerational stability, while, at the same time, maintaining life support services required to satisfy intergenerational requirements. Although there is a divergence in the perceived strengths, vulnerability, and relevant responses, sustainability has become an entity in policymakers' agenda and major organisational policies. It is more cumulatively integrated into the laws structuring social interventions and behaviour (Caniglia *et al.,* 2020). With a wide range of inconsistencies integrated and the various interest groups in complexity instrumentalised, it is a term that proves to be a political concept as permanent as democracy, justice and freedom (Geissdoerfer, 2019b).

These energy issues cannot be separated from the problems of climate and sustainability. Sustainability is a relatively recent goal to guarantee the quality of living for future generations and the environment while maintaining economic growth (Lazarevic & Martin, 2018). Developing sustainability practices is critical for the continuing growth of a nation's energy supply, as well as the planet's. Sustainable development is a cross-disciplinary framework composed of technological and non-technical sub-systems collaborating (Geissdoerfer, 2019b). Some of the major sub-systems are socio-economic, political and moral/ethical sub-systems, and other components of science and engineering that shape a technology sub-system in conjunction with sustainable engineering. Although energy is not our biggest challenge, correct use and energy practices are currently the most critical challenges facing this country. These efforts are to be taken to reverse the many trends impacting the global economy. Innovations and other sustainability sub-systems are necessary to create a sustainable economy (Rakhmawati *et al.,* 2020).

Humans need to think about longevity to achieve sustainability (Albert, 2019). The optimisation process of energy usage and the use of what people actually need are essential. Humans should turn to renewable energy sources to decrease their intake of energy. Humans will face several obstacles in selecting renewable energy sources. A life-cycle assessment (LCA) is one method of approaching a dynamic and essential challenge (Melara *et al.,* 2020). For comparing alternatives, relevant information would be used by LCAs of renewable energy sources in this study. The evaluation will start with the raw materials for energy creation (Almanza & Corona, 2020). Through a study using LCA, a sustainable measurement could be achieved. It is critical for the technology to be viewed in terms of sustainability indices for new technologies. An overview of alternative energy sources' technologies will help recognise the comparative sustainability that this sustainable energy generates (Nakhate *et al.,* 2020).

Life-Cycle Assessment

LCAs have emerged as the dominant analytical paradigm for measuring environmental impacts for biofuels and bioenergy systems (Nakhate *et al.,* 2020) and they have been used to measure the environmental impacts of goods or services. LCAs acknowledge the fuel life-cycle results at all stages, from extraction and conversion to the end use of raw materials. LCAs allow an analysis of the environmental effects at each level of the supply cycle, allowing the processes responsible for the most significant environmental pressure to be defined and the process enhancement areas to be tackled (Lazarevic & Martin, 2018). Also, before its widespread implementation, LCAs could be used to measure the predicted effect of any good or service, recognising and mitigating future toxic pollutants, waste, and environmental harm prior to its integration into the supply chain. LCA could also be used to evaluate the environmental output of two products of the same attribute and can also be used to guide environmental decision-making (Prasad *et al.,* 2020).

Sustainability and the Energy Industry

A variety of valuable and useful goods for consumer welfare include personal care products, health products, agrochemicals, and transportation fuels. Chemical technology and chemical companies offer their own services (Zaimes, 2017). However, such goods are processed by producing immense amounts of waste and several unhealthy pollutants into the air, water, and soil. Resource consumption and anthropogenic impacts are progressively becoming apparent in terms of the longstanding global ecological systems and the natural biogeochemical cycle. The environmental review results from the millennium ecosystem assessment (MEA) have been reported (Qi *et al.,* 2020). The impacts and substantial impacts of environmental changes on human and ecological well-being on the environment are apparent in international partnerships, which have seen a quicker and more extensive transition in habitats during the second half of the 20th century to anthropogenic resource depletion and unsustainable capital use than during any era in human history (Zaimes, 2017). Rockström *et al.* (2009) measured the Earth's transgression of environmental limits for climate change, ecology, nitrogen cycle equilibrium, and rapidly exceeding global fresh-water, land use, acidity, ocean and global phosphorous cycle balance. Traditional approaches for chemical process design have focused primarily on seeking the right economics relative to physical restrictions, namely the fulfilment of thermodynamic limits for heat and material balance (Kılkış, 2019; Moey *et al.,* 2020).

However, the worries about reducing fossil oil supplies led to the increase in compliance with regulations. The consequent movement for environmentally sustainable process design has caused manufacturers to see a decreased environmental footprint as one of the product design priorities. Market leaders have started to understand that a move towards sustainable planning can mitigate the industrial production's effect on the environment and it is also necessary for their companies' long-term growth and profitability (Suzuki *et al.,* 2017). The new area of science and engineering for sustainable development provides tools to identify, calculate and reconcile constraints on energy, human needs, and to maximise global and human benefits. The idea of sustainable development is multifaceted; it encompasses the human enterprise's whole, dealing with deeply interdisciplinary, cultural, social, political and economic problems (Xu & Chen, 2020). The great challenge for the chemical sector in producing new chemical processes is integrating environmental and sustainability aims and conventional design priorities. The rapid production of biofuels as a potentially stable and safer alternative for conventional fuels is a unique chemical industry challenge. Simultaneously, environmental and green externalities beyond the standard process architecture need consideration (Cai *et al.,* 2019).

Sustainable Business Models

The academic and practitioner interest in sustainable business models or business models for sustainability has quickly grown with particular issues in the Journal of Cleaner Production (Vol. 45, April 2013) and Organization and the Environment (Vol. 29, Is. 1, March 2016), providing an outstanding overview of the subject. There is also an increasing selection of review articles by Bocken *et al.* (2014), Boons and Lüdeke-

Freund (2013), Evans *et al.* (2017) and Maas *et al.* (2016). Following this, an updated and complemented literature review was conducted. When the definition was first developed, the key aim was to bring companies in the service of transitioning to a more sustainable business world and leverage the ability to implement sustainability issues into organisations and help companies accomplish their sustainability objectives (Geissdoerfer, 2019b). Today, the idea of sustainable business models is rapidly used as a source of competitive gain (Porter & Kramer, 2011). It can also be argued that the sustainable business design model may effectively substitute the business model's description in the same way that sustainable competitive advantage has replaced competitive advantage (Geissdoerfer, 2019b).

The common theme among the ideas in the literature is that sustainable business models are a variant of the conventional business model definition, with some elements and goals added to it; and, they either 1) add sustainability-oriented principles, concepts or objectives; or 2) integrate sustainability into their value proposition, value creation and distribution practices; and, 3) incorporate sustainability into their value proposition, value development and distribution activities (Geissdoerfer *et al.,* 2016; Lenssen *et al.,* 2013). There are different characteristics of these styles. For instance, circular business models generate sustainable value, use pro-active multi-stakeholder management, have a long-term perspective, and close, slow, intensify, dematerialize and narrow resource loops (Geissdoerfer *et al.,* 2016, 2018). This can be seen in Figure 4.

However, due to the potential trade-offs between these external features and the characteristics that refer to a sustainable business model, as illustrated in Figure 5, circumstances could constitute only a sub-category without being a sustainable business model. For instance, this may be due to the efficiency advantages of a new system that outweigh the environmental benefits of closing the loop on old technologies or the negative effect of circular action on employees' working conditions (Geissdoerfer, 2019b).

Sustainable Business Model Innovation for Microalgae

The sustainable business model innovation idea is crucial for companies to reach their environmental and social objectives by leveraging social, economic, and ecologically efficient solutions and technologies (Boons &

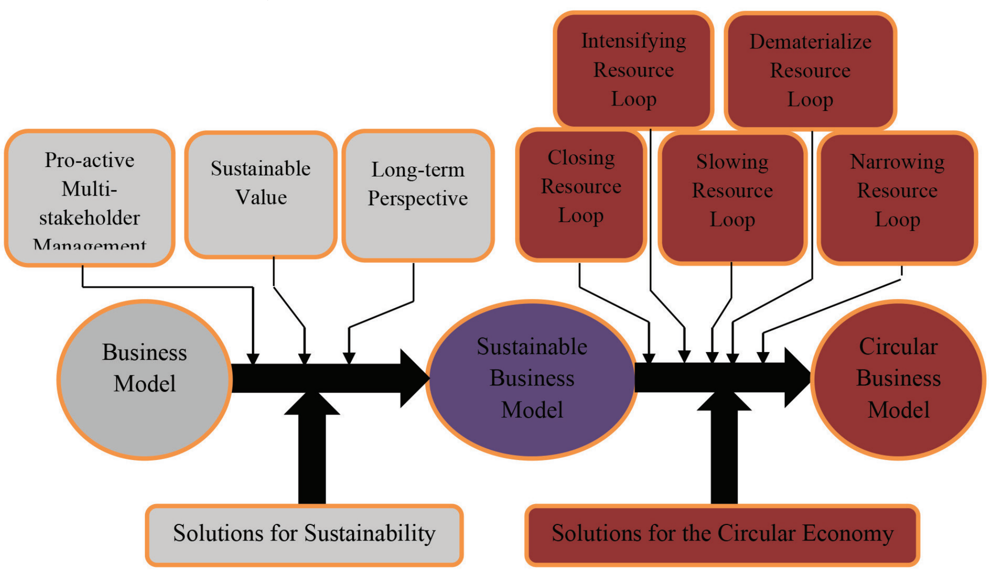

Figure 4: The Sustainable Business Model concept and its sub-categories (i.e., circular business models)

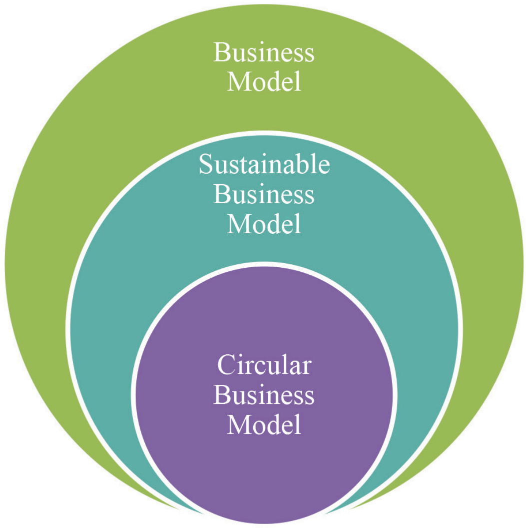

Figure 5: Imperfect overlap of the Sustainable Business Model concept and its sub-categories (i.e., circular business models)

Lüdeke-freund, 2013; Geissdoerfer *et al.,* 2016). Organisations involved in sustainable business model innovation can increase their economic, social, and environmental achievement (Nidumolu *et al.,* 2009) and increase flexibility and vulnerability to hazards through their environments (Geissdoerfer, 2019a). Business model innovation abilities are not only assumed to generate higher profits than product or method modifications (Lindgardt *et al.,* 2009). Still, they might fit to a "renewable" aggressive benefit (Casadesus-Masanell & Zhu, 2012) that would additionally enhance their quality for the organisational procedure (Casadesus-masanell & Ricart, 2010; Geissdoerfer *et al.,* 2018).

Business model innovation is seen as a continuum of business model discovery, adjustment, expansion, redesign, revision, creation, progress, acceptance, and transition, which is close to understanding traditional business model innovation scholars (Geissdoerfer *et al.,* 2018). The approach is a sustainable business model of innovation targeted at: 1) positive growth or healthy, respectively reduced, negative impacts on the economy, society and long-term viability of the company and its stakeholders; and, 2) incorporating techniques or features that foster sustainability or value in its business model, output and capture components.

There are four ways of sustainable innovation in business models, similar to the conventional innovation in business models shown in Figure 6, which are (1) sustainable start-ups: a new enterprise is created with a sustainable business model; (2) sustainable transformation of the business model: the existing business model is revised, leading to a sustainable business model; (3) diversification of the sustainable business model: without major modifications to the current business models of the sector and the introduction of an additional, sustainable business model; and, (4) acquisition of a sustainable business model: the discovery, integration and introduction into an entity of an alternative, sustainable business model.

It is expected that these four technologies seek to incorporate certain styles and techniques of sustainable business models. The styles include creativity in the circle market paradigm (Geissdoerfer *et al.,* 2018), bottom-of-the-pyramid firms in social organisations (Defourny & Nyssens, 2014) and product-service networks (Pigosso *et al.,* 2016). Bocken *et al.* (2014) reviewed the methods, as well as Ritala *et al.* (2018). They also synthesised nine standardised

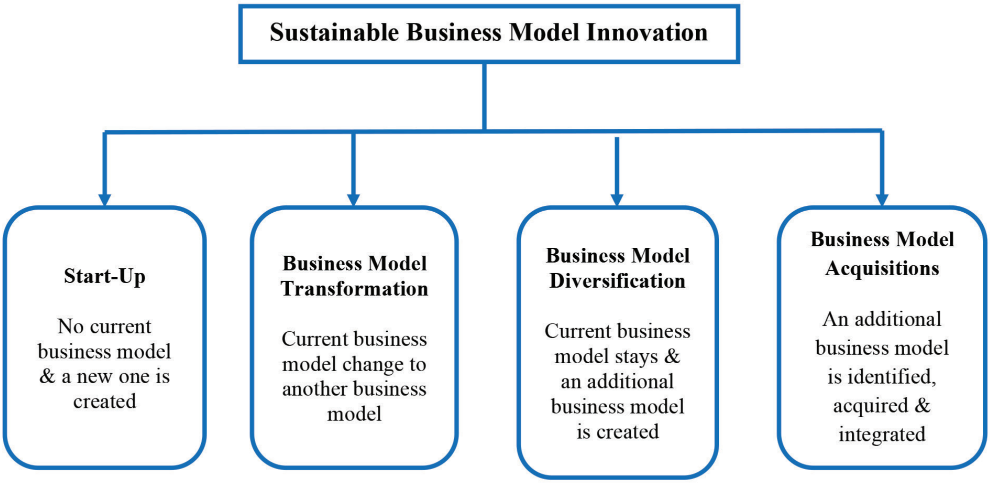

Figure 6: Sustainable business model innovation

Table 2: Overview of SBMI types, SBM types and SBMS types

Types	Examples	Description
Sustainable business model innovation types	1) Sustainable start-ups	It is a modern company with a progressive business plan.
	2) Sustainable business model transformation	The new business model has been updated, leading to a viable business model.
	3) Sustainable business model diversification	A viable business model is created without major improvements in the organisation's current business models.
	4) Sustainable business model acquisition	An alternative, viable business model is recognised, acquired, and introduced into the organisation.
Sustainable business model type	1) Circular business models	Business models that are closing, slowing, intensifying, dematerialising, or narrowing resource loops.
	2) Social enterprises	Business models that target social impacts by generating or fully reinvesting profits from economic activity.
	3) Bottom of the pyramid solutions	Business models that target clients at the bottom of the revenue pyramid.
	4) Product-service systems	A product, functionality, or result that is provided by business models, which integrate products and services into customer offerings.

Sustainable business model strategy types	1) Maximise material and energy efficiency	It aims to achieve less material and energy input more efficiently.
	2) Closing resource loop	It aims to close resource loops through reuse, recycling and remanufacturing.
	3) Substitute with renewables and natural processes	It aims to replace non-renewable resources with renewable, artificial ones, and processes with ones that imitate or use natural processes.
	4) Deliver functionality rather than ownership	It seeks to provide customers with the necessary features without possessing the product that offers the features.
	5) Adopt a stewardship role	It seeks to preserve natural structures by implementing a gatekeeper that restricts access or facilitates such behaviours.
	6) Encourage sufficiency	Targets information and benefits that facilitate less consumption.
	7) Repurpose for society or the environment	It aims to use corporate capital and skills to generate social or environmental benefits.
	8) Inclusive value creation	It seeks to offer value to previously unattended stakeholders or engage them in value development.
	9) Develop sustainable scale-up solutions	Targets the development of sustainable solutions and innovations.

strategies for sustainable business models, called “archetypes”. The tactics include (1) maximising material and energy efficiency; (2) closing resource loops; (3) replacing renewables and natural processes; (4) delivering functionality rather than ownership; (5) assuming a stewardship role; (6) promoting adequacy; (7) repurposing the environment or community; (8) generating inclusive value and (9) creating sustainable scale-up alternatives. Therefore, sustainable business model creativity focuses on (1) features of a sustainable business model, sustainable value development, constructive management of various stakeholders, and a long-term outlook; (2) four types of innovation-sustainable start-ups, sustainable transition of business models, diversification of sustainable business models, acquisition of sustainable business models; (3) the development of a form of sustainable business model, such as circular business models, social businesses, pyramid structures at the bottom, or product-service schemes and (4) the application of one or more strategies for a competitive business model. Table 2 offers a description of the viable types of business process innovation, business model types and strategies.

Organisations are in a situation where their operations are of an essential purpose (Loorbach & Wijsman, 2013). Also, suppose that organisations are working to adopt sustainability, which, in that case, organisations will still frequently use traditional modification methods that ultimately aim to extend the industry from the financial aspect, attempting to reach their business purposes. Modernisation applications concentrate on developing and intensifying current technologies and production methods by improving performance in energy and sources. However, not so many concentrate on successfully utilising another sustainable key driver, like mixing technological achievement with consumer interests to improve consumption models towards more sustainability (Daae & Boks, 2015; Nitkiewicz *et al.,* 2020).

For a long time, humans have brought unfavourable impacts on the planet, such as the Earth's increasing air, temperature and water pollution. However, something must be done about it. Some have suggested the transformation of our systems by improving economic impact, environmental influence and social arrangements that are the elements of sustainability. Sustainability is multidimensional, including social impact, environmental impact and economic impact (Mallette & Mallette, 2008). The purpose of sustainability is to provide the requirements of today without jeopardising the demands of tomorrow. It can be provided if all nations play their roles. Most countries recognise that new energy roots are not working to sustain growing communities, and existing non-renewables will be consumed without the population increase (Winickoff & Mondou, 2017).

Conclusion

There is a rising global interest concerning climate change compared with the increasing need for fossil carbon resources. Biofuels and bioproducts obtained through renewable biomass resources hold the potential to replace fossil carbon use in a sustainable manner. Microalgae are ensuring the availability of biomass feedstock due to their high germination speeds. Sustainable fuels from biomass have developed significantly due to the destruction of fossil fuels and the interests of global environmental transformation. Microalgae allow many benefits as specialists for bioenergy; their fast germination speed, excellent fertility and lipid content can be developed in an arable area, and their capacity to take CO_2 through flue gas can be utilised as a resource for photosynthesis. Microalgae can provide a comprehensive variety of biofuels, biodiesel, ethanol, methane, hydrogen and synthetic fuels using various transformation technologies. Enormous energy demands and the value for drying/dewatering and removal are significant disadvantages.

The suitability of microalgae for transformation into biofuel has been examined. It appears that innovative technologies, e.g. tubular PBRs, will improve the creation of microalgae biofuel for several fuel products, with the conversion of CO_2 for algae production, decreasing pollution. Several scholars have performed some life-cycle assessments. A significant review of those investigations revealed that sufficient LCAs of microalgae biofuel production research is still required to present a higher understanding of the circumstances. A more comprehensive understanding may arise through more organisations getting ahead in the microalgae transformation business (Singh & Gu, 2010; Singh *et al.,* 2017). It is clear from the significant assessment of algae design viability from an actual business view that the entire adjusted prices along with recurrent charges shall be a decision-making factor in the upcoming commercialisation of the microalgae biofuels.

Further numerous modifications are still required to improve technologies that can decrease the costs while improving yield. That can be achieved through comprehensible, extensive, and well-funded research and development applications. It is crucial in the initial stages of production that fixed innovative business models see the bioenergy potential of algae for the transport fuels business and the product of different higher-value goods to obtain practical economics. A maintained and sustainable application by technologists and administrators can appear through mastering this idea towards resolving the world's coming energy needs.

In order to attain sustainability, environmental influence needs to decrease considerably. The application of renewable natural substances can accommodate this. One approach to minimise ecological consequences is through the application of energy source and user behaviour. Utilising energy options is one of the answers to that obstacle. Several improvements have been designed to resolve energy pressure, such as using wind power, solar and biomass-obtained fuels. We also need to study the economic and social impacts in approaching the challenges of sustainable business models for microalgae biofuel.

Therefore, the analysis of literature verified the study gap. Several methods and processes have been described in the examined literature that promotes the creation of business models and creative support efforts. There are many instruments and procedures, as shown by Gassmann *et al.* (2014) and Ries (2011) which promote traditional business model creativity. While this indicates that the literature for conventional business model innovation tools and procedures is fairly mature, a review by Foss and Saebi (2017) revealed that there may be little grounding for empirical evidence in the literature. The advent of instruments that seek to use business model innovation as leverage to help companies meet their sustainability targets is a relatively recent development. For instance, sustainable business model creativity tools were also developed by Bocken *et al.* (2014), Evans *et al.* (2017), Geissdoerfer *et al.* (2016), Joyce and Paquin (2016), Lüdeke-Freund *et al.* (2018), Upward and Jones (2016) and Yang *et al.* (2017). These frameworks focus on single phases of sustainable business model innovation, with the exception of the sustainable business model processes of Lenssen *et al.* (2013) and Girotra and Netessine (2013) which combine diverse methods into a more comprehensive structure.

Evans *et al.* (2017) combine multiple tools into a prescriptive approach that offers some guidelines to practitioners on conceptualising a feasible business model, but without providing a descriptive framework for the whole process. Rana *et al.* (2013) published the technique, and it was developed based on a literature and knowledge review for either two (Rana *et al.,* 2013) or six (Holgado *et al.,* 2013) cases. A purely conceptual methodology, a prescriptive method used by the authors, incorporate and graduate management education, was used by Girotra and Netessine (2013) (sample design, short outline). The article is based on a minimal body of literature and appears oblivious to the innovation literature on sustainable business models. It is not clear from the authors' explanation of how or on what basis the method was derived. Compared with the literature on processes for traditional business models, both methods appeared very simplistic and only addressed issues that affect the early stages of the process. Prendeville and Bocken (2017) and Roome and Louche (2016) have neighbouring methods with a method context. However, with Prendeville and Bocken (2017) comparing traditional business model creativity with the service design method under the premise that socialisation leads to improved sustainability results, the reach of these methods is different, and Roome and Louche, (2016) address organisational change in the sense of two sustainability-focused situations. For most of the sustainable business model innovation method, this literature provides just little clarification. This suggests that the literature does not discuss science problems adequately, which reinforces the research gap.

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