FoodBev SETA

Food & Beverages Manufacturing
Sector Education and Training Authority

Exploring the Green Economy in the Food and Beverages Manufacturing Sector

Table of Contents

Table of Figures and Tables

Exploring the Green Economy in the Food and Beverages Manufacturing Sector

Abstract

Green economy is defined as an economic system based on sustainable development that improves social inequality and human well-being while reducing ecological shortage and environmental challenges to a substantial degree. Green economy has been identified as one of the pillars in economic recovery in South Africa (SA) and globally. SMME's development in support of the green economy is the new business opportunity as data indicates new ventures in the green economy is born out of SMME's. The ability to strategically invest in skills, skills development, infrastructure and value chains associated with the green economy is a global strategic differentiator.

The aim of this study is to explore the green economy globally with the aim of application in the South African food and beverages manufacturing sector, to investigate the factors, and benefits of green economy in the food and beverage manufacturing sector. This includes identify factors that would be important in the SA context. This study reviews global maturity in the green economy with the aim of reviewing SA specific adaption and adoption. The research seeks to illicit initial conversations and considerations at the SETA, in terms of key factors in the FoodBev sector, associated with the green economy. The key objective of the SETA is to drive skills development supporting the green economy.

Keywords*: green economy, food and beverage, manufacturing, sustainable development, ecology*

1. Introduction

(Muposhi, 2019) defined green economy as a system of interconnected economic activities aimed at promoting inclusive growth through the implementation of pro-environmental sustainability methods (Droste *et al.*, 2016) defined green economy as an alternative economy that can increase well-being and social equity while also minimizing environmental damage, climate change, addressing ecological scarcity issues, and incorporating natural resources into economic policy. For a better quality of life, the green economy attempts to develop a sustainable and efficient economy (Othman, Mat Su and Ya'Acob, 2018).

The green economy plays an important role in establishing a framework for transitioning to an economy that is intimately tied to long-term development (Babonea and Joia, 2012). The economic system is complex, and this vision must be perfect from the start to adapt in the long run. The green economy's primary performance metrics include reduced environmental degradation and dangers, green growth, and increased social fairness (Muposhi, 2019). The 5R-concept of recovering, reusing, recycling, reducing, and remanufacturing is considered critical to green economy's implementation (Tienhaara, 2014). Resource sustainability is a critical issue, especially when considering climate change over the next few decades.

A necessity in the development of a green economy is supporting policies. Implementing a green economy necessitates the active participation of consumers and the business community, as well as a fundamental framework of policies suggested and adopted at national and worldwide levels of leadership.

South Africa's green economy policy is in line with the country's national development goals of reducing poverty and unemployment, increased resource efficiency, reduced carbon emissions, and creation of green jobs (Mazhandu *et al.*, 2021). Environmental sustainability, sustainable production and consumption, water management, sustainable transport and infrastructure, clean energy and energy efficiency, green buildings and the built environment, resource conservation and management, sustainable waste management practises, agriculture, food production, and forestry are among the focus areas of South Africa's green economy vision (Muposhi, 2019).

The aim of this study is to explore the green economy in the South African food and beverages manufacturing sector, to investigate the impact, factors, and benefits of green economy in the food and beverage manufacturing sector, and to identify factors that would be important in the South African context. This study reviews global maturity in the green economy with the aim of reviewing SA specific application and forecasting of green skills. This document serves as an advisory towards considerations of the green economy in food and beverage manufacturing.

2. Literature Review

South Africa has incorporated green economic initiatives into its national goals (Musango, Brent and Bassi, 2014). Current research focuses on the public understanding of the green economy in relation to energy conservation, increasing market demand, creating new jobs, attaining sustainable economic development, and poverty eradication (Xie *et al.*, 2019; Jiang *et al.*, 2020).

Green economy adoption arose from a consensus that only collective economic adjustments on a global scale can mitigate the lethal consequences of climate change and environmental degradation (Georgeson, Maslin and Poessinouw, 2017). The essential ideas that define the concept of green economy include environment, social and economic. The social side pertains to enhanced human well-being and so-called equity, whilst the environmental side is extensively used to resolve issues related to climate change and its mitigation (Loiseau *et al.*, 2016; UNEP, 2019). Studies demonstrate that the green economy is preferable to modern economic development as a means of addressing today's economic, social, and environmental problems, such as enhancing human well-being, promoting social equity, preventing the depletion of natural resources, minimising environmental risks, and meeting the challenge of climate change (Merino-saum *et al.*, 2020). The green economy advocates good governance, transparency and accountability as essential requirements for sustainable development.

The FoodBev industry is an important economic sector for quality food supply, employment opportunities and a contributor to the gross domestic product (GDP) of countries globally. The food and beverage sectors have historically faced criticism for participating in

unfavourable environmental practices. Thus, the food and beverage industry is crucial in addressing the current global issues of food insecurity, and, climate change (Guiné, Ramalhosa and Valente, 2016; Bayona-Saez *et al.*, 2017). Many companies, in the food and beverage industry, have pledged to minimize ecological impact, with the major focus areas being reducing impact on the planet, improving sustainable food sourcing, lowering food waste, and expanding product range (Peleg, 2021).

The global food demand expected to rise between 59% and 98% by 2050 (Valin *et al.*, 2014) With, the growth in population, and increasing income levels, meat and other high-grade proteins are in high demand (Valin *et al.*, 2014) (Valin *et al.*, 2014). Thus, the food and beverage industry and wider food systems are an important entry-point to reduce greenhouse gas emissions and other environment impacts. The industry is in a position to stimulate the uptake of green practices, both vertically and horizontally, in its respective value chains (Francesco and Jenkins, 2020). FoodBev manufacturers and distributors are proving that green is crucial by reducing greenhouse gas emissions, and demonstrating positive social contribution, and increased revenue from green sources (Guiné, Ramalhosa and Valente, 2016; Bayona-Saez *et al.*, 2017; Francesco and Jenkins, 2020).

Climate change exacerbates pressure on natural and human resources, making it harder to produce enough food for everyone (Dombroski, 2020). With this in mind, the FoodBev industry is moving towards a more sustainable future. Additional considerations include new regulations around net zero emissions coming into effect (Cooper, 2022). This is supported by a growing trend in eating sustainably by adopting meals that have a lower environmental impact, with an awareness of food waste and plate portions (Dombroski, 2020). As a key player in the food value chain, (Santeramo, 2022) states that the agri-food sector ought to strive for sustainable intensification, boosting production while minimising negative environmental effects. (Genovese *et al.*, 2017) recommends sustainable management to assist farmers and producers to create more eco-friendly production-consumption systems based on reuse and recycling. Environmentally friendly agri-food systems promote the utilisation of natural resources known as technological and biological nutrients (Assandri *et al.*, 2021).

To eliminate world hunger, governments, manufacturers, and consumers all have a social responsibility. The threat posed by climate change and food security is becoming more apparent to consumers.

2.1 Circular Economy

The concept behind both the circular economy and the green economy is to adapt to or shift the current economy towards a more sustainable one (D'Amato *et al.*, 2017; Santeramo, 2022), This new economic model has been developed to defeat the traditional model that is based on the "take, make, and dispose" principle (Ghisellini, Cialani and Ulgiati, 2016), also named as "linear economy". The traditional economic models suggest that uneven production and consumption patterns are desirable welfare outcomes, but it is well-known that economic systems are interlinked with the environment (Genovese *et al.*, 2017). The circular economy addresses decoupling resource efficiency, production efficiency, and resource extraction without reducing economic activity (Mccarthy et al., 2018). The circular

economy is also defined as the development of a continuous virtuous cycle that reduces systemic risk by protecting and strengthening natural capital, optimizing resource development, and managing finite supplies and renewable energy flows. Focusing on the circular and green economy is promising for future research and would allow better understanding of the environmental and social challenges posed by a fast-growing economic development (Ghisellini, Cialani and Ulgiati, 2016).

The circular economy is changing the future of several industries, including the food and beverage industry (Alexandra, 2022). The adoption of circular approaches can alleviate the challenges associated with wastage and energy losses and resource consumption, providing both economic and environmental benefits to the FoodBev industry (Emily, 2021).

2.2 Sustainable Development and Green Economy

The terms “green economy” and “sustainable development" are often used reciprocally with the common goal of protecting environmental resources for future generations. In addition, both green growth and sustainable development focus on reducing social inequality. Despite their common fundamental goals, both concepts address various aspects of human well-being. Sustainability entails interdependent activities and advantages that continue to satisfy technological, economic, and institutional requirements (Diale, Maladzhi and Ohe, 2022). In South Africa, green economy is seen as either a strictly technical modification or "greening" of current processes, or as a profoundly transformational change that challenges all dimensions of the current system (Rosenberg, Lotz-sisitka and Ramsarup, 2018).

The green economy can open the way for achieving the sustainable development goals because it is characterised by economic growth that seeks to reduce carbon emissions, minimise pollution and energy use, ensure resource efficiency, and maintain ecosystem services while also addressing sustainable employment (Anggusti and Siallagan, 2018; Alwakid, Aparicio and Urbano, 2021). The green economy includes, but is not limited to, the following thematic areas (Asiimwe and de Kock, 2019):

- green energy,
- sustainable water provision,
- waste management,
- agriculture,
- trade in low-carbon products,
- cleaner and greener technologies,
- green buildings,
- green chemistry,
- sustainable transport (mini cars/cycles),
- improved air quality.

2.3 Skills Development for a Green Economy

Enabling the green economy is based on ensuring that sufficient tools and resources are in place, while also requiring the application of information technology and creativity (Jnr *et al.*, 2016). Enabling a green economy must begin with the examination of present global models and learning from existing success elements and difficulties. Several researchers are of the opinion that once the capacity building milestones relating to climate change and the green economy have been fully achieved, this mechanism can aid in the transition of 4IR

ecosystems to a green economy (Hojer and Wangel, 2015; Asiimwe and de Kock, 2019; Diale, Maladzhi and Ohe, 2022). Energy efficiency and clean technologies are further green economy boosters (Barbier, 2011).

Sustainability and climate education in higher education and work-based learning can catalyse the necessary societal transformations (Wall, 2022). Learning needs associated with a green economy could be a significant proportion of learning needs attributed to the wider concept of sustainable development or sustainability, if both share a fundamental commitment to profound social changes toward just transitions, economic equality, and ecological sustainability (Rosenberg, Lotz-sisitka and Ramsarup, 2018). A study by (Quiroz-Niño and Murga-Menoyo, 2017) states that training communities, easing the transfer of technology, and using technology to assist individuals learn skills and develop can contribute to the achievement of sustainable goals. As a result of training and progress in green technologies, people of any community will be able to build and think of products or services that enable them to be self-sufficient, create jobs, and train others (Carvalho *et al.*, 2018).
Europe, China, and Taiwan's development and innovation in the green economy, as well as the technological developments in digitalisation, could act as point of reference for the documentation and lessons learned relating to skills (Hojer and Wangel, 2015). In addition, education and training that produces highly qualified personnel will be required to fill the void and meet the demands of the impending industrial revolution (Anggusti and Siallagan, 2018; Asiimwe and de Kock, 2019).

Curriculum revision is essential with regard to the incorporation of digitalisation and 4IR-aligned skills, especially if the ecosystem is to be successfully implemented and enabled (Anggusti and Siallagan, 2018). It is possible to develop a memorandum of understanding with nations that are innovative practises leaders and to integrate such innovative practises into the green economy (Anggusti and Siallagan, 2018; Asiimwe and de Kock, 2019). Exchange programmes, a broadening of the breadth of career advice and mentoring, as well as the incorporation of commercialisation, brings entrepreneurship into play, which is a crucial factor in advancing the Sustainable Development Goals (SGDs) for eradicating poverty and reducing instances of social injustice (Diale, Maladzhi and Ohe, 2022).

Non-Governmental Organisations (NGOs) who aspire to achieve sustainability by developing green and smart cities must be supported in this regard (Lom, Pribyl and Svitek, 2016). Furthermore, smart cities model that emphasises communication between rural and urban areas will help accelerate the United Nations' SDGs of eradicating poverty through food security, sustainable agriculture, and farming, while using technology to share knowledge and communicate best practises across regions and countries (Okello, Saina and Ngode, 2019). To support the smart city paradigm, production, or transformation through 4IR can occur everywhere and at any time; a home can be transformed into a micro factory (Burma, 2016) or best practises in sustainable manufacturing can be distributed broadly to ensure connectivity and collaboration (Carvalho *et al.*, 2018). Technology can be utilised to improve food security such as ensuring that urban farming technologies reuse water to water plants. In New York City an, automated heating system enables heat from other buildings to heat plants for growth (Thomaier *et al.*, 2015). The urban regeneration revolution comprises sustainable mobility, digital information, autonomous vehicles, and networked digital infrastructure (Choi and Kim, 2017). This must be tied to equal resource access. To address the criteria of 4IR, industrial psychologists can assist with policy creation concerning the

interaction between people and machines, systems, and processes (Manda and Dhaou, 2019).

Simplifying processes will help assure the adoption and effectiveness of the system by contributing to efficiencies. On international markets, the impact and function of 4IR and rapid sustainable development on a single sector, such as food security, have been investigated (de Amorim *et al.*, 2019). (Diale, Maladzhi and Ohe, 2022) examined several aspects of sustainable development, such as water, energy, green building, infrastructure, waste, sustainable production, and manufacturing. In addition, the project intended to contribute by developing an ecosystem for contextualising 4IR technologies and their usefulness within a South African setting (Diale, Maladzhi and Ohe, 2022).

2.4 Policies Affecting Carbon Emissions in South Africa

Given the importance of minimizing carbon emissions and the potential advantages of a green-based society, the government of South Africa has implemented strategies to reduce carbon emissions to 34% and 42% by 2020 and 2025 respectively (Carbon Tax Laggards May Pay Dearly, Cautions Environmental Firm, 2017). The adoption of a carbon tax system is one of the most important direct steps to reduce emissions at the national level. The South African carbon tax act of 2019 came into effect on the 01 June 2019 (SARS website) The carbon tax rate started at R120 per ton of carbon dioxide equivalent emissions, and increases annually by inflation plus 2% until 2022, from which it increases by inflation annually (SARS website). The majority of industrialised nations consider climate change and CO_2 emission reductions as "the currency of argument in a climate-constrained world" (Griffin and Hammond, 2021).

2.5 Green Logistics

Green logistics contributes to the conservation of natural resources, provides a bridge between natural resources and products, and between products and consumers, and is a tool for closing the loop in the circular economy (de Souza *et al.*, 2021). In a circular economy, green logistics determines the effectiveness of the economic cycle. Therefore, important green logistics activities include environmentally friendly packaging, and green transportation, storage, and processing flow (Seroka-Stolka and Ociepa-Kubicka, 2019).

2.6 Ecosystems and Green Economy

Adopting green infrastructure or urban agriculture inside community gardens, green spaces, allotments, and parks is favoured to diversify ecosystem service provision, with each providing services such as vegetation grown and growing spaces (Evans *et al.*, 2022). In contrast, several locations are connected with the delivery of a. Natural spaces, indoor spaces, and religious spaces, offer a relatively small number of services, despite these spaces not being fully investigated in urban ecosystem studies (Loiseau *et al.*, 2016).

2.7 Hydrogen Economy

Hydrogen economy must be built on a sustainable hydrogen supply (Gondal, Masood and Khan, 2018). Existing hydrogen generation techniques rely mostly on fossil fuels and are therefore deemed unsuitable as a sustainable alternative to the "fossil economy." hydrogen production must be dependent on feedstocks "other than fossil fuels" Renewable energy sources are the most viable option for producing hydrogen in a sustainable manner (Agaton, Batac and Reyes, 2022). Therefore, hydrogen is a significant alternative source of energy for

decarbonizing the world (Song *et al.*, 2022). The hydrogen economy is intended to play significant roles in industrial power generation, and transportation sectors (Oliveira, Beswick and Yan, 2021). In the energy sector, the use of green hydrogen as a storage medium to mitigate the inherent uncertainty of solar and wind power output is being investigated (Song *et al.*, 2022). In the industrial sector, hydrogen is a substitute for coking coal in the iron and steel industry, in a process known as hydrogen-DRI (direct reduced iron) (Song *et al.*, 2022). Further, there is an assumption that green hydrogen can be used as a feedstock for the manufacturing of ammonia and other chemicals, as well as a heat source for the production of cement and other industrial products (Griffin and Hammond, 2021).

2.8 Developments in Green Economy

A stable and predictable macroeconomic environment is essential to facilitate domestic and foreign investment. This awareness pushes for an increasing attention on sustainability, including the agricultural sector. The agri-food system should pursue a sustainable intensification, increasing production while avoiding adverse environmental impacts. Sustainable management is a strategic goal to enable farmers and producers to establish greener production-consumption systems, based on reuse and recycle (Genovese *et al.*, 2017). The greener agri-food systems encourage the use of raw materials, known as technical and biological nutrients (Assandri *et al.*, 2021), as it does not have detrimental impacts on the environment (Genovese *et al.*, 2017).

Agrivoltaic is the use of the same land for agriculture and electricity generation (solar photovoltaic). Green economy principles are completely embraced by agrivoltaic systems; low-carbon technology, pollution reduction, efficient resource utilisation, increased employment, and prevention of the loss of agroecosystem services (UNEP, 2021). While the use of photovoltaic systems for converting solar energy into electricity demonstrates the integration of clean energy technologies and reduced greenhouse gas emissions, the more efficient use of natural resources under agrivoltaic systems is linked to increased land productivity and water productivity (Campana *et al.*, 2021). According to (Parkinson and Hunt, 2020), in places with significant groundwater stress, switching from irrigated to rainfed agriculture combined with agrivoltaics potentially reduce water shortages. Agrivoltaic systems improve rural living conditions in both developed and developing countries by offering employment opportunities and ensuring farmers' doubled and stabilised (less erratic) revenues and (Campana *et al.*, 2021). This has the potential to enhance the market for large-scale installations on agricultural land, resulting in several job opportunities (Campana *et al.*, 2021).

Table 1 is a summary of papers analysed. The review addresses the green economy and the green economy in FoodBev industry in a South African context. The bibliometric analysis addresses the countries of origin of authors, the keywords that are mostly used in relation to green economy and the key findings of the research papers reviewed. The research team explore the initial literature review as an indicator of the breath of the green economy.

Table 1: Key themes as extracted from initial literature review

Author & Year	*Sustainability*	*Networks/ Eco systems*	*Social*	*Systems*	*Digital/4IR*	Circular economy	Logistics	*Health*	Knowledge/ Research'	*Finance*	*Policy (Green/ Industrial)*	Climate Change	Hydrogen	Biofuels (Biogas)	Urban Agriculture	Net Zero	*Efficiency*	*Carbon*	Management
(Merino-Saum *et al.*, 2020)		x	x			x		x								x			
(Lee *et al.*, 2021)						x								x				x	
(Gondal, Masood and Khan, 2018)													x	x					x
(Griffin and Hammond, 2021)						x						x	x			x		x	
(Agaton, Batac and Reyes, 2022)									x	x			x	x				x	
(Song *et al.*, 2022)			x						x			x	x	x				x	
(Oliveira, Beswick and Yan, 2021)													x	x				x	
(Bherwani *et al.*, 2022)						x			x			x						x	
(Kang *et al.*, 2019)									x			x			x				x
(Giacomelli Sobrinho, Lagutov and Baran, 2020)									x		x	x							
(Łukasz Kurowski, Joanna Rutecka-Góra, 2019)									x	x		x							
(Ahmed, 2013)			x									x							x
(Nascimento *et al.*, 2019)	x				x	x	x		x			x							
(Olah, Goeppert and Prakash, 2009)									x				x					x	
(Hsu *et al.*, 2013)	x						x		x										x
(Zhang *et al.*, 2010)			x			x	x												x
(Liu and Dong, 2021)		x							x						x				
(Posso *et al.*, 2022)	x												x	x				x	
(Raman *et al.*, 2022)	x												x			x			
(Evans *et al.*, 2022)		x							x						x				
(Soares de Carvalho Freitas *et al.*, 2022)X				x		x								x				x	
(de Souza *et al.*, 2022)				x			x												
(Bozkurt, Xheneti and Vicky, 2022)	x					x			x			x							x
(Morseletto, 2020)	x					x						x							
(Seroka-Stolka and Ociepa-Kubicka, 2019)	x			x			x												x
(Khan and Haleem, 2021)	x					x			x										
(Ringel *et al.*, 2016)		x									x						x		
(Musango, Brent and Bassi, 2014)	x	x																x	x
(Abdul *et al.*, 2022)	x				x												x		
(Pan *et al.*, 2018)			x	x			x				x			x			x		
(Moşteanu *et al.*, 2020)		x			x					x									
(Mennicken, Janz and Roth, 2016)					x				x		x	x					x	x	
(Lee, Wang and Ho, 2022)										x	x								
(Mastini, Kallis and Hickel, 2021)		x								x	x								
(Mativengaa et al, 2016)				x							x								
(Loiseau et al. 2016)	x	x								x									
(Kothari et al., 2014)	x		x					x											
(Paul et al, 2019)	x																	x	

3. Methodology

This research study adopts a qualitative desktop research methodology and extracts secondary data from a variety of peer reviewed sources (Williams, 2015). The adoption of the method seeks to advance technological, policy and skills understanding of the green economy, for strategic skills investment in advancement of the growth of the green economy in SA. This approach is known as Technological Acceptance Modelling (TAM) and is well documented in the knowledge areas of theory of technological adoption (Ajibade, 2018). The objectives of this study are to:

- Landscape the green economy including defining green economy currently and the components of green economy,
- Understand green economy in the context of the South African FoodBev industry,
- Identify opportunities for green economy across the value chain of the South African FoodBev industry,
- Identify the skills required for development of a green economy.

The literature, the key data source, is analysed in multiple levels.

- The first analysis provides for keywords that direct a positive word sampling and SLR (Moher et al, 2015; Kraus et al, 2020).
- Second literature search based on the keywords derived from the first analysis.
- Bibliometric analysis of second literature search (in Scopus), which considers publications from 2012 to 2022. The publications are screened and sorted based on highest citied, most relevant and most recent publications.
- Compilation of screened data, data pre-processing, data analysis and data presentation.

The keywords are an essential part of a research paper, as it provides important information on the content the paper (Liu et al., 2011; Guo et al., 2015). Systematic analysis of keywords in specific research fields can indicate the development trends and research differences in the field (Guo et al., 2015). Keyword co-occurrence analysis is often used to analyse the strength of links between different keywords. The analysing of the co-occurrence relationships of keywords, details the internal composition relationship and structure in a certain academic domain and reveals the research frontiers of the discipline. Consequently, keywords co-occurrence analysis is a common research method in bibliometric analysis.

Figure 1 illustrates the approach adopted in this study.

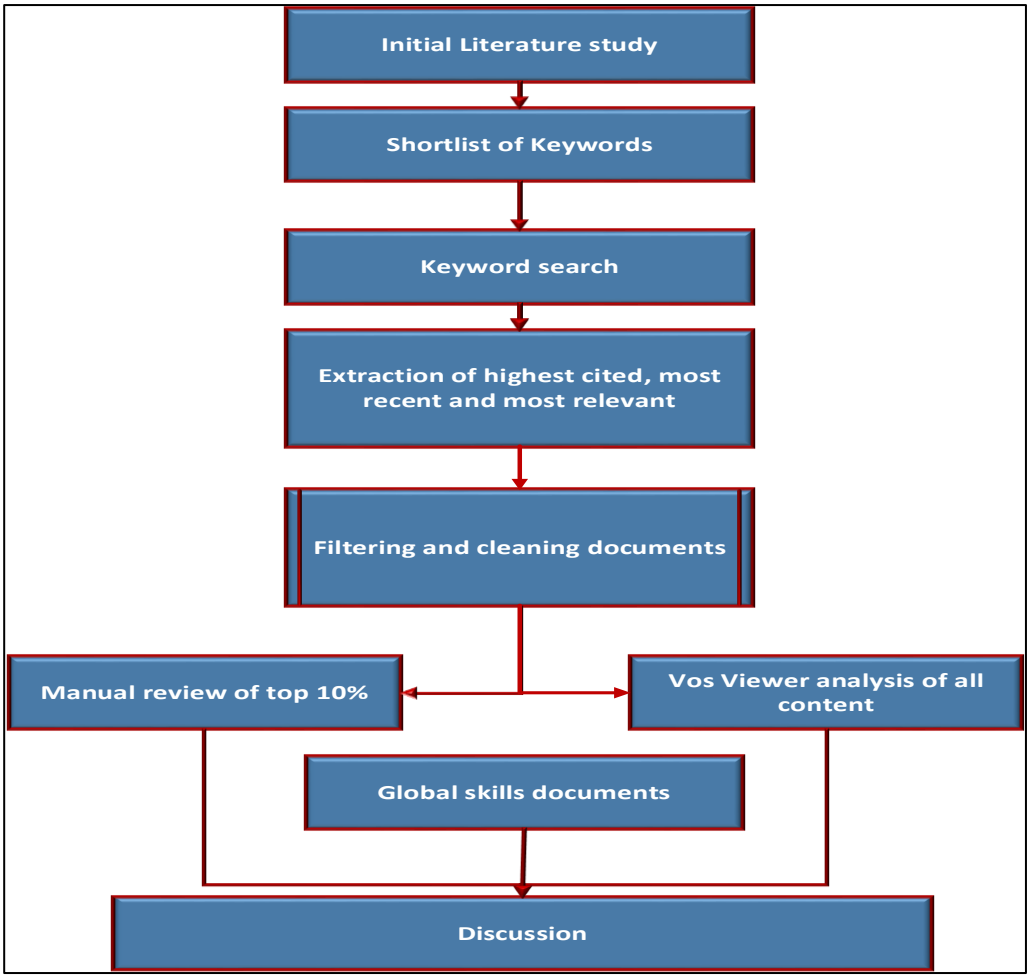


Figure 1: Methodology flow diagram

4. Results

An initial search is conducted with the primary keywords of "Green economy" and "FoodBev" with and the associated synonyms. This initial search resulted identified 26 862 publications. The papers are screened by applying the criteria of; papers in English only, full paper is available for download, and peer reviewed. This screening resulted in a paper count of 400 for analysis.

The analysis began by determining the countries in which green economies initiatives are active, hence, a country-of-origin analysis of authors is conducted. Figure 2 details the countries from which the green economy authors originate. The dominant researchers in this field (over 100 publications), in descending order, are based in China, the Russian Federation, the United States, and Italy. However, the publications from China (over 900), are at minimum three times greater than the remaining countries. Interestingly, in the top 10 author countries, six of the countries are classified as developing countries; China, Russia, India, Pakistan, Malaysia and South Africa. Based on the sizes of these countries, it is necessary to hold active debates discussing green economy topics. Green economy issues in countries that are developing ought to be considered as areas of focus in future research.

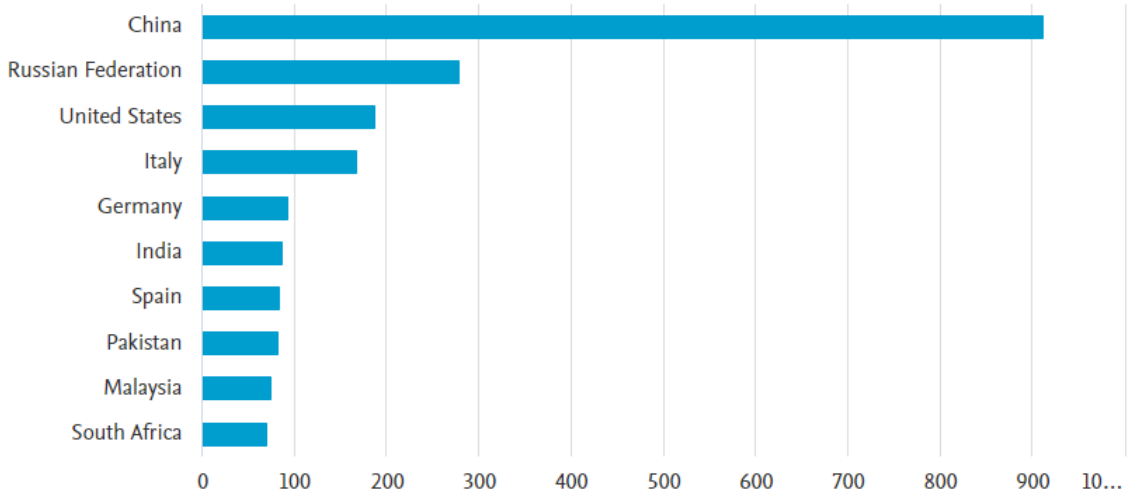


Figure 2: Country of origin of authors.

The initial literature analysis indicates that research on green economy has been growing in recent years and there are a significant number of keywords that have, and continue to, emerge from green economy. There are studies conducted that indicates how green economy has been integrated with 4IR and digitalization with the purpose of reducing the dangers of climate change, protecting the environment and eliminating carbon emissions globally.

a. Initial Search – Keyword Determination for Secondary Search

The 400 publications are analysed in two approaches: analysis of the highest cited papers and subsequently the filtered 400 papers. The highest cited papers are reviewed as an indication of green development. The result of both analyses is merged to provide a comprehensive set of keywords for further analysis. Relevant highest cited articles are detailed Table 2.

Table 2: Extract of relevant highest cited articles

Author	Title	Citations
Scarlat et al, 2015	The role of biomass and bioenergy in a future bio-economy: Policies and facts	484
Cuerva et al, 2014	Drivers of green and non-green innovation: Empirical evidence in Low-Tech SMEs	275
Jafari & McClements, 2017.	Nanotechnology Approaches for Increasing Nutrient Bioavailability	190
Sharma et al, 2020	Microbial strategies for bio-transforming food waste into resources	188
Thakur & Ragavan, 2013	Biosensors in food processing	157
Pal & Suresh, 2016	Sustainable valorisation of seafood by-products: Recovery of collagen and development of collagen-based novel functional food ingredients	122
Drewnowski et al, 2015	Energy and nutrient density of foods in relation to their carbon footprint	95
Cofrades et al, 2013	Design of healthier foods and beverages containing whole algae	13

The key themes extracted from the analysis of the highest cited papers are: biomass/ bioenergy/ bioavailability/ biotransformation, innovation, nanotechnology, valorisation, energy, algae for food production and environmental.

A bibliometric analysis is conducted on the two datasets (the highest cited papers and the filtered 400 papers), using VOSviewer. In support of the high-level review bibliometric network diagrams are developed for the two datasets, as illustrated in Figure 3, with the diagram on the right illustrating the highest cited results only and the diagram on the left illustrating the filtered 400 publications.

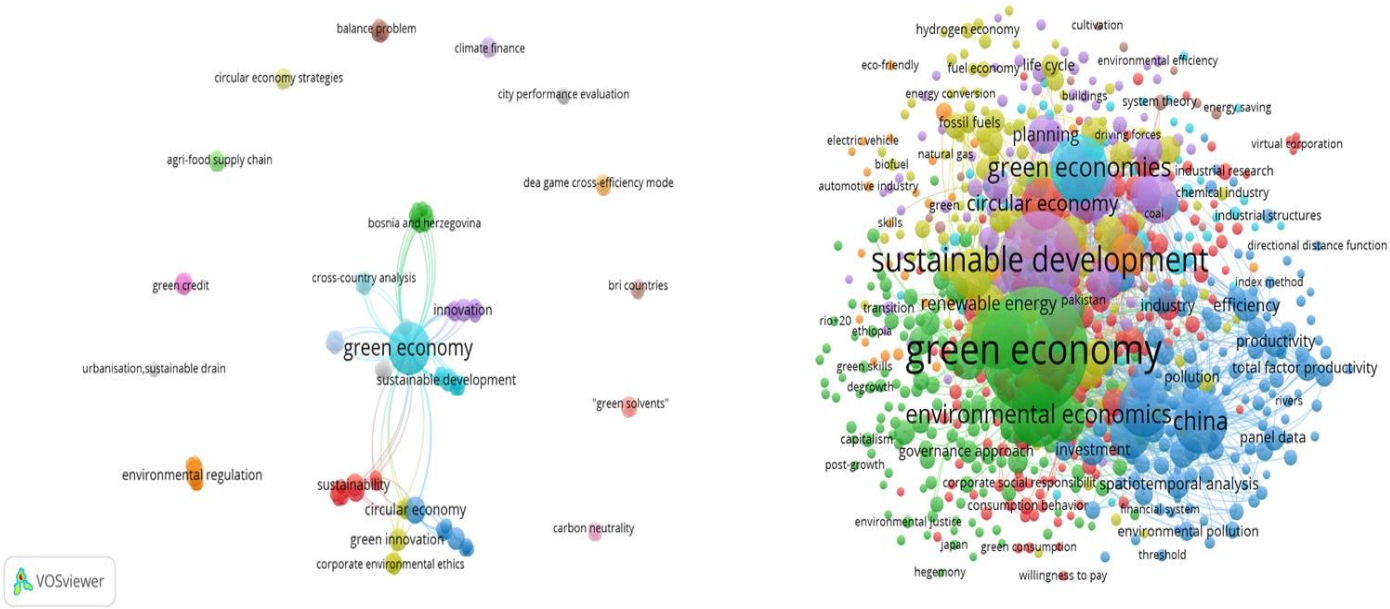


Figure 3: Network diagram for the highest cited papers (diagram on left) and filtered data set

The analysis of the highest cited papers indicates that green economy and sustainable development are very closely linked, while the circular economy, corporates and green innovation are strongly associated. For the filtered dataset (400 publications), two distinct clusters emerge on green economy (green bubbles) and China (blue bubbles). The data trends towards key areas such as productivity, efficiency, economics, green economics, sustainable development, and sustainable development.

The analysis of the highest cited papers together with the network diagrams for the highest cited papers and total papers, reveal the following themes as critical for the green economy:

- Agri-food supply chain
    - Urban sustainability
    - Green consumption
- Policy
- Systems
- Bio and innovative technologies
    - Biomass
    - Bioenergy

    - Bioavailability
    - Biotransformation
    - Nanotechnology
    - Valorisation
    - Green solvents
- Energy
    - Green
    - Energy conversion
    - Energy management
    - Hydrogen economy

The above-mentioned themes are now adopted as keywords in the secondary search focused on the food and beverage industry.

b. Themes analysis

In the second Scopus search, the search string is “green economy” AND “Theme as identified in Section 4.2” AND “food and beverages,” with the associated synonyms. For each of the themes, a dual analysis approach is adopted:

- Manual analysis of the top 10% of the highest cited, most relevant and most recent publications
- Bibliometric analysis of all publications in VOSviewer

The manual analysis results are first presented, followed by the bibliometric analysis.

i. Green policy

The literature emphasised the need for policies and legalisation to support the green economy. Green economy policies have various important components to consider including companies and country specific policies and co-operation between local governments and national authorities (Woo and Kang, 2021) identified two main corporate elements for green policy makers in the alignment of firm environmental strategy with strategic human resources (HR):

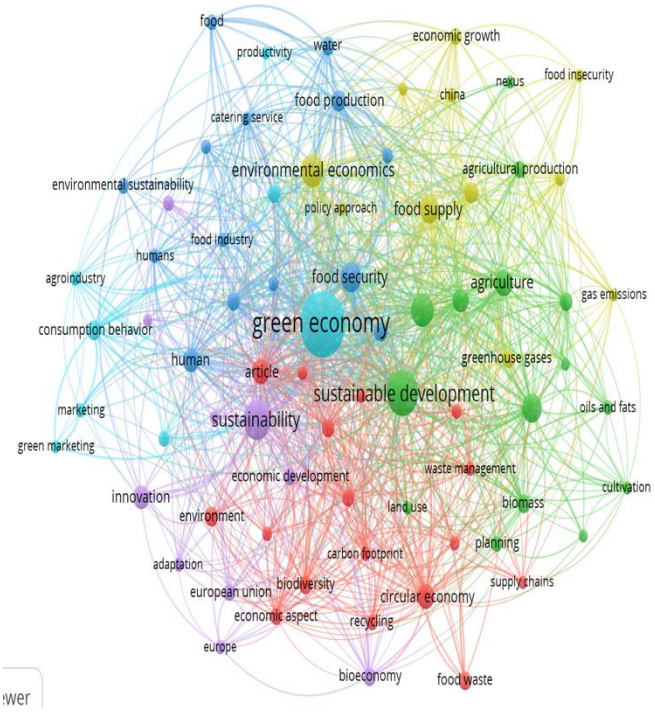
- an organizational culture that supports employee green practices and
- employee adaptability competency that enables workers to respond to the evolving environmental challenges as main component of analysis.

Taxes on unhealthy foods and beverages have shown reductions in purchases of targeted un- healthy products and nutrients (Sacks, Kwon and Backholer, 2021). Data from multiple sources have demonstrated that as the prices of unhealthy foods and beverages increase, purchase volume decreases. However, studies indicate potential for substitution to non-taxed unhealthy foods, which needs to be factored into taxation design.

A significant correlation between innovation capabilities, green process innovation, and sustainable performance is identified (Sarfraz *et al.*, 2022). The buffering role of digital leadership enhances the employees’ creative skills and sustainable performance. Additionally, the extent that green product innovation plays a mediating role between innovation capabilities, green process innovation, and sustainable performance has been contemplated. Literature also analyses the moderating role of digital leadership in sustainable performance

While environmental regulation may suppress local manufacturing carbon emissions, local government competition increases local manufacturing carbon emissions (Li, 2022). Table 3 details a few of the critical publications identified and the network diagram

Table 3: Key publication on policy related to green economy and the network diagram

Authors & Year	Keywords	Findings
(Liu, Xin and Li, 2022)	Environmental regulation · Local government competition · Manufacturing carbon emissions · Regional boundary	
(Sarfraz *et al.*, 2022)	green production; green innovation; sustainability; digital leadership; manufacturing firm	
(Medeiros, Valente and Castro, 2022)	green economy; PO SEUR; Portugal; public policies; sustainable development; sustainability	
(Zhang *et al.*, **2022**)	Central environmental inspection (CEI) · Environmental regulation · Green innovation · Bargaining intentions · Political connections · Industry competition	
(Woo and Kang, 2021)	environmental performance; adaptability competency; corporate culture	
(Can, Ben Jebli and Brusselaers, 2022)	Environmental degradation · Green economy · Green Openness Index · Green Trade Openness Index · Green products · Sustainable development	
(Di Pirro *et al.*, 2022)	human health; human well-being; urban sustainability; green deal; urban forests; green roofs; multifunctionality	
(Zacchia *et al.*, 2022)	green transition; higher education; Africa	

The network diagram indicates a few clear nodes around the green economy and policies:

- Agriculture, waste management, gas emissions, oils and fats and land use.
- Food security, environmental sustainability, productivity, food production and green marketing. This cluster is blended with food supply and production and environmental economics.
- Sustainable development, circular economy, food waste, carbon with links to the bio economy.

Europe and China are the only region and country identified in the network diagram, indicating their significant presence in the green policy sphere, hence an initiation point for further work on South African and food and beverage green policy development.

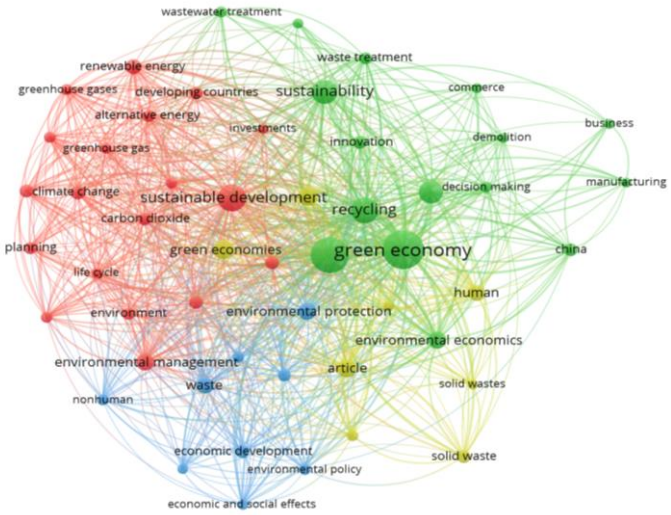
ii. Energy

The research on the green economy, energy and the food and beverages sector, is found to be diverse. Implementing green economy initiatives across developed, emerging and developing economies from North and South America, Europe, Africa, and Asia involve substantial mitigations in terms of greenhouse gas emission levels, and a judicious use of global resources. Applying such solutions will benefit not only the wellbeing and living

conditions of the current populations, but also the wellbeing of future populations. Batrancea et al., 2021 Algae is identified as an emerging food and beverage and energy technology.

The papers have a significant focus on energy, with the following energy options identified; ionizing and ultraviolet radiation, ohmic heating, high-power ultrasound, high hydrostatic pressure, and pressurized carbon dioxide (López-Pedrouso *et al.*, 2019). Table 4 details a few of the critical publications identified and the network diagram

Table 4: Key publication on energy related to green economy and the network diagram

Author & Year	Keywords	Findings
(Li *et al.*, 2022)	Energy efficiency, Green innovation, CO_2 emission, China	
(Batrancea *et al.*, 2021)	green economy, sustainable development, low carbon, renewable energy, CO_2 emissions, restructuring model	
(Xing, Li and Yu, 2022)	green economy, econometric estimation, China, green finance, economic recovery, public expenditure	
(Iglinski *et al.*, 2021)	renewable energy, energy transition, decarbonization strategy, energy potential, PEST analysis, Pomerania Voivodeship	

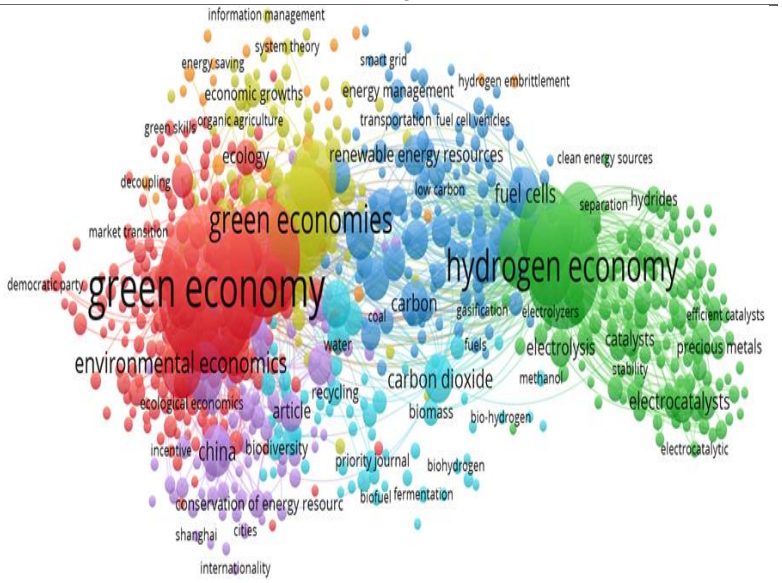
The network diagram indicates a few clear nodes around the green economy and energy:

- Biomass, biofuel, bioenergy as sustainable energy sources
- Waste and waste usage/ treatment
- Economic development

iii. Hydrogen economy

Hydrogen is a potential option to move SA away from a fossil fuel based economy to renewable or green based economy. (Imasiku *et al.*, 2021) presents policy options and approaches to enhance hydrogen energy production and ramp the transition from a fossil fuel-based economy to a hydrogen energy-based economy. (Raman *et al.*, 2022) reviews the potential of green hydrogen, which is produced by the electrolysis of water and renewable sources. Table 5 details a few of the critical publications identified and the network diagram

Table 5: Key publication on hydrogen economy and the network diagram

Author & Year	Keyword	Findings
Imasiku et at, 2021	policies, green hydrogen, renewable energy, climate change, sustainable development, Southern Africa	
Raman et al, 2022	Green hydrogen, Sustainable Development Goals (SDGs), Bibliometrics, Altimetric, Citations analysis, Net-zero	
Alkhaledi et al,2022	Liquefied hydrogen, LH2 tanker, Hydrogen economy, Economic, Green economy, Tanker ship	
Raman et al, 2022	Green hydrogen, Sustainable Development Goals (SDGs), Bibliometrics, Altimetric, Citations analysis, Net-zero	
Díaz and Ordóñez, 2021	Hydrogen, sustainable fuels and chemicals, Catalysis, green energy, catalytic reforming, liquid hydrogen carriers, hydrogen economy	

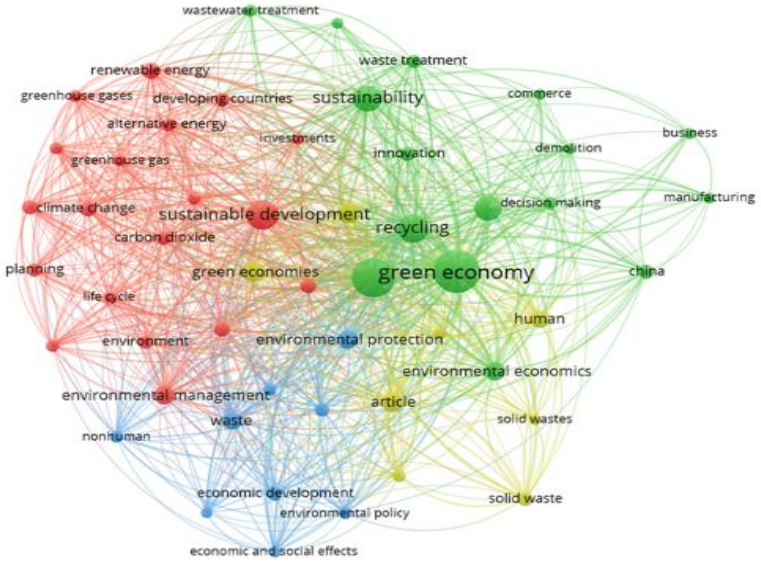
The finding associated with the hydrogen economy and food and beverage manufacturing as extracted from the network diagram indicates a few clear nodes:

- Electrolysis and catalyst
- Energy/ energy management and renewable energy
- Biofuel/bio hydrogen and biomass

iv. Waste reuse, upcycling, and management

Waste recovery, reuse, and recycling are important concepts of the green economy, especially with the organic food waste. Peura et al, 2022 reviewed the evolution of material treatment; from the throw away culture towards modern circulation and how the 'old' garbage is being transformed into products and services. (Boom Cárcamo and Peñabaena-Niebles, 2022) highlights solid waste management for reduction of environmental concerns and waste management issues in emerging and frontier countries. Table 6 details a few of the critical publications identified and the network diagram

Table 6: Key publication on waste reuse and the network diagram

Author & Year	Keywords	Findings
(Peura et al, 2022)	Waste management, Reuse of waste, Circular economy, Product service systems	
Carcamo et al, 2022	Industrial symbiosis, Waste management, Recycling, Industrial residuals, Emerging and frontiers countries	
Gorbatchev and Zenchanka, 2022	Sustainable development, Waste management, Green economy, Circular economy, Partnership	

The network diagram indicates a few clear nodes around the green economy and waste reuse:

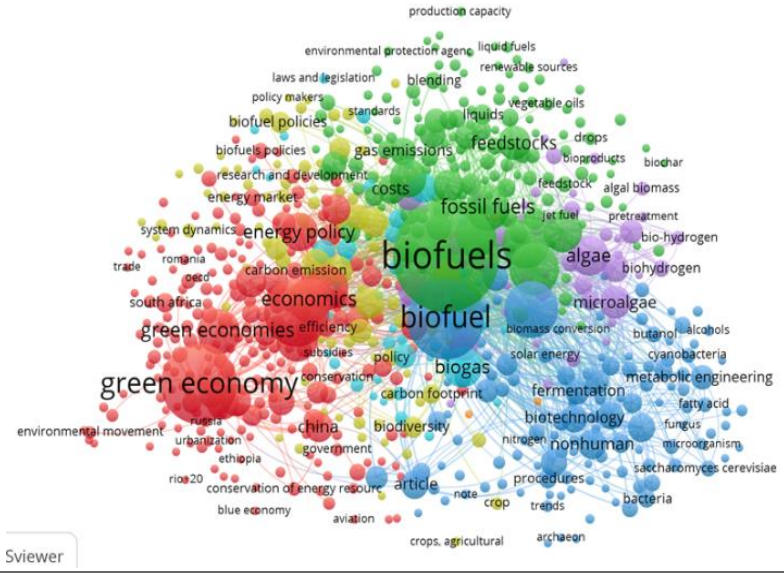
- Solid waste reuse
- Waste to Renewable energy
- Innovation

v. Biofuels or household biogas

The use of available microalgae to produce biochemically renewable products currently represents an untapped potential that could lead to the solution of several problems through green technologies Sosa-Hernández et al,2019. As such, if the social, industrial and research communities collaborate to strive towards a greener economy by preserving the existing biodiversity and optimizing the use of the currently available resources, the enrichment of our society and the solution to several environmental problems could be attained. Khan et al, 2021reviewed the benefits, limitations, and trends in different generations of biofuels and details the social, economic, and environmental aspects.

Studies have found that policies aiming to improve energy security and autonomy, through support to biofuels, have successfully bolstered the efficiency and competitiveness of the Brazilian biofuel sector, which relies on a large internal market and expanding export markets.

Table 7: Summary of Green economy AND Biofuels OR Household biogas

Author & Year	Keywords	Findings
Sosa-Hernández et al,2019	microalgae, biodiversity, bioactive compounds, green extractions, pharmaceutical, secondary metabolites, biofuels	
Portner et al, 2014	green economy, Biofuels, Jatropha, Ethiopia, smallholders	
Berchin et al, 2018	Sustainable development Biofuel, Energy policy, Green economy	
Khan et al, 2021	Biofuels, Sustainability, Bioeconomy, solar fuels	
Dessie el at, 2020	Waste biomass, Value-added products, Valorization, Lignocellulose, Bio-based	

The network diagram indicates a few clear nodes around the green economy and Biofuel:

- Algae/ Microalgae
- Bio hydrogen
- Biotechnology
- Bacteria
- Vegetable oils

As a key and important subset, anaerobic digestion is a well established process for production of biofuels, and given the potential of products/raw materials from the food and beverage sector as a source for biofuel production, a search on anaerobic digestion was conducted. The prevalence of urban biowaste and food waste makes anaerobic digestion (AD) an attractive treatment and recovery option for organic materials (Casallas-Ojeda, Marmolejo-Rebellón and Torres-Lozada, 2021).

(Bona *et al.*, 2020) identified he integration of microalgae growth and anaerobic digestion process as a viable solution to achieve (i) reduced emissions due to carbon recovery; (ii) optimum integrated management of anaerobic digestion waste and (iii) biomass production by low-cost nutrients and carbon. Nutrient recovery technologies like anaerobic digestion, which breaks down manure to produce nutrient-rich products that can be used to replace synthetic fertilizers, have increased significantly. Table 8 details a few of the critical publications identified and the network diagram

Table 8: Key publication on anaerobic digestion and the network diagram

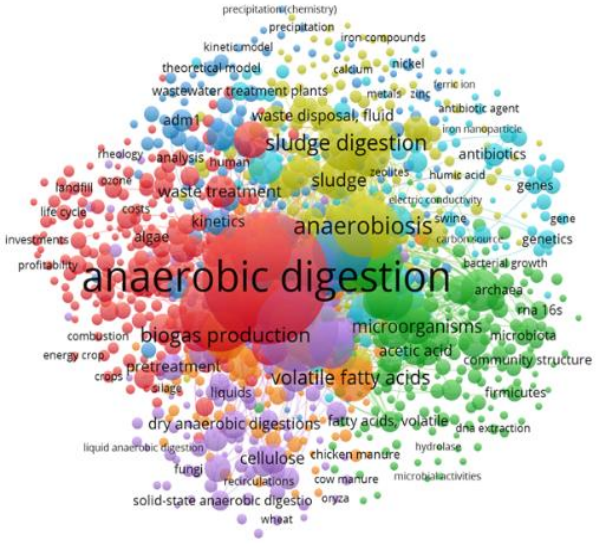
Author & Year	Keywords	Findings
(Abudula *et al.*, 2018)	electrospinning; hybrid nanofiber; chitin–lignin; sol–gel composite; PGS; mechanical properties	
(Lenzo *et al.*, 2018)	social life cycle assessment; life cycle assessment; sustainability; textile sector	
(Kim *et al.*, 2021)	ocean thermal energy conversion (OTEC); seawater utilization technologies; green energy; green hydrogen; green economies	
(Magdalena, Greses and Gonz, 2020)	Anaerobic digestion Biomethane Microalgae Population dynamics Short-chain fatty acids UASB reactor	
(Bona *et al.*, 2020)	Microalgal cultivation · Digestate · Solid oxide fuel cell-exhausts · Carbon recovery · Proton transfer reaction mass spectrometry · Nutrient recycling	
(Valenti and Toscano, 2021)	sewage sludge; biogas; bio methane; GIS; spatial analysis; waste valorisation; renewable energy; circular economy	

Table 8 provides basic insights into the technology adoption around anaerobic digestion and provides some details on the technology and supporting components. Key nodes around anaerobic digestion are: biogas, micro, sludge and waste treatment and food products (fungi, wheat, algae, crops).

The research team also pick up valorisation, biotechnological approaches have been shown to be applicable for the production of biopharmaceutical products, whey derived food products and bioplastics (Ahmad et al., 2019).

vi. Crops/ farming or agriculture or agro processing or urban agriculture

Crops, and agro processing is among the most significant consideration for the food and beverage manufacturing sector. Literature identifies green crops to agro processing as a key area contributing to green agro. Musvoto et al, 2015 identifies enabling policies and institutions, relevant information and skills, and innovation to support sustainable agricultural production, and social and economic systems. Šafář et al, 2022 demonstrates how the Earth observation (EO) aspect can improve agriculture. Zabaznova et al, 2022 recommends the use of innovative technology in reconstructive agriculture for higher yields, decreased fertilizers, pesticides, and water use, towards enabling low food prices. In the South African context, the township economy and the urban agriculture is quite significant. Table 9 details a few of the critical publications identified and the network diagram

Table 9: Key publication on crops/ farming, agriculture, agro-processing, urban agriculture and the network diagram

Author	Title	TC
Tuck et al, 2012	Valorization of biomass: Deriving more value from waste	1403
Poeplau & Don, 2015	Carbon sequestration in agricultural soils via cultivation of cover crops	575

Author	Title	TC
Nkoa, 2014	Agricultural benefits and environmental risks of soil fertilization with anaerobic digestates	508
Shiferaw et al, 2013	Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security	336
Orsini et al, 2013	Urban agriculture in the developing world	298
Chai et al,2016	Regulated deficit irrigation for crop production under drought stress.	252
Duru et al,2015	How to implement biodiversity-based agriculture to enhance ecosystem services:	246
Mok et al,2014	Strawberry fields forever? Urban agriculture in developed countries	241
Andersson & D'Souza,2014	From adoption claims to understanding farmers and contexts: A literature review of Conservation Agriculture (CA) adoption among smallholder farmers in southern Africa	217
Powlson et al,2016	Does conservation agriculture deliver climate change mitigation through soil carbon sequestration in tropical agro-ecosystems?	209
Aubry et al, 2012	Urban agriculture and land use in cities: An approach with the multi-functionality and sustainability concepts in the case of Antananarivo (Madagascar)	109
Knox et al, 2012	An evaluation of China's agricultural green production: 1978–2017	107
Liu et al, 2020	The impact of green economy measures on rural employment: Green jobs in farms	41
Unay-Gailhard & Bojnec, 2019	Sustainable commercialization of new crops for the agricultural bioeconomy	34
Jordan et al, 2016	Imperatives for an agricultural green economy in South Africa	19
Musvoto et al, 2015	Water regulation, crop production, and agricultural water management-Understanding farmer perspectives on irrigation efficiency	18

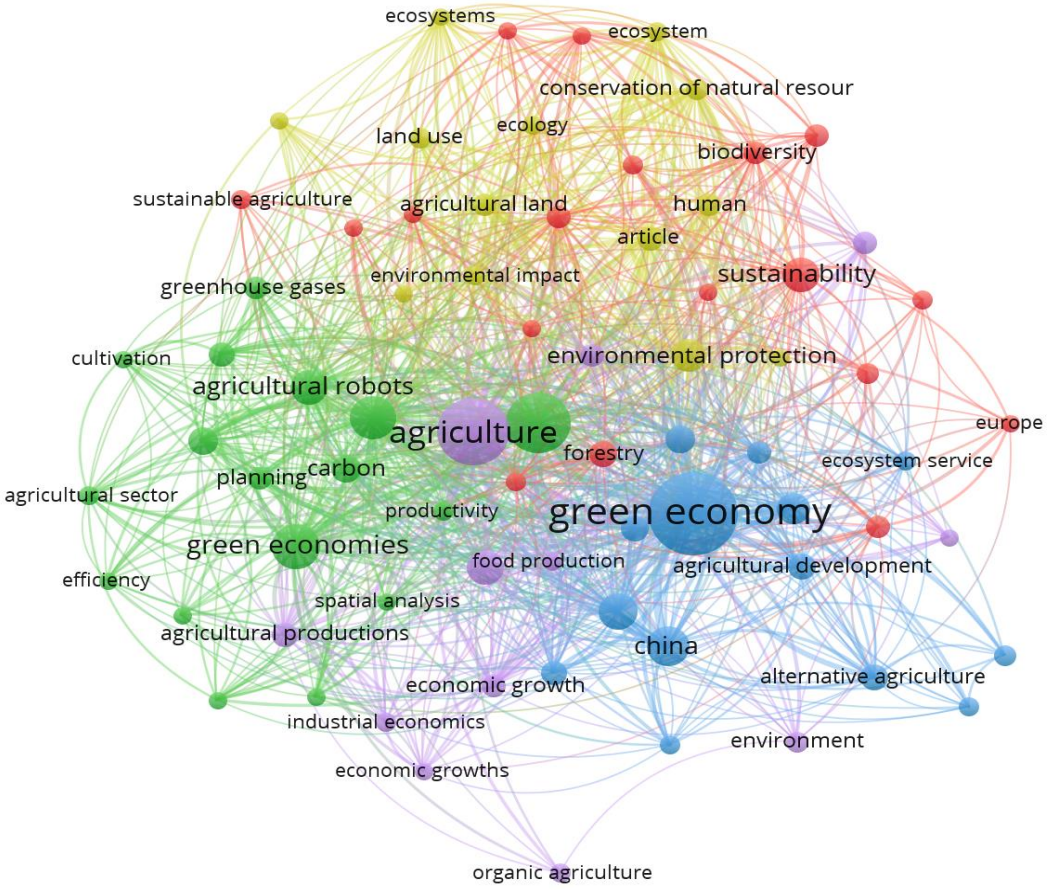


Figure 4: Network diagram for crops/ farming, agriculture, agro processing, urban agriculture and the network diagram

The network diagram indicates a few clear nodes around the green economy and crops/ farming and agriculture:

- Sustainability, economic growth, productivity
- Agricultural robots
- Greenhouse gases

Based on the analysis of the publications, the following sub-focus areas were identified:

Food production

Organic farms and arable land are increasing, with literature from Europe indicating the following associations for green economy and food and beverages (Licastro and Sergi, 2021)

- Low-income consumers also buy organic food,
- Massive potential for biomass and biogas, organic farming,
- Increasing renewable energy production (biogas and biofuel),
- Green jobs could decrease the unemployment rate,
- Higher education is a positive driver,
- Law on microcredit organisations allows financing green SMMEs,
- Organic farms create green jobs

Fish Processing

The valorisation of waste from fish into specified higher value products is an emerging green option. Where the waste is reduced but more importantly the overall efficiency of the process and its energy utilisation is optimised. Waste and smell is also reduced, significantly. The chemical solvent used is reduced, so a reduction in upstream impact. The actual conversion time is reduced so that labour and other cots are positively impacted (Khawli *et al.*, 2019).
Kim *et al.*, 2021 analysed the economics of using OTEC in combination with tuna fisheries, seabed minerals and green hydrogen and found that OTEC has the potential to minimize carbon emissions, increase efficiencies, and create new high-quality green-technology industries and livelihoods.

Nanotechnology for food processing and sustainable agricultural development

Nanotechnology has been used extensively in the food processing industry, including organic nano-sized additives for food, supplements, and animal feed, as well as nanocarrier systems for the delivery of nutrients and supplements (Patra *et al.*, 2017).

Nanotechnology can play a significant role in productivity through the regulation of nutrients (Gruère, 2012; Mukhopadhyay, 2014), as well as in the monitoring of water quality and pesticides for the sustainable growth of agriculture (Ram, Vivek and Kumar, 2014). The application of nanotechnology research in the agriculture industry has evolved into a crucial component of sustainable development. Nanotubes, fullerenes, biosensors, controlled delivery systems, and nano filtration were applied in the agri-food sectors (Sabir, Arshad and Chaudhari, 2014). Nano sensors are frequently used in agriculture environmental monitoring of contamination in soils and water, due to their effectiveness and speed (Patra *et al.*, 2017). Nano-detection technology, including biosensors, electrochemical sensors, optical sensors, and devices will be the primary tools for detection of heavy metals in-trace range (Patra *et*

al., 2017). In addition, to directly catalyse the breakdown of waste and harmful chemicals, nanomaterials also help increase the effectiveness of microbes in this process.

5. Green Economy and Skills

The summative on green is that green talent increased from 9.6% in 2015 to 13.3% in 2021 (Global green skills report, 2019). In the last five years in the US, renewables & Environment jobs increased by 237while oil and gas jobs increased by 19% (Global green skills report, 2019).

Green entrepreneurship has had significant growth as compared to traditional entrepreneurship in the U.S. and worldwide. Green entrepreneurship has seen a shift from the traditionally sectors. In Brazil, the farming sector start-up has the highest share of green skills (82%), followed by oil and gas sector (74%) and biotechnology (59%) In India, the farming, oil & gas and automotive industry start-up green talents range from 45% to 60%. Advances in farming (urban farming included) has resulted in Singapore achieving green talent growth in the farming sector. Australia and Singapore have made significant advances in terms of growth of green talent in the dairy industry (Global green skills report, 2019). Some of the roles created to address the global challenge of decarbonisation and its associated complexities, include 'Programme Director of Carbon' and 'Chief Climate Risk Officer'. Traditional health, safety, and environment (HSE) roles are being delineated to create new and specific roles such environmental sustainability manager (Add reference the Deloitte UK report).

Table 10 represents a summary of green economy jobs and skills in the food and beverage sector and its broader up and downstream value chain.

Table 10: Green skills and green job (Global green skills report, 2019) (Add references here as per the source column;

Category	Green job	Skill	skill category	Source	Comment
General		sustaibability	sustainble developmnet	Global green skills job	
	Sustainabiility professionals			Source: Deloitte - UK	
	Programme Director of Carbon				
	Chief Climate Risk Officer				
	Chief Sustainability Officers				strong technical and subject matter knowledge; skills in strategy and communication in order to contribute to top level decisions
	and Chief Climate Officers				
	Compliance manager			Global green skills job	
	Facilities manager				
	Technical sales representative				
	Surveaillance supervsior				
	Risk advisor				
		green process design		SSG skills demand for the future economy	
		sustainability design			
		life cycle asssessments			
Environment		remediation	environmental remediation	Global green skills job	
		occupational saftey and health advisor	environmental policy		fasting growing skill
		climate	eocosystem management		fasting growing skill
		environmental awarness	ecosystem management		
		EHS	environmental auditing		
		Corporate social responsibility	environmental policy		
		recycling	envirnmental remediation		
		Environmental services	Ecosystem Management		fasting growing skill
		Oil spill response	Environmental Remediatio		fasting growing skill
		Sustainable Growth Environmental Auditing	Environmental Auditing		fasting growing skill
		Surface water	Ecosystem Management		fasting growing skill
		Sustainable business strategies Pollution Pre	Pollution Prevention		fasting growing skill
		Sustainable landscapes Ecosystem Managem	Ecosystem Management		fasting growing skill
	ecologist				
		environmental impact assessment			
	Environmental helath and safety specialist				
			environmental management sy	SSG skills demand for the future economy	
			Waste management		
			environmental management in		
			environment and social govern		
	geologist			Global green skills job	
Enegry		renewbale energy	renewable energy generation		fasting growing skill
		solar energy	renewable energy generation		
	wind turbine technician				
	solar consultant				
			energy management	SSG skills demand for the future economy	
			energy trading		
			business intelligence and data		
			technology road mapping		
			environmental management sy		
			sustainable engineering		
			artificial intelligence applicatio		
			environmental sustainability m		
			solar photvolatic systems desig		
			energy managemnet and audit		
			sustainable manufacturing		
			solar photovoltaic energy asses		
			demand management plan dev		
			demand management opertaio		
			carbon footprint management		
			battery systems design manage		
			solar photovolatic project finac		
Hydrogen ec		hydrogen production		Source: The green employment and skills trasnformation - insights from a european ...	
		project management, Health, Safety and		Source: Deloitte - UK	
		Environment (HSE) or engineering skills			

Policy		Green policy development		source: Skills for green jobs – 2018 update- Cedefop	
	Regulatory affiars consultant			Global green skills job	
	policy advisor			Global green skills job	
Dairy Industr			nutrient recovery technologies'	dairy industry -FAO	
			precision farming,		
		Prescison feeding techniques	Feed and feeding management		
		Biofuels and biogas prodcution	Manure management		
			Fertiliser management		
			Animal health and husbandry		
		soil carbon stirage	Carbon capture and sequestrat		
			renewable energy	Green milk – making dairy more environmentally friendly and Energy management for a net zero dairy supply chain under climate change	
			energy efficiency	Green milk – making dairy more environmentally	
		Automation for supply chain food saftey		Energy management for a	
			biotechnology (whey derived fo	Energy management for a	
			IoT (monitoring fo prodict for f	Energy management for a net zero dairy supply chain under climate change	
Urban agricu		agroecological approaches	organic farming	Urban agriculture	
			bioenergy		
			renewable, environmentally su		
			Soiless cultures		
			Hydroponics		
			Aquaponics		
			Aeroponics		
		sharing economy	business models		
			vertical framing	Urban agriculture and Life cycle cost analysis of tomato production in innovative urban agriculture systems	
			rooftop green houses	agriculture systems	
			integrated roof top green houe	Life cycle cost analysis of tomato production in	
Finance	Private equity specialist (china)			Global green skills job	
Water	water resources engineer (india)			Global green skills job	
Manufacturi	Process safety engineer (india)			Global green skills job	
	laboratory opertaions manager (india)			Global green skills job	
			design for manufacturing and a	SSG skills demand for the	
			design for maintability	SSG skills demand for the future economy	
			sustainable engineering	SSG skills demand for the future economy	
Business	director of business startegy (singapore)			Global green skills job	
	director of information technology (sinagapore)			Global green skills job	
Carbon			carbon footprint management	SSG skills demand for the	
Buildings			green buildings and facilities m	SSG skills demand for the future economy	
			space design	SSG skills demand for the	
			uutilities management	SSG skills demand for the future economy	
Food			sustainabe food profuction des	SSG skills demand for the future economy	
Agri-tech (we can add urban agricutlure as a sub-category)			Irrigation management	SSG skills demand for the future economy	
		Aeroponics	agriculture and aquaculture ski		
		animal husbandry	agriculture and aquaculture ski		
		ecology	agriculture and aquaculture ski		
		horticulture	agriculture and aquaculture ski		
		hydroponics	agriculture and aquaculture ski		
		plant nutrition	agriculture and aquaculture ski		
		precision agriculture	agriculture and aquaculture ski		
		urban agriculture	agriculture and aquaculture ski		
		social media marketing	business development and mar		
		portfolio management	business development and mar		
		stratgeic partnership	business development and mar		
		intellectual property management	business development and mar		
		logistics management	business development and mar		
		environmental impact analysis	sustainability and environment		
		environmental management	sustainability and environment		
		sustainable engineering	sustainability and environment		
		process automation	manufacturing and engineering		
		IoT, AI, sensors and monitors	manufacturing and engineering		
		Programming	manufacturing and engineering		
		data analytics and visualisation	manufacturing and engineering		

6. Discussion and Way Forward for FoodBev SETA

The research paper presented herein provides a global view of the green economy, with a focus on the FoodBev sector. It is quite interesting to understand that the Food and Beverage sector has taken up various opportunities to adopt green economy. Conventional green technologies are identified within the core value chains from the farming process into manufacturing and novel solutions to reuse/ upscale waste. None conventional green technologies are identified in terms of energy generation and processes such as valorisation.

The research team identifies the need for research and policy, both at a country level and at a company level, to drive the green economy. The literature, and global data, supports that fact that green is the key opportunity to create new companies through SME development. There are various areas of skills support and development but with the food and beverage industry being organic a key focus on the bio sector would be very strategic. This would be followed by the energy aspects in support of manufacturing demand and from waste and by products of the Foodbev manufacturing processes. Our recommended actions:

1. Investments in policy, research, technical and SME development.
2. Focus on the bio economy, focus on skills development herein.
3. Develop skills toward SME support in the area of the green economy and Food and Beverages.
4. The following skills are identified as globally highlighted.

Sustainable engineering	Environmental remediation	Renewable energy generation
Biotechnology	Environmental policy	Business intelligence and data analytics
Sustainable engineering	Ecosystem management	IoT
Sustainable food production design	Chief Sustainability Officers	Design for manufacturing and assembly
Sustainability and environment skills	Pollution Prevention	Design for maintainability
Carbon footprint management	Manufacturing and engineering	IT and data skills

References

1. Abudula, T. *et al.* (2018) 'The effect of poly (glycerol sebacate) incorporation within hybrid chitin-lignin sol-gel nanofibrous scaffolds', *Materials*, 11(3). doi:10.3390/ma11030451.
2. Ajibade, P. (2018) 'Technology acceptance model limitations and criticisms: Exploring the practical applications and use in technology-related studies, mixed-method, and qualitative researches', *Library Philosophy and Practice*, 2019(July 2018).
3. Alwakid, W., Aparicio, S. and Urbano, D. (2021) 'The Impact of International Trade on Sustainable Development in Saudi Arabia', *Croatian International Relations Review*, 27(88), pp. 74–95. doi:10.2478/CIRR-2021-0013.
4. de Amorim, W.S. *et al.* (2019) 'Urban challenges and opportunities to promote sustainable food security through smart cities and the 4th industrial revolution', *Land Use Policy*, 87(May), p. 104065. doi:10.1016/j.landusepol.2019.104065.
5. Anggusti, M. and Siallagan, H. (2018) 'Sustainable development in the wake of the 4th industrial revolution in Indonesia', *IOP Conference Series: Materials Science and Engineering*, 420(1). doi:10.1088/1757-899X/420/1/012103.
6. Asiimwe, M.M. and de Kock, I.H. (2019) 'An analysis of the extent to which industry 4.0 has been considered in sustainability or socio-technical transitions', *South African Journal of Industrial Engineering*, 30(3), pp. 41–51. doi:10.7166/30-3-2245.
7. Assandri, D. *et al.* (2021) 'Suitability of composting process for the disposal and valorization of brewer's spent grain', *Agriculture (Switzerland)*, 11(1), pp. 1–12. doi:10.3390/agriculture11010002.
8. Babonea, A.-M. and Joia, R.-M. (2012) 'Transition to a green economy - a challenge and a solution for the world economy in multiple crisis context.', *Theoretical & Applied Economics*, 19(10), pp. 105–114. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=82956545&lang=pt-br&site=ehost-live.
9. Barbier, E. (2011) 'The policy challenges for green economy and sustainable economic development', *Natural Resources Forum*, 35(3), pp. 233–245. doi:10.1111/j.1477-8947.2011.01397.x.
10. Batrancea, L.M. *et al.* (2021) 'An empirical investigation on the transition process toward a green economy', *Sustainability (Switzerland)*, 13(23), pp. 1–12. doi:10.3390/su132313151.
11. Bayona-Saez, C. *et al.* (2017) 'Open innovation in the food and beverage industry', *Management Decision*, 55(3), pp. 526–546. doi:10.1108/MD-04-2016-0213.
12. Bona, D. *et al.* (2020) 'Management of Digestate and Exhausts from Solid Oxide Fuel Cells Produced in the Dry Anaerobic Digestion Pilot Plant: Microalgae Cultivation Approach', *Waste and Biomass Valorization*, 11(12), pp. 6499–6514. doi:10.1007/s12649-019-00931-3.
13. Boom Cárcamo, E.A. and Peñabaena-Niebles, R. (2022) 'Opportunities and challenges for the waste management in emerging and frontier countries through industrial symbiosis', *Journal of Cleaner Production*, 363(June). doi:10.1016/j.jclepro.2022.132607.
14. Campana, P.E. *et al.* (2021) 'Optimisation of vertically mounted agrivoltaic systems', *Journal of Cleaner Production*, 325(July), p. 129091. doi:10.1016/j.jclepro.2021.129091.
15. Can, M., Ben Jebli, M. and Brusselaers, J. (2022) 'Can green trade save the environment? Introducing the Green (Trade) Openness Index', *Environmental Science and Pollution Research*, 29(29), pp. 44091–44102. doi:10.1007/s11356-022-18920-w.
16. Carvalho, N. *et al.* (2018) 'ScienceDirect ScienceDirect ScienceDirect ScienceDirect Studying noise measurement and analysis Costing models for capacity optimization in Industry 4 . 0 : Trade-off between used capacity and operational efficiency', *Procedia Manufacturing*, 22, pp. 533–538. Available at: https://doi.org/10.1016/j.promfg.2018.03.078.
17. Choi, C. and Kim, C.-I. (2017) 'The 4th Industrial Revolution, Smart Cities, and Sustainable Urban Regeneration : A Perspective Study', *Journal of Environmental Policy and Administration*, 25(S), pp. 61–91. doi:10.15301/jepa.2017.25.s.61.
18. D'Amato, D. *et al.* (2017) 'Green, circular, bio economy: A comparative analysis of sustainability avenues', *Journal of Cleaner Production*, 168, pp. 716–734. doi:10.1016/j.jclepro.2017.09.053.
19. Diale, C.D., Maladzhi, R.W. and Ohe, H. Von Der (2022) 'Ecosystem for 4 th Industrial Revolution to Accelerate Sustainable Development Goals in the South African Context : A Conceptual Framework'.
20. Dombroski, S. (2020) *8 Reasons Sustainability is Critical in Food and Beverage Manufacturing*, *Food SafetyTech*. Available at: https://foodsafetytech.com/column/8-reasons-

sustainability-is-critical-in-food-and-beverage-manufacturing/.
21. Droste, N. *et al.* (2016) 'Steering innovations towards a green economy: Understanding government intervention', *Journal of Cleaner Production*, 135, pp. 426–434. doi:10.1016/j.jclepro.2016.06.123.
22. Francesco, M. and Jenkins, T. (2020) *Available, Systemic approach to switching on the green economy needed. [online] People in Need.* Available at: https://www.peopleinneed.net/systemic-approach-to-switching-on-the-green-economy-needed-8672gp.
23. Genovese, A. *et al.* (2017) 'Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications', *Omega (United Kingdom)*, 66, pp. 344–357. doi:10.1016/j.omega.2015.05.015.
24. Georgeson, L., Maslin, M. and Poessinouw, M. (2017) 'The global green economy: a review of concepts, definitions, measurement methodologies and their interactions', *Geo: Geography and Environment*, 4(1). doi:10.1002/geo2.36.
25. Ghisellini, P., Cialani, C. and Ulgiati, S. (2016) 'A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems', *Journal of Cleaner Production*, 114, pp. 11–32. doi:10.1016/j.jclepro.2015.09.007.
26. Global green skills report (2019) *Skills for green jobs: 2018 update: European. European synthesis report*, 한국노동연구원.
27. Gruère, G.P. (2012) 'Implications of nanotechnology growth in food and agriculture in OECD countries', *Food Policy*, 37(2), pp. 191–198. doi:10.1016/j.foodpol.2012.01.001.
28. Guiné, P., Ramalhosa, E. and Valente, P. (2016) 'New Foods, New Consumers: Innovation in Food Product Development', *Current Nutrition & Food Science*, 12(3), pp. 175–189. doi:10.2174/1573401312666160608120727.
29. Hojer, M. and Wangel, J. (2015) 'ICT Innovations for Sustainability', *Advances in intelligent systems and computing*, 310, pp. 351–365. doi:10.1007/978-3-319-09228-7.
30. Iglinski, B. *et al.* (2021) 'Physical Aspects in Light of EU Energy Transformation'.
31. Imasiku, K. *et al.* (2021) 'A policy review of green hydrogen economy in Southern Africa', *Sustainability (Switzerland)*, 13(23), pp. 1–17. doi:10.3390/su132313240.
32. Jiang, L. *et al.* (2020) 'The Measurement of Green Finance Development Index and Its Poverty Reduction Effect : Dynamic Panel Analysis Based on Improved Entropy Method', 2020.
33. Jnr, B.A. *et al.* (2016) 'Development of a Green ICT Model for Sustainable Enterprise Strategy', *Journal of Soft Computing and Decision Support Systems*, 3(3), pp. 1–12.
34. Khawli, F. Al *et al.* (2019) 'Innovative green technologies of intensification for valorization of seafood and their by-products', *Marine Drugs*, 17(12), pp. 1–20. doi:10.3390/md17120689.
35. Kim, H.J. *et al.* (2021) 'The suitability of the pacific islands for harnessing ocean thermal energy and the feasibility of OTEC plants for onshore or offshore processing', *Geosciences (Switzerland)*, 11(10). doi:10.3390/geosciences11100407.
36. Lenzo, P. *et al.* (2018) 'Sustainability performance of an italian textile product', *Economies*, 6(1). doi:10.3390/economies6010017.
37. Li, Y. *et al.* (2022) 'Energy efficiency and green innovation and its asymmetric impact on CO2 emission in China: a new perspective', *Environmental Science and Pollution Research*, 29(31), pp. 47810–47817. doi:10.1007/s11356-022-19161-7.
38. Licastro, A. and Sergi, B.S. (2021) 'Drivers and barriers to a green economy. A review of selected balkan countries', *Cleaner Engineering and Technology*, 4, p. 100228. doi:10.1016/j.clet.2021.100228.
39. Liu, C., Xin, L. and Li, J. (2022) 'Environmental regulation and manufacturing carbon emissions in China: a new perspective on local government competition', *Environmental Science and Pollution Research*, 29(24), pp. 36351–36375. doi:10.1007/s11356-021-18041-w.
40. Loiseau, E. *et al.* (2016) 'Green economy and related concepts: An overview', *Journal of Cleaner Production*, 139, pp. 361–371. doi:10.1016/j.jclepro.2016.08.024.
41. Lom, M., Pribyl, O. and Svitek, M. (2016) 'Industry 4.0 as a part of smart cities', *2016 Smart Cities Symposium Prague, SCSP 2016*, pp. 2–7. doi:10.1109/SCSP.2016.7501015.
42. López-Pedrouso, M. *et al.* (2019) *Green technologies for food processing: Principal considerations*, *Innovative Thermal and Non-Thermal Processing, Bioaccessibility and Bioavailability of Nutrients and Bioactive Compounds*. Elsevier Inc. doi:10.1016/B978-0-12-814174-8.00003-2.
43. Magdalena, J.A., Greses, S. and Gonz, C. (2020) 'Anaerobic degradation of protein-rich biomass in an UASB reactor : Organic loading rate effect on product output and microbial

communities dynamics', 274(July). doi:10.1016/j.jenvman.2020.111201.
44. Manda, M.I. and Dhaou, S. Ben (2019) 'Responding to the challenges and opportunities in the 4th industrial revolution in developing countries', *ACM International Conference Proceeding Series*, Part F1481, pp. 244–253. doi:10.1145/3326365.3326398.
45. Mazhandu, Z.S. *et al.* (2021) 'A Review of Plastic Waste Management Practices: What Can South Africa Learn?', *Advances in Science, Technology and Engineering Systems Journal*, 6(2), pp. 1013–1028. doi:10.25046/aj0602116.
46. Medeiros, E., Valente, B. and Castro, P. (2022) 'How Impactful Are Public Policies on Environmental Sustainability ? Debating the Portuguese Case of PO SEUR 2014 – 2020'.
47. Merino-saum, A. *et al.* (2020) 'Unpacking the Green Economy concept : A quantitative analysis of 140 de fi nitions', *Journal of Cleaner Production*, 242, p. 118339. doi:10.1016/j.jclepro.2019.118339.
48. Mukhopadhyay, S.S. (2014) 'Nanotechnology in agriculture: Prospects and constraints', *Nanotechnology, Science and Applications*, 7(2), pp. 63–71. doi:10.2147/NSA.S39409.
49. Muposhi, A. (2019) 'Emergence of green marketing capitalism in South Africa: Implications for green economy agenda', *International Journal of Business and Management Studies*, 11(1), pp. 1–15. Available at: https://dergipark.org.tr/en/download/article-file/703894.
50. Musango, J.K., Brent, A.C. and Bassi, A.M. (2014) 'Modelling the transition towards a green economy in South Africa', *Technological Forecasting and Social Change*, 87, pp. 257–273. doi:10.1016/j.techfore.2013.12.022.
51. Okello, G.O., Saina, E. and Ngode, L. (2019) 'Analysis of Institutional Factors Influencing Adoption of Zero-grazing Dairy Farming Technology among Smallholder Farmers in Bondo Sub County, Kenya', *Asian Journal of Agricultural Extension, Economics & Sociology*, 36(November 2018), pp. 1–12. doi:10.9734/ajaees/2019/v36i330243.
52. Othman, N.F., Mat Su, A.S. and Ya'Acob, M.E. (2018) 'Promising Potentials of Agrivoltaic Systems for the Development of Malaysia Green Economy', *IOP Conference Series: Earth and Environmental Science*, 146(1). doi:10.1088/1755-1315/146/1/012002.
53. Parkinson, S. and Hunt, J. (2020) 'Economic Potential for Rainfed Agrivoltaics in Groundwater-Stressed Regions', *Environmental Science and Technology Letters*, 7(7), pp. 525–531. doi:10.1021/acs.estlett.0c00349.
54. Patra, J.K. *et al.* (2017) 'Nanotechnology in Sustainable Agriculture: Recent Developments, Challenges, and Perspectives'. doi:10.3389/fmicb.2017.01014.
55. Peleg, L.A. (2021) *Sustainability in the Food and Beverage Industry | Precognize*. Available at: https://www.precog.co/blog/sustainability-food-and-beverage-manufacturing/ (Accessed: 22 June 2022).
56. Di Pirro, E. *et al.* (2022) 'Facing Multiple Environmental Challenges through Maximizing the Co-Benefits of Nature-Based Solutions at a National Scale in Italy', *Forests*, 13(4), pp. 1–17. doi:10.3390/f13040548.
57. Quiroz-Niño, C. and Murga-Menoyo, M.Á. (2017) 'Social and solidarity economy, sustainable development goals, and community development: The mission of adult education & training', *Sustainability (Switzerland)*, 9(12). doi:10.3390/su9122164.
58. Ram, P., Vivek, K. and Kumar, S.P. (2014) 'Nanotechnology in sustainable agriculture: Present concerns and future aspects', *African Journal of Biotechnology*, 13(6), pp. 705–713. doi:10.5897/ajbx2013.13554.
59. Raman, R. *et al.* (2022) 'Green-hydrogen research : What have we achieved , and where are we going ? Bibliometrics analysis', *Energy Reports*, 8, pp. 9242–9261. doi:10.1016/j.egyr.2022.07.058.
60. Rosenberg, E., Lotz-sisitka, H.B. and Ramsarup, P. (2018) 'The green economy learning assessment South Africa', 8(3), pp. 243–258. doi:10.1108/HESWBL-03-2018-0041.
61. Sabir, S., Arshad, M. and Chaudhari, S.K. (2014) 'Zinc oxide nanoparticles for revolutionizing agriculture: Synthesis and applications', *Scientific World Journal*, 2014. doi:10.1155/2014/925494.
62. Sacks, G., Kwon, J. and Backholer, K. (2021) 'Do taxes on unhealthy foods and beverages influence food purchases?', *Current Nutrition Reports*, 10(3), pp. 179–187. doi:10.1007/s13668-021-00358-0.
63. Santeramo, F.G. (2022) 'Circular and green economy: the state-of-the-art', *Heliyon*, 8(4), p. e09297. doi:10.1016/j.heliyon.2022.e09297.
64. Sarfraz, M. *et al.* (2022) 'Exploring a Pathway to Sustainable Performance in Manufacturing Firms: The Interplay between Innovation Capabilities, Green Process, Product Innovations and Digital Leadership', *Sustainability*, 14(10), p. 5945. doi:10.3390/su14105945.

65. Thomaier, S. *et al.* (2015) ‘Farming in and on urban buildings: Present practice and specific novelties of zero-acreage farming (ZFarming)’, *Renewable Agriculture and Food Systems*, 30(1), pp. 43–54. doi:10.1017/S1742170514000143.
66. Tienhaara, K. (2014) ‘Varieties of green capitalism: economy and environment in the wake of the global financial crisis’, *Environmental Politics*, 23(2), pp. 187–204. doi:10.1080/09644016.2013.821828.
67. UNEP (2019) ‘The green tinge of success: How green innovation can give micro-firms a competitive edge’, *Strategic Direction*, 35(3), pp. 23–24. doi:10.1108/SD-12-2018-0248.
68. UNEP (2021) *Green Economy | UNEP - UN Environment Programme*. Available at: https://www.unep.org/regions/asia-and-pacific/regional-initiatives/supporting-resource-efficiency/green-economy (Accessed: 21 June 2022).
69. Valenti, F. and Toscano, A. (2021) ‘A gis-based model to assess the potential of wastewater treatment plants for enhancing bioenergy production within the context of the water–energy nexus’, *Energies*, 14(10). doi:10.3390/en14102838.
70. Valin, H. *et al.* (2014) ‘The future of food demand: Understanding differences in global economic models’, *Agricultural Economics (United Kingdom)*, 45(1), pp. 51–67. doi:10.1111/agec.12089.
71. Wall, T. (2022) ‘A manifesto for higher education , skills and work based learning : through the lens of The Manifesto for Work’.
72. Williams, S.. (2015) ‘The incursion of Big Food industry in middle-income countries: a qualitative documentary case study analysis of the soft drinks in China and India’, *Public Health* [Preprint], (25(4), 455–473 (2015)).
73. Woo, E. and Kang, E. (2021) ‘Employee Environmental Capability and Its Relationship with Corporate Culture’.
74. Xie, H. *et al.* (2019) ‘Spatial-temporal disparities and in fl uencing factors of total-factor green use ef fi ciency of industrial land in China’, *Journal of Cleaner Production*, 207, pp. 1047–1058. doi:10.1016/j.jclepro.2018.10.087.
75. Xing, L., Li, J. and Yu, Z. (2022) ‘Green Finance Strategies for the Zero-Carbon Mechanism : Public Spending as New Determinants of Sustainable Development’, 10(July). doi:10.3389/fenvs.2022.925678.
76. Zacchia, G. *et al.* (2022) ‘Higher Education Interdisciplinarity: Addressing the Complexity of Sustainable Energies and the Green Economy’, *Sustainability (Switzerland)*, 14(4), pp. 1–18. doi:10.3390/su14041998.
77. Zhang, Z. *et al.* (2022) ‘How does Chinese central environmental inspection affect corporate green innovation? The moderating effect of bargaining intentions’, *Environmental Science and Pollution Research*, 29(28), pp. 42955–42972. doi:10.1007/s11356-022-18755-5.