



Driving Sustainable Development through Green Technology Innovations

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Abstract

The urgency to address environmental challenges in the twenty-first century, particularly the looming threat of climate change, has become imperative for safeguarding our existence. Amidst this crisis, Global youth have emerged as influential agents of change, spearheading innovative solutions in green technology. This paper delves into the pivotal role of global youth in driving transformative efforts towards a sustainable future. It examines how youth serve as catalysts for change by promoting green technology for sustainable development globally, especially against the backdrop of escalating environmental concerns. Through a comprehensive review of the literature and case studies, this study explores different facets of youth engagement in green technology, including innovation, entrepreneurship, collaborative networks, policy advocacy, behavioural shifts, and long-term impacts. It elucidates the mechanisms through which youth-driven initiatives contribute to global environmental Sustainability and societal transformation, drawing from empirical verification and theoretical frameworks. Furthermore, this paper discusses the implications for research, policy formulation, and practical implementation in harnessing the potential of youth as drivers of innovation and Sustainability. It underscores the significance of recognizing and fostering youth as critical stakeholders in shaping a global, more durable, and environmentally conscious future.

Keywords: *environmental challenges, green technology, innovation, sustainable development*

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Introduction

Over the past 65 years, there have been changes in global climatic shifts alongside the phenomenon of global warming, which constitute significant global shifts and establish a complex challenge at the international level, affecting different facets of ecology, environment, socio-political dynamics, and socio-economic spheres. Climate change, marked by escalating temperatures globally, is a critical issue that has garnered attention from many scholars and policymakers alike (Eisma, 2021; Yadav et al., 2015). The industrial revolution has exponentially exacerbated the Earth's climate predicament (Yadav et al., 2015). Urgent actions and interventions are deemed necessary to mitigate the destructive impacts of climate change in cleaner agriculture production (Izaguirre et al., 2021; Jurgilevich et al., 2017). The ramifications of climate change transcend sectoral boundaries and are compounded by uncertainties, which are increasingly acknowledged in local, national, and international policymaking (Ferreira et al., 2020).

Climate change is characterised by long-term shifts in temperature, precipitation patterns, and environmental parameters such as pressure and humidity (Lipczynska-Kochany, 2018; Michel et al., 2021; Murshed and Dao, 2020). Notable effects include erratic weather patterns, glacial retreats, and rising sea levels (Lipczynska-Kochany, 2018; Michel et al., 2021; Murshed & Dao, 2020). Before the Industrial Revolution, natural phenomena such as volcanic eruptions, forest fires, and seismic activities were the primary sources of greenhouse gas emissions (Murshed, Abbass & Rashid, 2020; Sovacool et al., 2021; Usman & Balsalobre-Lorente, 2021; Murshed, 2020).

The United Nations Framework Convention on Climate Change (UNFCCC) reached a significant milestone with the Paris Agreement in 2015, aiming to mobilise global efforts toward combating climate change. This agreement seeks to limit global temperature rise well below 2°C above pre-industrial levels, aiming to cap the increase at 1.5°C (Sharma et al., 2020; Sharif

et al., 2020; Chien et al., 2021). Additionally, it emphasises enhancing nations' resilience to climate impacts and aligning financial flows with low-carbon and climate-resilient pathways (Shahbaz et al., 2019; Anwar et al., 2021; Usman et al., 2021). A comprehensive work program was initiated to operationalise the Paris Agreement on climate change adaptation, involving collaboration among Parties and subsidiary bodies (Murshed et al., 2021). Mitigation strategies under the agreement include peaking global emissions as soon as possible and achieving a balance between emissions and removals by the second half of the century. Adaptation efforts focus on enhancing societies' resilience to climate impacts and supporting adaptation in developing countries (Murshed et al., 2020).

Literature Review

Sustainability involves a business strategy to create enduring value by considering how an organization operates in ecological, social, and economic contexts. Green innovation refers to enterprises employing advanced technologies to foster economic growth while prioritizing environmental preservation (Li et al., 2022). The United Nations Sustainable Development Goals serve as foundational pillars for sustainable development. Key goals such as Affordable and clean energy (Goal 7), Industry, innovation, and infrastructure (Goal 9), Sustainable cities and communities (Goal 11), Responsible consumption and production (Goal 12), and Climate Action (Goal 13) are integral to driving advancements in Green Tech and Clean Tech innovation (U.N., 2022). The Sustainable Development Goals, adopted by all U.N. Member States in 2015 as part of the 2030 Agenda for Sustainable Development, represent a global commitment to eradicate poverty, protect the planet, and enhance the well-being of all people (UN, 2022).

With scientific and technological progress, agricultural productivity has increased significantly, and industries globally manufacture different products. However, the central challenge remains ensuring the Sustainability of this



agricultural and industrial productivity without compromising environmental integrity, human well-being, and future generations. Expanding farming lands and intensive use of fertilizers and pesticides pose significant environmental risks. Moreover, the livestock sector contributes to greenhouse gas emissions, while industrial activities generate non-biodegradable products like plastics and contribute substantially to air pollution. Climate-related challenges such as droughts and floods further exacerbate these issues globally. Addressing these challenges necessitates embracing sustainability principles and integrating green and clean technologies across agriculture and industry sectors. This chapter will explore the roles of Sustainability, green innovation, and clean technology in fostering a healthy environment for present and future generations (Kenton, 2022).

The United Nations Brundtland Commission defined Sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (U.N., 2022). Sustainability reshapes our interaction with nature and resources in a rapidly changing world. Previous misconceptions regarding toxic waste disposal, which have long-term detrimental effects on the atmosphere, water, and other essential elements crucial for human survival, underscore the urgent need for improved resource management. Embracing Sustainability entails meeting current needs while safeguarding future generations’ ability to do the same (Cuyper, 2022).

The concept of Sustainability spans multiple dimensions, including environmental stewardship, societal well-being, and economic vitality. The International Institute for Environment and Development (Mining, Minerals, & Sustainable Development Project, 2002) expands this understanding by framing Sustainability as integrating economic activity with environmental integrity, social equity, and effective governance system, which aims to maximize contributions to current well-being while ensuring fairness in sharing costs and benefits, all without compromising the potential for future generations to meet their needs

(Hasani et al., 2023).

The Sustainability and Innovation Global Executive Study highlighted that business model innovation, top management support, customer collaboration, and sound business cases are critical for deriving economic value from sustainability initiatives (Kiron et al., 2012). Moreover, companies reporting such practices have seen increased profitability (Kerzner, 2019). Economic Sustainability correlates positively with perceived innovation in the market, encouraging firms to invest in research and development to seize growth opportunities (Di Simone et al., 2022).

Global indicators reveal progress towards sustainable development goals: Access to electricity, renewable energy capacity, sanitation services, and mobile network coverage have significantly improved over recent decades. However, challenges like agricultural Sustainability persist amid a growing global population and climate change impacts such as temperature rise, water scarcity, land degradation, and deforestation (Cherotich et al., 2012; Imaro et al., 2021; Guleria et al., 2023). Addressing these challenges requires innovative approaches in agriculture, including biotechnological advancements to develop stress-tolerant crops and sustainable farming practices (Guleria et al., 2023).

The United Nations emphasizes that achieving sustainable development goals necessitates urgent action to combat climate change, biodiversity loss, pollution, and waste, transforming societies and economies worldwide (UNEP) (Hasani et al., 2023).

Defining innovation can be challenging due to its varying interpretations across different contexts, often conflated with creativity. Nevertheless, innovation can be briefly described as the process of implementing novel ideas into commercially viable products or services that offer improvements to customers, which can range from entirely new concepts to enhancements of existing products or services. The imperative to address pressing contemporary issues has spurred ventures into uncharted territories such as smart cities, recognized as crucial frameworks

for tackling challenges like pollution, climate change, and urban management while fostering new ideas and technological advancements (UNEP) (Li et al., 2022).

From an economic perspective, innovation encompasses any initiative that enhances societal value, thereby improving the welfare of its inhabitants. Enterprises embracing high technology are often seen as innovative, with management playing a pivotal role by encouraging creativity and providing necessary resources for innovation (Gong et al., 2021). Leadership style is identified as crucial in organizational innovation, particularly within high-tech enterprises where empowering team leadership effectively stimulates creative passion among employees (Jing et al., 2022). Wan et al. (2022) emphasize the pivotal role of innovation in transforming and upgrading industries to navigate resource and environmental constraints, thereby enhancing competitive advantages through green enterprise innovation.

Green innovation emerges as indispensable in addressing environmental challenges and promoting sustainable practices across industries. It encompasses innovations in products, processes, and services aimed at minimizing environmental impact, such as reducing pollution and adopting eco-friendly materials and practices (Wang & Liu, 2022). Eco-innovations are recognized for their role in advancing sustainable development and transitioning towards circular economies, particularly in sectors like food systems, where they mitigate waste and enhance efficiency (Hamam et al., 2022).

Plastics, integral to diverse sectors, including packaging, construction, and healthcare, present economic benefits and significant environmental challenges due to inadequate recycling infrastructure and widespread pollution of water bodies (World Economic Forum, 2016). Coordinated global initiatives are crucial to address these challenges, involving protocols, large-scale innovations, and engagement with policymakers (World Economic Forum, 2016). Renewable energy is critical in combating climate change, with global capacities expanding

annually to reduce greenhouse gases and air pollution. However, urgent and accelerated action is necessary to limit global temperature rise to 1.5 degrees Celsius this century (UNEP). The rapid advancement of science and technology over recent decades has significantly boosted agricultural productivity through enhanced seeds, fertilizers, insecticides, pesticides, and other chemicals. However, the indiscriminate application of these agricultural chemicals and ongoing deforestation have emerged as critical environmental concerns, and challenges include land degradation, biodiversity loss, deforestation, overfishing, and the greenhouse effect (Chen et al., 2019).

Simultaneously, advancements in communication and technology within the industrial sector have drastically increased production and productivity, effectively shrinking the world into a global village. Digital information sharing, fast transportation, and high-tech products have notably enhanced living standards, particularly in more developed countries. Yet, these advancements have also brought significant consequences, such as air pollution, food waste, plastic pollution, and global warming. Therefore, ensuring Sustainability has become a paramount concern for the current generation to safeguard a habitable environment and resource base for future generations, with green tech and clean tech playing crucial roles in achieving this goal (Li et al., 2022).

Clean technology, or cleantech, is defined as any practical product, service, or technology that minimizes the use of scarce natural resources and produces less waste compared to mainstream counterparts. Overcoming the misconception that cleantech is a luxury reserved for elites is essential for mainstream adoption (Wilder W& Pernick, 2014). This includes products and services employing renewable materials and energy sources, maximizing resource efficiency, reducing pollution and waste, delivering equal or superior performance to traditional options, and promising enhanced profitability for investors, corporations, and customers (Wilder W& Pernick, 2014).

Project management is vital for organizations



to achieve their strategic priorities by aligning projects with organizational strategies. Incorporating green innovation into corporate strategy enhances competitiveness and market share by integrating advanced technologies that foster economic growth while prioritizing environmental protection (Li et al., 2022). Adopting green innovation practices within the manufacturing sector is critical to mitigating industrial waste and environmental pollution, ensuring sustainable operations, and fulfilling corporate social responsibilities (Wang & Yang, 2021; Chen et al., 2020).

The United Nations Environment Programme’s Climate Technology Centre and Network facilitates technology transfer and collaboration among stakeholders to accelerate the deployment of climate-friendly technologies. This initiative provides technical assistance and access to information and fosters partnerships

across academia, the private sector, and research institutions (UNEP) (Chen et al., 2017).

Renewable energy sources such as solar, wind, hydro, and nuclear power play pivotal roles in reducing greenhouse gas emissions and diversifying energy sources. Solar power, for instance, converts solar radiation into electricity and is particularly suitable for regions with high solar irradiation, contributing significantly to clean energy solutions worldwide (UNEP).

In regions lacking access to electricity, introducing clean energy solutions enhances healthcare and education and creates new jobs and sustainable economic opportunities, thereby reducing poverty (UNEP). The results show the electricity used in different regions of the world (see Table 1).

The results show that one in every ten people still lacks access to electricity, with a significant

Table 1: *Percentage of Population with Access to Electricity*

Regions	2000	2005	2010	2015	2020
World	78.2	80.6	83.2	86.6	90.5
Sub-Saharan Africa	25.7	29.3	33.1	38.8	48.1
Northern Africa and Western Asia	87.9	89.5	91.5	92.7	94.0
Northern Africa	81.2	84.1	87.2	89.1	91.2
Western Asia	94.1	94.4	95.2	95.8	96.5
Central and southern Asia	59.6	67.5	75.2	85.8	96.1
Central Asia	99.4	99.7	99.7	97.3	100.0
Southern Asia	58.1	66.3	74.3	92.7	96.0
Eastern and south-eastern Asia	92.4	94.0	95.8	89.1	98.1
Eastern Asia	97.3	98.4	75.2	95.8	99.2
South-eastern Asia	78.8	82.4	99.7	85.8	95.5
Latin America and the Caribbean	91.7	93.6	74.3	97.3	98.5
Oceania	80.0	82.1	82.1	87.1	91.0
Australia and New Zealand	100.0	100.0	100.0	100.0	100.0
Oceania (ex. Australia and New Zealand)	26.0	35.0	35.0	54.4	68.5
Europe and North America	100.0	100.0	100.0	99.4	100.0
Europe	100.0	100.0	100.0	99.1	100.0
North America	100.0	100.0	100.0	100.0	100.0
Landlocked developing countries	34.9	38.0	43.1	48.2	59.5
Least developed countries	20.1	26.2	33.1	42.5	54.7
Small island developing states	71.9	72.2	74.3	78.7	83.3

Source: Gaga (2024, p. 114)

majority residing in rural areas of developing regions, notably sub-Saharan Africa. Energy remains the foremost contributor to climate change, responsible for 73% of human-caused greenhouse gas emissions. Globally, access to electricity increased from 78.2% in 2000 to 90.5% in 2020, reaching full coverage in Europe, North America, Australia, and New Zealand, while the least developed countries lag behind (Table 1). Energy efficiency plays a crucial role, with appropriate policies capable of achieving over 40% of the emissions reductions

necessary for global climate targets, even without new technologies. Approximately 2.8 billion people, nearly one-third of the worldwide population, still rely on polluting and unhealthy fuels for cooking (Table 2). Despite reductions in emissions across developed countries from 2000 to 2019 (Table 3), disparities in clean fuel adoption persist, particularly in North Africa and landlocked developing nations (Giannetti et al., 2020).

Table 2: Carbon Dioxide Emission (in kilograms) per GDP

Regions	2000	2005	2010	2015	2020
World	0.35	0.34	0.32	0.29	0.26
Sub-Saharan Africa	0.24	0.24	0.21	0.19	0.18
Northern Africa and Western Asia	0.26	0.26	0.27	0.26	0.24
Northern Africa	0.11	0.23	0.22	0.23	0.22
Western Asia	0.18	0.28	0.29	0.27	0.25
Central and southern Asia	0.36	0.33	0.33	0.30	0.27
Central Asia	1.04	0.82	0.73	0.48	0.46
Southern Asia	0.31	0.29	0.30	0.29	0.26
Eastern and south-eastern Asia	0.41	0.46	0.45	0.39	0.34
Eastern Asia	0.47	0.53	0.51	0.44	0.38
South-eastern Asia	0.22	0.22	0.21	0.20	0.20
Latin America and the Caribbean	0.19	0.19	0.18	0.17	0.15
Oceania	0.43	0.40	0.37	0.32	0.29
Australia and New Zealand	0.42	0.39	0.36	0.31	0.28
Oceania (ex. Australia and New Zealand)	0.00	0.00	0.00	0.00	0.00
Europe and North America	0.34	0.30	0.27	0.23	0.20
Europe	0.28	0.25	0.23	0.19	0.17
North America	0.41	0.36	0.32	0.27	0.24
Landlocked developing countries	0.56	0.48	0.41	0.30	0.30
Least developed countries	0.12	0.12	0.12	0.12	0.12
Small island developing states	0.23	0.19	0.16	0.14	0.13

Source: Gaga (2024, p. 115)

Table 3: Percentage of the Population with Primary Reliance on Clean Fuels and Technology

Regions	2000	2005	2010	2015	2020
World	49	52	57	63	69
Sub-Saharan Africa	9	10	12	13	17
Northern Africa and Western Asia	80	86	89	91	92
Northern Africa	75	82	87	89	91
Western Asia	85	89	92	93	93
Central and southern Asia	26	31	37	48	63
Central Asia	77	81	85	86	86
Southern Asia	24	29	35	46	62
Eastern and south-eastern Asia	42	46	56	68	77
Eastern Asia	48	52	60	71	81
South-eastern Asia	23	31	45	59	69
Latin America and the Caribbean	80	83	85	87	88
Oceania	78	77	77	77	77
Australia and New Zealand	>95	>95	>95	>95	>95
Oceania (ex. Australia and New Zealand)	10	11	12	13	15
Europe and North America	>95	>95	>95	>95	>95

Source: Gaga (2024, p. 115).

Table 4: Installed renewable electricity-generating capacity

Regions	2000	2005	2010	2015	2020
World	64.5	75.1	102.0	155.8	245.7
Sub-Saharan Africa	26.8	24.3	24.2	28.0	37.6
Northern Africa and Western Asia	66.6	68.2	76.7	105.7	152.3
Northern Africa	28.7	27.6	34.9	37.7	51.5
Western Asia	103.0	106.3	114.5	166.9	244.1
Central and southern Asia	29.9	38.3	47.3	61.5	90.6
Central Asia	196.3	188.5	190.0	196.9	214.7
Southern Asia	23.6	32.7	42.0	56.4	85.8
Eastern and south-eastern Asia	54.6	73.5	133.6	256.4	459.7
Eastern Asia	60.8	86.7	165.4	327.9	602.6
South-eastern Asia	38.4	39.8	55.4	86.4	129.8
Latin America and the Caribbean	245.9	261.6	284.7	333.1	424.6
Oceania	52.0	54.2	59.0	67.8	73.8
Landlocked developing countries	79.2	74.2		86.5	97.6
Least developed countries	17.4	17.6	25.0	29.5	37.9
Small island developing states	30.7	43.1	43.4	53.8	79.9

The results show that the renewable energy sector employed a record 11.5 million people in 2019, and the transition required to meet the Paris Agreement's temperature targets could generate an additional 18 million jobs. Installed renewable electricity capacity increased significantly from 64.5 to 245.7 watts per capita between 2000 and 2020, reflecting a growing reliance on renewable energy sources. As of 2017, renewable sources accounted for 17.5% of global power generation, with the proportion of the population primarily dependent on clean fuels and technologies rising from 49% in 2000 to 69% in 2020, showing minimal change in developed countries during this period (see Table 3 and 4).

Research Gap

The identified research gaps encompass the selected twenty articles (see Table 5), a wide display of sustainability and environmental management topics. Critical areas for further investigation include exploring specific strategies and technologies for enhancing cleaner energy adoption and assessing their real-world effectiveness; understanding implementation challenges and success factors for achieving sustainable supply chain management; investigating the effectiveness of preventive methods for combating smog pollution and enhancing public participation in addressing it; developing innovative solutions for reducing food waste throughout the supply chain; examining the environmental and economic implications of reverse logistics and closed-loop supply chains across industries; assessing the socio-economic implications of water footprint reduction strategies and identifying opportunities for sustainable water management practices; investigating the financial impact and motivations for implementing green supply chain practices in different industrial sectors.

Our review also identified the research gap in evaluating the practical implications and implementation challenges of promoting strong Sustainability in companies, exploring the practical applications of ecosystem-based approaches in addressing environmental challenges, evaluating the socio-economic and policy implications of different pathways for

sustainable energy transition, assessing the performance and durability of concrete made with recycled aggregates for construction; addressing methodological challenges in assessing the environmental and economic impacts of green supply chain practices; evaluating the social, environmental, and economic impacts of corporate social responsibility programs; exploring the role of innovation in driving sustainability transitions across different industries; and assessing the environmental impacts and long-term Sustainability of nanocatalysts for biodiesel production. Additionally, further research is needed to develop climate-resilient agricultural practices and policies to mitigate the adverse impacts of climate change on food production and livelihoods.

Research Methodology

The research methods employed in "Harnessing Global Youth Power: Driving Sustainable Development through Green Technology Innovations" include bibliometric analysis and content analysis. Bibliometric analysis is used to answer questions such as identifying the highly cited years in the Journal of Cleaner Production (JCP) field, determining the most highly cited article, and identifying countries with the highest publication rates in this journal. Content analysis is utilized to identify frequently repeated keywords across a selection of twenty articles and to determine the leading future research agenda based on the findings presented. The method section discusses the valuable insights offered by a collection of articles on "Harnessing Global Youth Power: Driving Sustainable Development through Green Technology. Authored by scholars, the articles comprehensively analyse different aspects of climate change adaptation, though some lack empirical evidence or focus solely on theoretical frameworks. Despite this, the resources demonstrate high credibility and authority, and they are published in peer-reviewed journals and affiliated with valued institutions.

The methodology part of this article also introduces different platforms and databases,



each providing unique contributions to understanding different subjects. The resources include Google Scholar, Bielefeld Academic Search Engine (BASE), EBSCOhost Academic Search, and Premier for scholarly articles. Other resources mentioned include EdiLex for Finnish legislation, SpringerLink, Science Direct, Google Scholar for access to literature, Impact Factor for journal prestige, and platforms like Press Reader, ProQuest Databases, PubMed, ISI Web of Sciences, the OCEM Journal of Technology, Management and Social Sciences, offering diverse scholarly content.

However, we emphasized the need for critical evaluation of the reliability, accessibility, and relevance of these sources to understand the impact of climate change in advancing climate change adaptation globally to sustain agricultural production. We filtered twenty highly cited articles based on cleaner production. ISI Web of Science and Bielefeld Academic Search Engine (BASE) were the leading search engines. Initially, fifty articles were collected from where different sources of journals were found. Still, we excluded other journal sources and only focused on the JCP to understand climate change

adaptation comprehensively globally. We only concentrated on journals from 2015 to 2024 and excluded other publications based on years of publication and source titles of fifty journals. The focused journals were journal of cleaner production, technological forecasting and social change, construction and building materials, and journal of chemosphere (see Table 5).

Results and Discussion

The results of the selected twenty articles are analysed based on the authors' names and publication years, sources of journal sources, journal titles, citation counts, findings, and keywords (see Table 5).

The result analysis addresses different aspects of sustainability research, including ecosystem dynamics, supply chain management impacts, green innovation, water footprint, structural equation modelling, food waste, cleaner energy, agricultural impacts, corporate social responsibility, and nanocatalysts for biodiesel production. It offers new definitions for ecosystem concepts, identifies key factors driving supply chain management practices, highlights top publishers in green innovation,

Table 5: Summary of the selected twenty articles from the JCP in different years

Authors and Publication year	Citation Count	Findings	Keywords
Yow et al (2016)	137	The findings highlight cleaner energy's crucial role in promoting sustainable production by reducing greenhouse gas emissions and pollutants. The results further the importance of prioritising cleaner energy through enhanced efficiency, cleaner fuel adoption, improved production methods, CO2 capture, process optimisation, and waste management.	Cleaner energy, cleaner production, modelling, simulation, optimisation improved waste management
Govindan et al. (2016)	127	The results emphasise the importance of adopting a corporate sustainability approach for long-term, high-quality, sustainable business operations, which involves integrating Sustainability throughout the supply chain rather than focusing solely on individual entities, leading to the emergence of 'sustainable supply chain management,' which integrates sustainability principles into traditional supply chain practices.	Sustainable supply chain management, relationships governance, innovation, modelling

Shi et al.(2016)	77	The Special Volume outlines an interdisciplinary approach to combat smog pollution, emphasising the importance of preventive methods, balancing environmental, economic, and social objectives, and promoting adequate information disclosure and public participation in addressing smog pollution in rapidly industrialising regions.	Smog haze prevention post-fossil-carbon societies human health risks from some fog, ecosystem risks from smog
Chen et al.(2017)	138	Results indicate a significant surge in F.W. research over the last 18 years, particularly in the past eight years. A total of 2340 research articles were published across 801 journals and spanned 161 subject categories in the Web of Science	Food waste, bibliometrics study, chronological distribution, research consolidation, top productive countries, clean energy, management innovation
Govindan et al. (2017)	406	The findings clarify the primary patterns regarding reverse logistics and closed-loop supply chains within the JCP. Additionally, the assessments uncover potential avenues for further research directions within the journal.	Ecosystem concept, management of technology and innovation, research stream, industrial ecology, business ecosystem.
Zhang et al. (2017)	169	Results from the bibliometric analysis of Water Footprint research spanning 2006 to 2015 show a substantial rise in research output. The results further reveal that the JCP, Environmental Science and Technology, and Ecological Indicators are the top three journals with the highest number of publications in this field.	Bibliometric SCI-expanded water footprint co-word analysis social network analysis
Oliveira et al. (2018)	204	The study highlights the significance of “GSCM financial impact” and “motivations for GSCM implementation,” particularly in automotive, textile/manufacturing, and electronic sectors., which emphasises the widespread adoption of empirical procedures and identifies notable citations, and 11 GSCM research clusters, providing valuable insights and guiding future research directions.	Green supply, chain management literature review research profiling research area clusters



Oliveira et al. (2018)	85	This study proposes a framework of specific actions to promote strong Sustainability (S.S.) by companies, derived from content analysis of JCP articles and expert interviews, offering practical guidance for organisations to enhance resource efficiency, promote sustainable development, and facilitate the transition towards a more sustainable manufacturing process.	Strong Sustainability, triple bottom line framework sustainability actions specialists' analysis
Turkeli et al. (2018)	97	The results emphasise the importance of adopting a corporate sustainability approach for long-term, high-quality, sustainable business operations, which involves integrating Sustainability throughout the supply chain rather than focusing solely on individual entities, leading to the emergence of 'sustainable supply chain management,' which integrates sustainability principles into traditional supply chain practices.	Circular economy EU-28 China Bibliometric and network analysis Regions and Cities Sustainable supply chain management, relationships governance, innovation, modelling
Tsujimoto et al. (2018)	247	The results of this study introduce an integrated model of current literature, offering new definitions for "ecosystem" and "coherent ecosystem, which explains ecosystem evolution and destruction of climate change dynamics., emphasises the importance of the ecosystem concept, and proposes directions for further research.	Ecosystem, business, ecosystem, platform management multi-level perspective coherent ecosystem
Ingrao et al. (2018)	76	The results emphasise the contributions to five key research themes: biomass, biomaterials, and bioenergy; agriculture; forestry; production and packaging of foods and feeds; and miscellaneous applications.	Academic research, bioeconomy, greening effects, societal sectors, sustainable

Chen et al. (2019)	84	The Special Issue emphasises the importance of integrating new energy technologies, environmental sciences, economics, and management to understand and design pathways for sustainable energy transition, focusing on four themes: sustainable energy economics and management, renewable energy generation and consumption, environmental impacts of energy systems, and electric vehicle and energy storage, suggesting the necessity for innovative strategies in governance, management, and education to drive sustainable energy transition globally.	Energy transition renewable energy systems energy economics and management electric vehicle
Chen et al. (2019)	85	This comprehensive literature review on recycled aggregate (R.A.) synthesised existing research topics, identified gaps, proposed suggestions for promoting R.A. usage, and outlined future research directions, bridging scientific research and industry practice while guiding interdisciplinary approaches in RA-related academic work.	Circular economy recycled aggregate construction waste sustainable concrete literature review
Melfi et al. (2020)	146	The results highlight the extensive application of Structural Equation Modelling in green research, especially in manufacturing, with SmartPLS as the main tool and resource-based theory as the primary framework. The JCP is the leading publisher, especially in 2016, and the United States leads in research output, underlining SEM's importance in green supply chain management research.	Green SCM green supplier environmental SCM sustainable SCM supplier structural equation modelling (SEM) systematic literature review
Giannetti et al. (2020)	102	The Virtual Special Issue underscores the vital role of cleaner production in achieving United Nations sustainable development targets, emphasising the need for interdisciplinary cooperation and research to assess the effectiveness and integrate cleaner production solutions with broader sustainability approaches.	Sustainable development goals, cleaner production interventions
Ye et al. (2020)	126	The study reveals that corporate social responsibility involvement in sustainable development has emerged as a significant and prosperous research topic, with identified influential journals, authors, evolving research frontiers, and distinct evolutionary stages from 1997 to 2019.	corporate social responsibility, sustainable development knowledge map bibliometric analysis, Cite Space

Joensuu et al. (2020)	114	The results emphasise Corporate Social Responsibility's evolving nature in Sustainable Development, which has collected significant attention recently. Corporate Social Responsibility, Environment Management, Sustainability, and the JCP are crucial in facilitating scholarly discussions.	The built environment, circular economy, sustainable development, urban development, cradle to cradle, waste hierarchy
Takalo et al. (2021)	194	The results identified the JCP and Business Strategy and the Environment as the primary publishers of Green Innovation. Additionally, the study outlined future research opportunities, providing valuable guidance for continued exploration in the field.	Green innovation, systematic literature review research, profiling research area clusters
Mofijur et al. (2021)	87	Nanocatalysts exhibit significant potential for enhancing biodiesel production efficiency and yield, offering a promising avenue for cost-effective development.	Biofuel feedstock biodiesel production technologies alternative fuel clean energy nanocatalysts development environmental sustainability
Ahmed et al. (2024)	137	The results highlight sorghum and barley as the majorly impacted stable crops through changes in meteorology. Furthermore, the study shows that barley production has a vital contribution to causing insecurity of food in Ethiopia	Climate change implications; mitigation and adaptation strategies; agricultural productivity; food security

notes a rise in water footprint research, emphasises the use of structural equation modelling in green research, and observes a surge in food waste studies. Additionally, the result analysis underlines the critical role of cleaner energy in sustainable production, the impact of climate change on stable crops, and the evolving nature of corporate social responsibility involvement in sustainable development. It also explores potential solutions such as recycled aggregates for sustainability challenges.

From 2016 to 2020, the JCP maintained a consistent publication trend, peaking notably in

2017. Significant contributions emerged each year, with notable publications in 2016 covering topics such as cleaner energy, Sustainability in supply chain management, and strategies for preventing smog crises. The following year, 2017, saw substantial advancements in different areas, including food waste research, reverse logistics, closed-loop supply chains, and water footprint mapping. In 2018, attention shifted towards green supply chain management, strong sustainability initiatives, circular economy principles, and the potential of the bioeconomy.

By 2019, the focus expanded to encompass sustainable energy transition pathways and the adoption of recycled aggregates in construction materials. In 2020, emphasis was placed on evaluating green and sustainable supply chain management, achieving sustainable development goals through cleaner production, and implementing circular economy practices in the built environment.

Notably, 2021 witnessed a particular focus on green innovation and the impact of nanocatalysts on biodiesel sources. The JCP emerged as the primary source, publishing different articles and reviews on different sustainability topics, followed by notable contributions from sources of Technological Forecasting and Social Change, Construction and Building Materials, and Chemosphere. Noteworthy reviews, such as those on reverse logistics and closed-loop supply chains, ecosystem concepts, and green innovation, garnered high citation counts, indicating their significant influence in the field. Additionally, articles addressing cleaner energy and the impact of climate change on agricultural productivity in Ethiopia also received considerable attention, underscoring the importance of these topics in sustainability research (see Table 1).

Several highly cited articles have emerged from different years, covering critical sustainability and environmental management topics. In 2016, the JCP addressed the transition towards Sustainability in supply chain management and global efforts to prevent smog crises, garnering 127 and 77 citations, respectively. Subsequently 2017, the journal contributed significantly, with studies on food waste, reverse logistics, and water footprint research amassing citations of 138, 406, and 169, respectively. Notably, in 2018, the Technological Forecasting and Social Change journal published a highly cited review on the ecosystem concept, accumulating 247 citations. In 2020, the focus shifted back to the JCP, with notable reviews on green supply chain management, sustainable development goals, corporate social responsibility, and circular economy practices, accumulating citations

ranging from 102 to 146.

The results show a broad spectrum of sustainability and environmental research topics, ranging from cleaner energy and production methods, modelling, simulation, and optimization for waste management improvement, to sustainable supply chain management emphasizing governance and innovation. The results further focus on smog haze prevention, transitioning to post-fossil-carbon societies, and addressing human health risks from fog and ecosystem impacts. The results also incorporate food waste management, bibliometrics, chronological distribution studies, and identifying top productive countries in clean energy and management innovation, keywords used in the selected articles. The results also summarized the keywords, e.g., ecosystem management, industrial ecology, business ecosystems, circular economy principles, sustainable energy transitions, and cleaner production interventions. All keywords collectively aim to understand and mitigate climate change implications, including strategies for enhancing agricultural productivity and ensuring food security amidst ongoing environmental challenges (see Table 5).

Discussion

The analysis of sustainability research from 2016 to 2020 encompasses a diverse range of topics, including ecosystem dynamics, supply chain management impacts, green innovation, water footprint, and more, providing a comprehensive overview of current trends and challenges in Sustainability. This temporal examination reveals evolving research focuses over the years, offering valuable insights into the trajectory of sustainability studies. Highlighted by high citation counts in journals such as the JCP and Technological Forecasting and Social Change, different articles and reviews underscore their influential contributions to the field. Identifying key publishers in green innovation and sustainability research enhances understanding of pivotal sources in the discipline. However, limitations include a predominantly narrow focus on specific journals, potentially overlooking contributions from diverse disciplines and



lesser-known journals. There is also concern about publication bias towards highly cited articles, possibly neglecting innovative studies offering novel perspectives. Moreover, the analysis leans towards research outcomes from Western countries, potentially marginalizing insights from regions with distinct sustainability challenges (Di Simone et al., 2022; Ferreira et al., 2020).

Methodological rigor, particularly concerning the consistency and robustness of approaches like structural equation modelling, remains unspecified, which may impact the reliability of findings. Additionally, prioritizing quantitative metrics over qualitative insights suggests potential oversights in nuanced interpretations and implications of sustainability research. Addressing these weaknesses would strengthen future research efforts, fostering a more inclusive and balanced approach to global sustainability challenges and solutions (Chie et al., 2021; Gong et al., 2021).

This study critically evaluates the findings from a collection of articles on harnessing global youth power to drive sustainable development through green technology. These articles cover different aspects of climate change adaptation and focus on the international context. The review methodology employed in this study allows for identifying research gaps and facilitates future primary investigations into climate change adaptation globally (Hamam et al., 2022; Hasani et al., 2023). The analysis highlights the pressing issue of climate change, which has garnered attention from researchers and policymakers globally. The Industrial Revolution is identified as a significant contributor to exacerbating the Earth's climate predicament, necessitating urgent actions and interventions to mitigate its devastating impacts. The discussion emphasises the need for cleaner agriculture production methods to address climate change challenges (Imoro et al., 2021; Jing et al., 2022).

Furthermore, this study examines the characteristics and impacts of climate change, including long-term shifts in temperature, precipitation patterns, and environmental parameters. The effects of climate change, such

as erratic weather patterns, glacial retreats, and rising sea levels, are outlined, underscoring the urgency of addressing this global issue (Li et al., 2022; Murshed et al., 2020). The Paris Agreement, a milestone in international climate action, is discussed as a significant initiative to mobilise efforts to combat climate change. The agreement's objectives, including limiting global temperature rise and enhancing resilience to climate impacts, are highlighted as the importance of operationalizing its provisions through collaborative efforts among nations. The result summarises highly cited articles from the JCP on climate change adaptation, focusing on Sustainability in agriculture production. The findings from all articles (see Table provide valuable insights into different aspects of sustainability research, including ecosystem dynamics, supply chain management impacts, green innovation, and circular economy practices (Sharif et al., 2020; Sovacool et al., 2021).

This study also evaluates the publication trends over the years, noting significant contributions from the JCP and other sources. The analysis identifies critical topics and methodologies covered in the literature, such as structural equation modeling, bibliometric analysis, and systematic literature reviews, highlighting the diverse range of research themes within the Sustainability and environmental management field. Additionally, the discussion addresses the geographical distribution of publications, with China emerging as the country with the highest occurrence of publications. The contributions from other countries are also noted, indicating the global interest and involvement in climate change adaptation research (U.N., 2022; Wang & Liu, 2022).

The results provide a critical synthesis of the findings from the reviewed articles, emphasising the importance of addressing climate change challenges through interdisciplinary approaches, policy formulation, and technological innovation. It underscores the need for continued research and collaboration to advance climate change adaptation efforts and promote sustainable development globally (Yong et al., 2016; Wang & Yang, 2021).

Conclusion

This study explores the intersection of climate change, Sustainability, and green innovation, focusing on global implications. It underscores the multifaceted impacts of climate change on ecology, socio-political dynamics, and economic sectors. The research investigates how Sustainability and green innovation can mitigate these effects, examining initiatives such as the Paris Agreement and identifying research gaps in the current literature. The literature review stresses the urgency of adopting sustainability strategies amid climate change, highlighting green innovation's role in balancing economic growth with environmental preservation through frameworks like the U.N. Sustainable Development Goals and the Paris Agreement. Employing bibliometric and content analyses, the study synthesizes insights from scholarly articles on green technology innovations and sustainable development, revealing significant progress and challenges in adopting cleaner energy sources and promoting sustainable practices globally. The findings emphasize the ongoing need for international collaboration to develop effective strategies and technologies, ensuring global sustainability goals are met and mitigating environmental impacts for future generations.

This study also evaluates publication trends over the years, noting significant contributions from different sources and highlighting critical topics and methodologies in Sustainability and environmental management. The geographical distribution of publications highlights the global interest and involvement in climate change adaptation research. Finally, the conclusion emphasises the ongoing need for research, collaboration, and innovative solutions to address climate change challenges and promote sustainable development globally.

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