

ACHIEVING SUSTAINABILITY VIA OFFICIAL STATISTICS: INSIGHTS FROM LITERATURE AND BIBLIOMETRIC APPROACHES

William Ben Gunawan ^{1*}

¹ INTI International University, Nilai, Malaysia 71800

*Email Corresponding Author: wbswilliambenwb@gmail.com

Abstract

In the pursuit of sustainable development, data-driven decision-making is essential. This study explores the pivotal roles that official statistics, systematically produced by national statistical offices and related agencies, play in advancing sustainability agendas. While extensive research has examined big data and sustainability metrics, the specific contributions of official statistics remain underexplored. To bridge this gap, the study employs a mixed-methods approach combining bibliometric analysis and a structured literature review. A total of 865 Scopus-indexed documents were analyzed to map the intellectual landscape, disciplinary scopes, and thematic clusters associated with the intersection of official statistics and sustainability. The results reveal a growing scholarly interest, with a dominant presence in decision sciences, social sciences, economics, and business fields, and emerging contributions in engineering, environmental sciences, and medicine. Official statistics are found to support sustainability by enabling evidence-based governance, monitoring progress toward the Sustainable Development Goals (SDGs), and fostering accountability and transparency. Thematic cluster analysis further highlights the roles of official statistics in policy modeling, health surveillance, environmental monitoring, and socio-economic planning. However, gaps in disciplinary engagement and geographical representation signal the need for greater integration and capacity-building, particularly in data-intensive scientific domains. This study underscores the strategic value of official statistics as a public good, and recommends strengthening statistical systems, fostering interdisciplinary collaboration, and enhancing data accessibility. These actions are vital to align national and global sustainability efforts with reliable, standardized, and inclusive statistical evidence.

Keywords: Official Statistics, Sustainability, SDGs, Bibliometric Analysis, Public Policy

1. INTRODUCTION

In an era defined by rapid technological advancement, globalization, and complex societal challenges, data has emerged as a cornerstone of modern governance, policy-making, and strategic planning. Statistics, particularly when derived from credible and systematically collected data sources, enable governments, organizations, and researchers to make informed decisions [1]. As big data and data science technologies continue to proliferate, the value of structured, high-quality statistical information becomes even more critical [2]. These developments underscore the necessity of harnessing data not just for economic progress but for achieving broader goals such as environmental sustainability, social equity, and institutional resilience. Notably, the global big data analytics market is forecasted to reach about 84 billion U.S. dollars in 2024 and to grow to 103 billion U.S. dollars by 2027, indicating a substantial expansion across industries [3].

Within this data-driven landscape, official statistics occupy a unique and authoritative position. Official statistics are generated through methodologically rigorous processes and adhere to international standards of reliability, accuracy, and impartiality [4]. These data products encompass a wide range of thematic areas, including population demographics, labor markets, environmental indicators, health statistics, and economic performance. Unlike data from private or ad hoc sources, official statistics serve as a

public good, offering a standardized foundation for evaluating and comparing conditions across time and geography [5].

The relevance of official statistics has gained heightened prominence with the global commitment to the Sustainable Development Goals (SDGs). As countries strive to meet targets related to poverty reduction, education, health, and environmental protection, the demand for transparent and reliable data has surged [6]. Official statistics provide the metrics necessary for tracking progress, identifying gaps, and assessing policy effectiveness. From national climate reports to social inequality indices, these statistics inform critical decisions at all levels of governance and development planning [7].

Despite their significance, the intersection between official statistics and sustainability has not been exhaustively explored in scholarly literature. While there is a growing body of work on sustainability metrics and big data applications [8]–[10], studies that specifically examine the role of official statistics in supporting sustainability goals remain fragmented. There is a need for a comprehensive understanding of how official statistics contribute to sustainability both in theory and in practice, and how this relationship is evolving in the face of emerging data ecosystems and stakeholder demands.

This study aims to address that gap by investigating the question: What roles do official statistics play in achieving sustainability? To answer this, the research adopts a dual approach: a structured literature review and a bibliometric analysis. The literature review provides qualitative insights into conceptual and practical linkages, while the bibliometric analysis maps the intellectual landscape, trends, and key contributors in the field. Together, these methods offer a robust lens through which to understand the evolving role of official statistics in the sustainability agenda.

2. METHOD

This study adopts a mixed-method approach that integrates bibliometric analysis and literature review to explore the roles of official statistics in achieving sustainability. Bibliometric analysis serves as a quantitative technique to uncover patterns, intellectual structures, and thematic trends within academic literature, while the literature review offers qualitative depth and contextual interpretation of the findings [11]. The combination of these methods allows for a comprehensive understanding of how official statistics contribute to sustainability efforts across various disciplines and regions.

Bibliometric analysis was selected for its objectivity and capacity to map the scholarly landscape of a research domain using quantifiable indicators such as keyword co-occurrences [12]. This method enables the identification of influential publications, prolific authors, and emerging themes, thereby illustrating the development and direction of the field. For this study, the Scopus database was chosen due to its extensive coverage of peer-reviewed journals across multiple disciplines, its detailed citation indexing, and its compatibility with bibliometric tools like VOSviewer [13].

The bibliometric dataset was generated through a systematic search conducted on 30th May 2025 using the keyword "official statistic*" in the Scopus database. This search yielded 865 documents, comprising journal articles, conference papers, book chapters, and reviews without restriction on publication year. The search strategy was intentionally broad to capture the full spectrum of literature relevant to official statistics and their potential linkage to sustainability themes. All retrieved documents were exported from

Scopus in compatible formats for analysis using VOSviewer, a software tool widely used for constructing and visualizing bibliometric networks. The bibliometric analysis was structured around keyword co-occurrence analysis to detect thematic clusters and trends. To maintain analytical rigor, thresholds were established within VOSviewer, a minimum of seven keyword occurrences. These parameters ensured that both prolific and emerging contributors were captured, while avoiding excessive fragmentation in the network visualizations.

Complementing the bibliometric analysis, a literature review was conducted to delve deeper into the conceptual linkages between official statistics and sustainability. Literature published between 2020 and 2025 was reviewed using both Google Scholar and Scopus databases. The same keyword string (“official statistic*”) was applied, and additional inclusion criteria were used to ensure relevance and quality: (i) the article must be written in English or Indonesian; (ii) full text must be accessible; and (iii) the document must be published in a peer-reviewed journal or edited book. This step helped identify prevailing discussions, policy perspectives, and case-based evidence related to the role of official statistics in supporting sustainable development.

Together, the bibliometric and literature review methods provide a robust framework for addressing the central research question: What roles do official statistics play in achieving sustainability? By mapping both the quantitative structure and qualitative content of the literature, this study aims to contribute to academic discourse and inform future research, practice, and policy on the use of official statistics in promoting SDGs.

3. RESULTS AND DISCUSSION

3.1 Temporal Distribution of Research

Figure 1 presents the annual distribution of publications retrieved from the Scopus database using the keyword “official statistic*,” spanning from 1979 to 2025. The figure reveals a notable upward trajectory in academic interest over the past four decades, with significant growth occurring after 2008. From 1979 through the early 2000s, the number of publications remained consistently low, averaging fewer than five records per year. This modest output likely reflects the limited visibility or perceived relevance of official statistics in broader academic discourses during that time.

Beginning in the late 2000s, the number of publications began to increase gradually, coinciding with the global shift toward data-driven policy and governance. The years between 2011 and 2016 mark a period of steady growth, culminating in a sharp surge in 2017, when the number of records reached 70. This momentum continued to build, peaking in 2019 and 2020 with 94 and 95 records respectively, the highest annual outputs in the dataset. These peaks collectively represent more than 20% of the total retrieved records, signifying a period of heightened scholarly engagement with official statistics.

The surge between 2017 and 2020 may be attributed to growing global attention to the SDGs, which officially took effect in 2016, and the subsequent demand for reliable, standardized data to monitor progress. The visibility and policy relevance of official statistics likely prompted an expansion of academic inquiry into their applications, limitations, and transformative potential in sustainability contexts.

Following the 2020 peak, a downward trend is observed. The number of publications decreased to 68 in 2021 and further declined to 50 in 2023 and 49 in 2024. Although this represents a reduction from the peak years, the figures remain relatively high compared to pre-2017 levels, indicating sustained, albeit moderated, scholarly interest. As of 2025, only 18 records were retrieved, though this figure may be provisional given the mid-year timing of the data collection.

Overall, the temporal trend suggests that research on official statistics has gained substantial traction over the past decade, particularly in relation to their role in global development and sustainability. The fluctuation in recent years may reflect changing research priorities, the maturation of foundational studies, or the emergence of new data paradigms such as big data and citizen-generated statistics, which could complement or compete with traditional official sources.

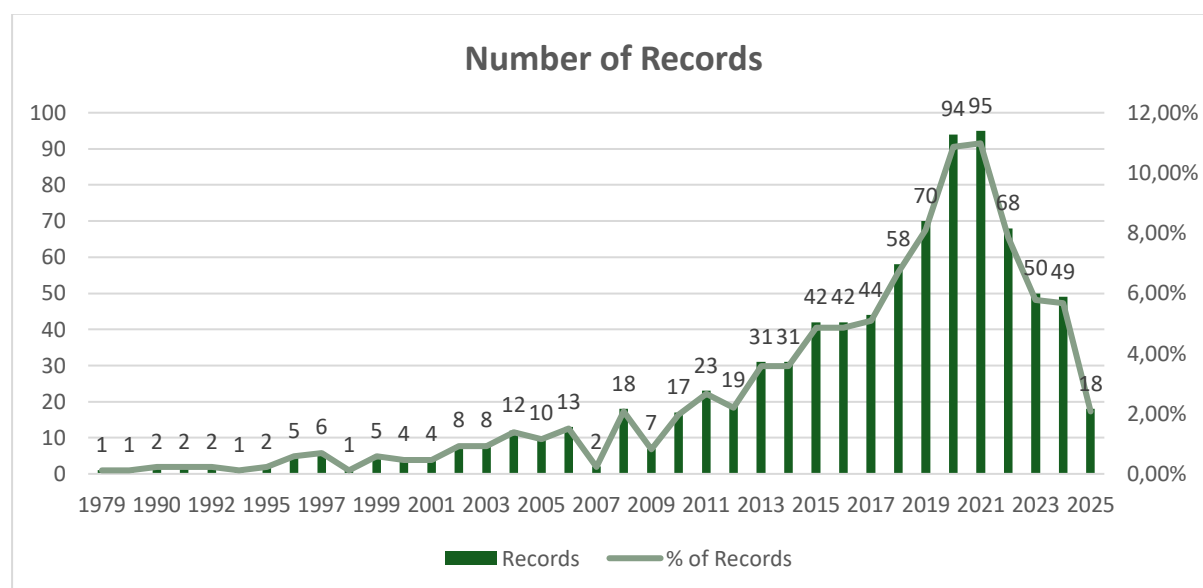


Figure 1. Publications over the year based on the keywords searched.

3.2 Country Distribution of Research

Figure 2 presents the distribution of publications by country, showcasing the top 10 contributing nations to research on the selected topic. Italy leads with 100 publications, reflecting its dominant role in shaping the academic discourse in this area. The United States follows closely with 94 records, underscoring its continued investment in sustainability-related research, particularly in connection with official statistics. The United Kingdom (86) and Germany (80) also emerge as major contributors, reinforcing the strong research capacities of European countries in this field.

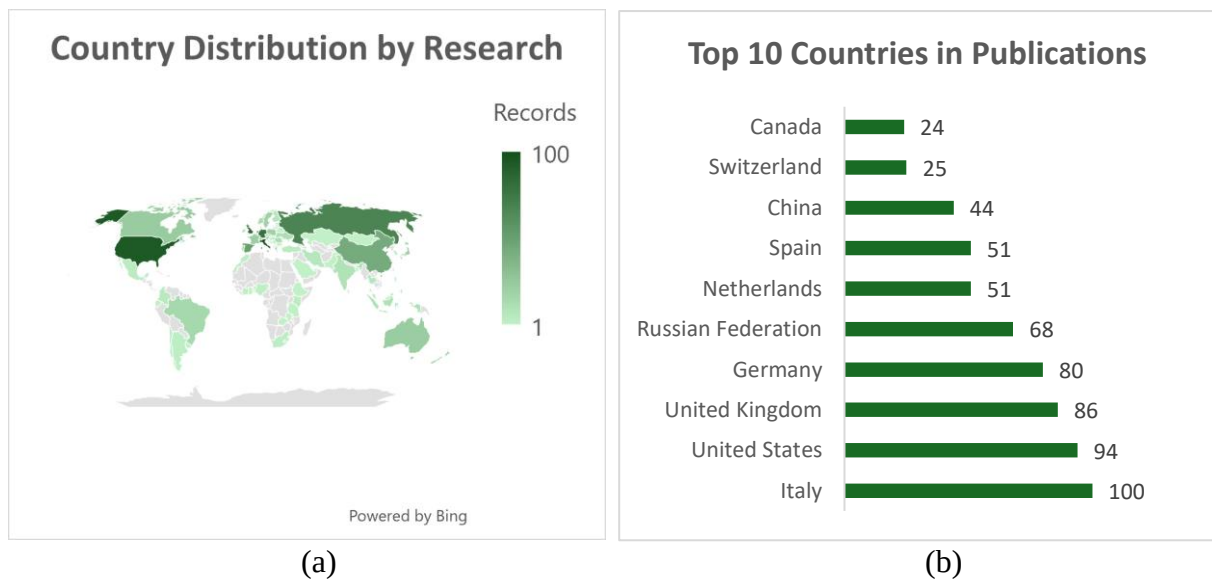


Figure 2. Number of documents published by each country regarding the research topic. (a) All Countries. (b) Top 10 Countries.

Notably, the Russian Federation (68) and the Netherlands (51) reflect solid mid-tier contributions, on par with Spain (51), suggesting an active engagement with sustainability issues, possibly linked to national policy priorities or institutional capacities in statistical systems. China (44) also ranks within the top 10, highlighting growing academic interest in sustainability in the context of its national development strategies. Switzerland (25) and Canada (24), though smaller in total output, indicate meaningful participation, likely driven by targeted research initiatives or collaborations.

The variation across countries may reflect differences in national statistical capacities, research funding, and policy focus on sustainability. The concentration of publications in economically advanced countries also points to a potential imbalance in global scholarly engagement, highlighting the need for increased research output from underrepresented regions to ensure a more inclusive global perspective on sustainability and the role of official statistics.

3.3 Document Type

Figure 3 shows the distribution of document types within the dataset, highlighting that the majority of publications are in the form of journal articles (58.3%) and conference papers (30.6%). This dominance indicates a growing and dynamic research landscape, where peer-reviewed articles reflect a solidifying academic foundation, while the substantial share of conference proceedings suggests that the field is still evolving and open to fresh ideas and exploratory approaches. The presence of book chapters (4.7%) and reviews (4.0%) further supports the development of broader theoretical frameworks, though to a lesser extent. The relatively minimal proportions of other document types such as notes, editorials, and letters underline that most contributions are formal research outputs.

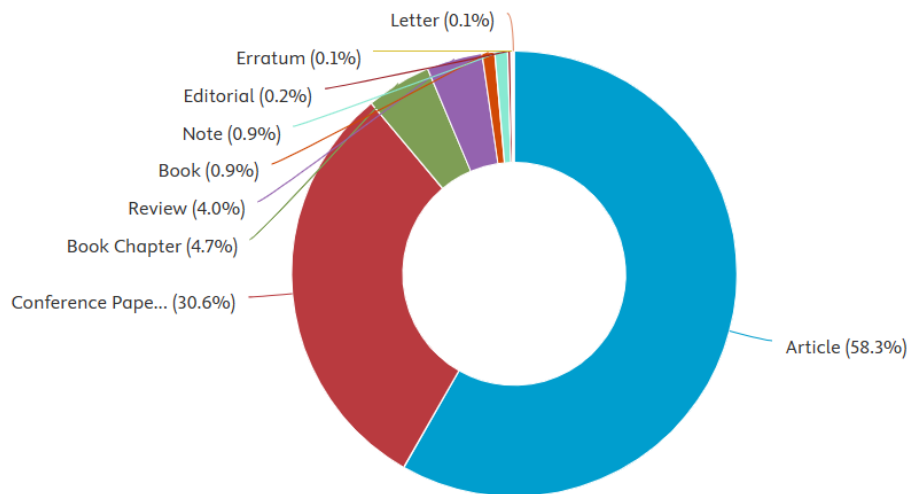


Figure 3. Type of documents related to research keywords.

3.4 Document by Subject Area

Figure 4 displays the subject area distribution of publications related to official statistics and sustainability. The most represented fields are Decision Sciences (14.9%), Computer Science (12.5%), Mathematics (12.0%), and Social Sciences (10.9%), indicating a strong methodological and interdisciplinary orientation. Business, Economics, and Management-related disciplines also show significant engagement, reflecting interest in policy and application contexts. However, relatively lower shares are observed in Engineering (7.5%), Environmental Sciences (5.5%), Earth and Planetary Sciences (3.6%), and Medicine (2.6%). These figures suggest untapped potential for expanding research into these critical domains, especially as sustainability challenges increasingly demand technical, environmental, and health-related insights supported by robust official statistics.

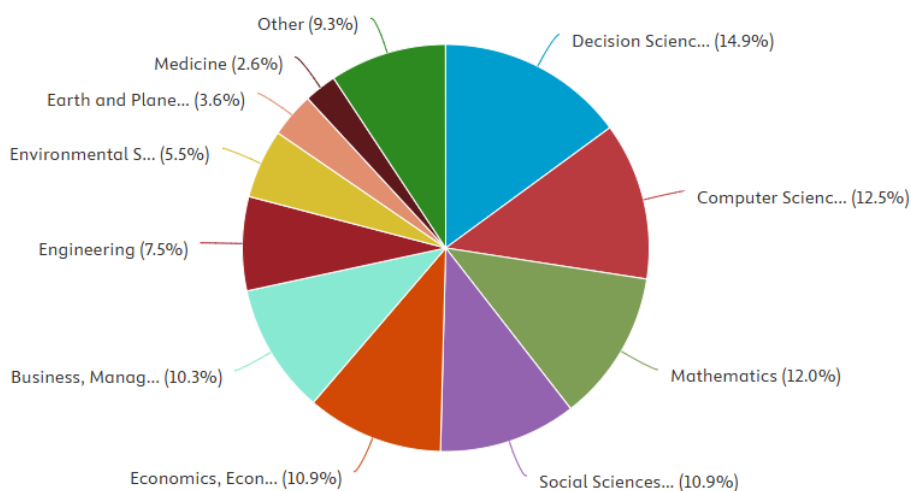


Figure 4. Distribution of documents based on subject areas.

3.5 Keywords Co-Occurrences Analysis

The keyword co-occurrence analysis, as illustrated in Figures 5A and 5B, provides a detailed overview of the thematic structure and temporal progression of academic

literature related to official statistics in the context of sustainability. Utilizing VOSviewer, the analysis offers both a network visualization (Figure 5A) and an overlay visualization (Figure 5B), shedding light on the most prominent research themes, their interconnections, and their evolution over time. These findings are essential in identifying both the foundational areas of research and the emerging domains that could benefit from deeper academic inquiry, particularly in sustainability-related disciplines.

In the network visualization (Figure 5A), several distinct clusters emerge, each representing a particular thematic focus. At the center of the map, the keyword "official statistics" appears as the most prominent and interconnected term, forming the backbone of the bibliometric network. Closely linked to it are a range of other keywords that represent various applied and methodological dimensions of statistical practice.

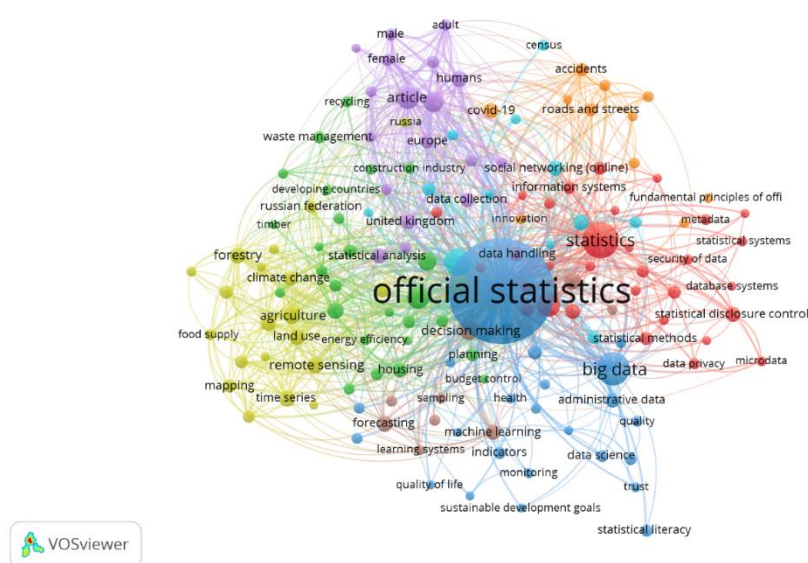


Figure 5A. Network map of co-occurrences analysis results keyword-wise.

One of the most significant clusters is the blue cluster, which encapsulates themes surrounding data science, big data, and governance. This cluster includes key terms such as "big data," "data science," "machine learning," "monitoring," "indicators," "trust," and "sustainable development goals." These keywords suggest a robust body of research focused on the application of advanced computational tools and digital technologies in official statistics. The presence of terms like "administrative data," "quality," and "statistical literacy" underscores the growing emphasis on using administrative records and enhancing the public's understanding of data as part of national statistical strategies. The integration of big data and machine learning with official statistics indicates a paradigm shift toward real-time data collection, dynamic monitoring, and predictive analytics, which are increasingly necessary for tracking progress toward the SDGs.

Another major area is the red cluster, which focuses on statistical infrastructure and methodologies. This includes terms such as "metadata," "statistical systems," "statistical methods," "data privacy," "microdata," "security of data," and "statistical disclosure control." The clustering of these terms points to ongoing efforts in strengthening the technical underpinnings of national and international statistical systems. These efforts are particularly crucial for ensuring the accuracy, reliability, and ethical use of statistical outputs. As sustainability-oriented policymaking demands high-quality, disaggregated,

and secure data, this cluster reflects the foundational work necessary to support those goals. Moreover, discussions about data privacy and microdata show that statistical agencies are actively addressing concerns about data confidentiality and responsible data sharing.

The green cluster highlights the environmental dimension of official statistics. It includes keywords such as "climate change," "agriculture," "forestry," "food supply," "remote sensing," "mapping," "land use," and "energy efficiency." These terms demonstrate how official statistics are being applied in monitoring natural resources, land cover changes, and agricultural productivity. The presence of "remote sensing" and "mapping" in this cluster suggests the use of geospatial and satellite technologies to complement traditional survey-based statistics. As sustainability challenges such as biodiversity loss, deforestation, and climate variability become more acute, integrating environmental data into official statistics will be crucial for evidence-based environmental policymaking and sustainable resource management.

The yellow cluster focuses on planning, forecasting, and decision-making, incorporating terms like "forecasting," "sampling," "planning," "budget control," and "decision making." This cluster reflects the role of official statistics in supporting government and institutional planning activities. It shows that statistics are not just tools for monitoring the past and present but also essential for anticipating future trends, allocating resources, and designing interventions. The linkages between planning and decision making with more technical terms such as "sampling" and "forecasting" suggest that methodological precision is considered essential for actionable planning, especially in the context of long-term sustainability strategies.

The purple cluster addresses social and demographic aspects, including terms like "covid-19," "humans," "male," "female," "Europe," "Russia," "United Kingdom," and "construction industry." This cluster appears to capture region-specific research and demographic variables that have featured prominently in official statistics, especially in light of recent events such as the COVID-19 pandemic. The pandemic prompted an urgent need for timely, disaggregated data on health, mortality, and social vulnerabilities, placing official statistics at the forefront of crisis management and public health strategy. This cluster reflects how statistical systems adapted to support epidemiological tracking and resource distribution during a global health emergency.

Finally, the orange cluster includes themes related to infrastructure and information systems, with keywords such as "accidents," "roads and streets," "social networking (online)," "information systems," and "census." These keywords show that official statistics are also deeply involved in urban planning, transportation, and digital infrastructure. The presence of "census" here reaffirms the fundamental role of population data in understanding demographic distribution and urban development trends.

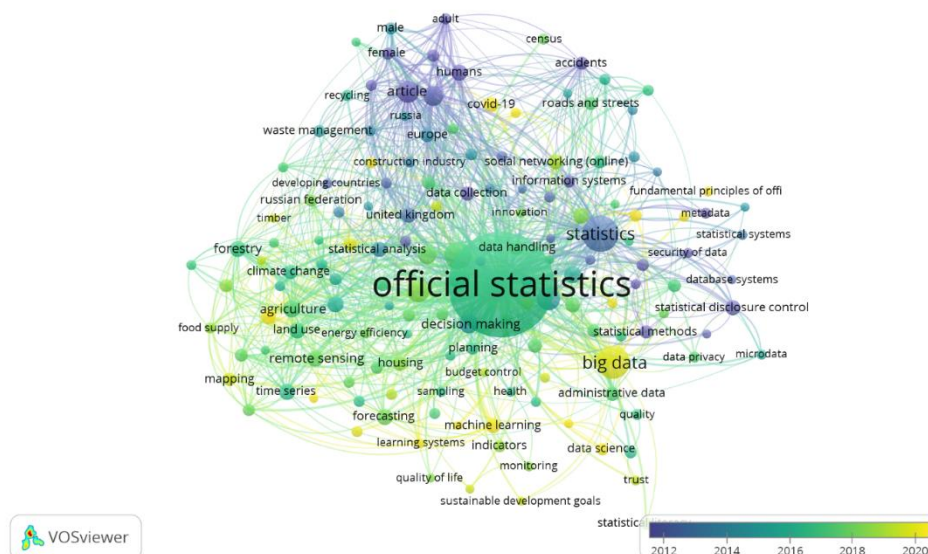


Figure 5B. Overlay map of co-occurrence analysis results keyword-wise.

The overlay visualization (Figure 4B) provides an additional layer of understanding by revealing the temporal development of these research themes. In this visualization, the color gradient indicates the average year of publication in which the keyword appeared. Darker colors correspond to earlier publications (around 2012), while brighter colors signify more recent developments (closer to 2020).

From this overlay, it is evident that foundational and methodological terms such as "statistics," "statistical methods," "metadata," and "data privacy" appear in darker shades, suggesting they have long been central topics within the literature. These represent the traditional focus areas of official statistics, especially in terms of ensuring data quality, security, and systemic coherence. In contrast, newer and more application-oriented keywords such as "sustainable development goals," "machine learning," "remote sensing," "climate change," and "data science" are highlighted in lighter colors, reflecting an increased academic interest in these topics from 2018 onwards. This trend demonstrates a shift in scholarly focus toward integrating statistical systems with environmental monitoring and digital innovation in response to sustainability challenges.

Notably, keywords such as "quality of life," "monitoring," "trust," and "data literacy" also appear as relatively recent interests. This suggests a broader societal orientation in the use of official statistics, focusing not only on technical excellence but also on public engagement and social outcomes. These emergent themes align with the growing expectations for NSOs to contribute to inclusive, transparent, and responsive governance.

The keyword co-occurrence analysis paints a comprehensive picture of the multidimensional landscape of research on official statistics. The centrality of "official statistics" as a hub across diverse clusters reveals its importance in connecting fields as varied as environmental science, health, governance, data science, and public administration. The evolution of keywords over time also highlights a dynamic field that is rapidly expanding into new areas of technological and policy relevance. Particularly promising are the intersections between official statistics and sustainability-related domains such as climate change, agriculture, land use, and public health, which are increasingly informed by innovations in machine learning, remote sensing, and big data.

These findings suggest significant opportunities for future research, especially in underexplored fields like Engineering, Environmental Sciences, Earth & Planetary Sciences, and Medicine, where the application of official statistics to sustainability goals is still emerging but holds vast potential.

3.6 Roles of Official Statistics in Achieving Sustainability

Decision Sciences

The field of Decision Sciences focuses on the use of analytical tools, quantitative methods, and data modeling to support informed decision-making in both public and private sectors. At its core, it deals with optimizing processes, minimizing risks, and allocating resources effectively under uncertainty. Within this framework, official statistics function as indispensable inputs, offering credible, standardized, and regularly updated data that underpin nearly all aspects of the decision-making lifecycle H[1]. Their role is especially vital in complex, multi-objective decisions that characterize sustainability efforts.

In public administration and governance, decision sciences rely heavily on official statistics to support evidence-based policymaking, a practice central to SDG 16 (Peace, Justice and Strong Institutions). Data on demographics, household income, education, health, and crime collected through national censuses and administrative records enables governments to allocate budgets effectively, design targeted interventions, and evaluate the impact of public programs [14]. For instance, local governments may use statistical forecasts to determine where to build new schools or hospitals, ensuring equal access to essential services [15].

One key application of official statistics in decision sciences is optimization modeling for urban and regional planning. These models integrate geospatial, population, transportation, and environmental data to develop sustainable urban solutions, linking directly to SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities). For example, traffic congestion and pollution can be mitigated through simulation-based planning that incorporates official transport and emissions statistics to model alternative road networks or public transit systems [16], [17].

In the context of disaster risk management, decision sciences utilize official statistics to predict, prepare for, and respond to natural hazards such as floods, earthquakes, or droughts. Statistical data on vulnerable populations, historical weather events, and infrastructure resilience feed into early warning systems and scenario planning tools [18], [19]. These support SDG 1 (No Poverty) and SDG 13 (Climate Action) by enabling timely interventions that protect the most at-risk communities and reduce socioeconomic vulnerability.

Decision sciences also support supply chain and logistics optimization, particularly for sustainability-focused sectors such as food systems, renewable energy, or water management. Here, official statistics on production volumes, labor availability, and transportation capacity help minimize waste and improve distribution efficiency, thereby contributing to SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), and SDG 12 (Responsible Consumption and Production). For instance, agricultural statistics can inform decisions on crop storage and market logistics to reduce post-harvest losses [20].

Moreover, multi-criteria decision analysis (MCDA), a core tool in the discipline, frequently incorporates national and international statistical indicators to rank alternatives and assess trade-offs in sustainability planning [21], [22]. This method is particularly useful when dealing with conflicting objectives such as economic growth versus environmental protection and is often applied in the context of SDG 7 (Affordable and Clean Energy) and SDG 8 (Decent Work and Economic Growth). Reliable official data ensures that these models remain robust and credible.

The monitoring and evaluation (M&E) of sustainability policies is another area where decision sciences, empowered by official statistics, play a central role. Tracking progress toward the SDGs requires measurable indicators, many of which are produced by NSOs [23], [24]. For example, metrics such as infant mortality rates, literacy levels, or access to clean energy serve as feedback mechanisms in adaptive policy models, promoting transparency and continuous improvement in sustainability governance.

Ultimately, the integration of official statistics in decision sciences ensures that strategies addressing sustainability are grounded in reality, not assumptions. Whether it is formulating long-term development plans, navigating crisis scenarios, or fine-tuning resource allocations, official statistics make it possible to model potential outcomes with a high degree of reliability. This enhances not only the efficiency and accuracy of decisions but also their legitimacy, supporting a more accountable and sustainable development pathway.

Computer Sciences

The integration of official statistics within the realm of computer sciences plays a pivotal role in enhancing data-driven decision-making and accelerating sustainable development. As the volume and complexity of data continue to grow, computer science techniques provide the necessary infrastructure and algorithms to manage, process, and analyze massive datasets derived from official sources. These datasets are essential for monitoring trends, evaluating policy outcomes, and optimizing resource allocation. The synergy between official statistics and computer science fosters an environment where evidence-based approaches can thrive, thereby enabling governments, institutions, and civil society to act efficiently in pursuit of sustainable goals [25].

One of the primary contributions of computer sciences is in the domain of data mining and machine learning. These tools allow researchers and policymakers to detect patterns, forecast outcomes, and model various sustainability scenarios using official data. For instance, climate-related data from national meteorological agencies can be used to train predictive models that anticipate extreme weather events or track long-term changes in environmental conditions [26], [27]. This directly supports SDG 11 and SDG 13 by improving resilience planning and urban development strategies.

In addition, computer sciences facilitate real-time monitoring through the use of artificial intelligence (AI) and the Internet of Things (IoT). These technologies can be integrated with official statistical systems to automate data collection and streamline reporting mechanisms. For example, smart sensors embedded in transportation infrastructure can continuously generate traffic data, which NSOs can aggregate to assess mobility patterns and emissions [28], [29]. This contributes to SDG 3 (Good Health and Well-Being) and SDG 9 by optimizing transport efficiency and reducing health risks from pollution.

Moreover, advancements in data visualization and geospatial analytics within computer science provide accessible platforms for communicating official statistics to diverse audiences. Dashboards, interactive maps, and mobile applications make statistical information more intuitive and actionable for decision-makers and the general public [30]. These visualization tools help bridge the gap between complex datasets and meaningful insights, supporting transparency and participatory governance, key aspects of SDG 16 and SDG 17 (Partnerships for the Goals).

Cybersecurity and data governance are also critical areas where computer sciences bolster the credibility and ethical use of official statistics. Ensuring the privacy, confidentiality, and security of sensitive data is paramount, especially when statistics involve personal or administrative records [1]. Cryptographic techniques, secure access protocols, and anonymization methods help maintain trust in official data systems. These measures align with the ethical standards emphasized in the UN Fundamental Principles of Official Statistics and contribute indirectly to SDG 16 by promoting responsible institutions.

Another vital intersection between computer science and official statistics lies in software engineering and systems architecture. Efficient statistical information systems (SIS) depend on robust platforms that support data integration, harmonization, and interoperability. These systems enable multi-sectoral data exchanges and facilitate harmonized reporting across ministries, regions, and international bodies [31]. For instance, integrating agricultural production data with trade statistics can enhance food security analysis [32], supporting SDG 2 and SDG 12.

The development of open data platforms and APIs by NSOs powered by computer science is transforming the way stakeholders interact with official statistics. Open access to standardized datasets empowers researchers, journalists, NGOs, and startups to innovate and generate new knowledge. Such democratization of data aligns with the "leave no one behind" principle of the 2030 Agenda and supports a wide range of SDGs by catalyzing collaborative solutions across disciplines.

In conclusion, the contribution of computer sciences to the application and evolution of official statistics is indispensable for achieving sustainability. Through advanced analytics, real-time systems, ethical safeguards, and accessible interfaces, computer science enhances the relevance, timeliness, and usability of statistical information. As the global community moves further into the digital age, the fusion of computer science and official statistics will become increasingly central to measuring progress, anticipating challenges, and guiding sustainable development pathways.

Mathematics

Mathematics forms the foundational backbone of official statistics, underpinning the methodologies used to collect, process, analyze, and interpret data critical for sustainable development. From sampling theory to inferential statistics and optimization algorithms, mathematical techniques ensure the accuracy, reliability, and validity of statistical outputs. These rigorously derived figures are indispensable for guiding evidence-based policy and tracking progress across the SDGs. In this context, mathematics enables governments and international bodies to move beyond anecdotal evidence toward objective, quantifiable measures of sustainability.

A core mathematical contribution lies in the area of statistical modeling. Techniques such as linear regression, time series forecasting, and Bayesian inference are widely used to estimate indicators and project future trends. For instance, using official population data and birth rates, demographers can forecast population growth [33] and assess implications for SDG 3 and SDG 4 (Quality Education). Similarly, environmental statisticians may employ stochastic models to simulate carbon emissions trajectories under different policy scenarios [34], thus informing SDG 7 and SDG 13.

Mathematical optimization plays a critical role in resource allocation and policy impact simulations. Through linear programming and other techniques, decision-makers can determine the most efficient ways to distribute limited resources such as vaccines, educational funding, or clean water infrastructure based on statistical data [35], [36]. This application directly supports goals like SDG 1, SDG 2, and SDG 6, where targeted interventions are necessary for maximum social impact.

Additionally, error estimation and uncertainty quantification are essential mathematical tools in the production of official statistics. Confidence intervals, margins of error, and sensitivity analyses enable users to interpret statistical indicators more judiciously. For example, when publishing national poverty-related rates, statistical agencies include confidence intervals that allow policymakers to account for potential variability and make more robust decisions [37], [38]. These methods foster transparency and reliability, reinforcing public trust in data and aligning with SDG 16.

Mathematics also facilitates the harmonization and standardization of indicators across regions and sectors. Concepts like index numbers, weighting schemes, and normalization functions are applied to aggregate disparate data sources into coherent national or global indicators [39]. The Human Development Index (HDI), Gender Inequality Index (GII), and SDG composite indicators all rely on mathematical formulae grounded in official statistics. This comparability is crucial for monitoring SDG progress across countries and identifying best practices.

Advanced areas of mathematics, such as network theory and spatial statistics, are increasingly used to model complex systems and interdependencies in sustainability studies. For example, spatial regression models can evaluate the relationship between environmental degradation and socio-economic factors across regions [40], supporting interventions that align with SDG 11 and SDG 15 (Life on Land). Similarly, mathematical epidemiology relying on differential equations has become vital in modeling disease spread, helping to guide responses to pandemics [41] in line with SDG 3.

In sum, mathematics not only ensures methodological rigor in the production of official statistics but also empowers a wide array of sustainability applications, from forecasting and optimization to spatial analysis and ethical data usage. Its role is both foundational and forward-looking, enabling statistical systems to evolve in complexity and precision as new sustainability challenges emerge. Strengthening mathematical capacity within national statistical systems (NSS) is thus a critical investment for any country seeking to achieve the SDGs through sound, scientific, and data-driven policymaking.

Social Sciences

The Social Sciences offer a critical lens through which the societal dimensions of sustainability are examined, and official statistics provide the empirical backbone to these

inquiries. Disciplines such as sociology, political science, anthropology, and human geography rely heavily on statistical data to understand patterns of inequality, governance, social behavior, and cultural transformation. Through structured surveys, census data, and administrative records, NSOs deliver the necessary evidence for understanding social dynamics, which directly supports the advancement of SDGs such as SDG 1, SDG 5 (Gender Equality), SDG 10 (Reduced Inequalities), and SDG 16.

One of the most significant contributions of official statistics in this domain is the measurement of inequality and social exclusion. Social science research benefits from data on income distribution, labor market participation, household composition, and access to public services, allowing scholars and policymakers to assess disparities across socioeconomic, gender, ethnic, and geographic lines. These measurements are vital for designing inclusive policies that target marginalized populations, thereby fostering social cohesion and contributing to SDGs focused on equity and human rights.

In political science and governance studies, official statistics serve as an empirical basis to monitor institutional performance and public trust. Data on voter turnout, civic participation, rule of law, corruption perception, and public service delivery enables evaluation of democratic governance and institutional accountability [42], [43]. This supports SDG 16, which emphasizes transparent, effective, and inclusive institutions. Furthermore, longitudinal datasets provide a time-based understanding of how governance reforms or crises affect citizen well-being and engagement, helping to shape better institutions over time.

Anthropological and cultural studies benefit from demographic and ethnographic statistics that shed light on language, religion, identity, and migration patterns. Such data informs public discourse on multiculturalism, integration policies, and indigenous rights. For example, official statistics on indigenous populations, their geographic distribution, and socio-economic status [44] are fundamental for advancing SDG 10 and SDG 11. Recognizing and preserving cultural diversity is a cornerstone of sustainable development that goes way beyond economic metrics.

Social statistics are also indispensable for evaluating the social determinants of health, education, and well-being. Household surveys and labor force data reveal how employment, housing, education, and family structures intersect to influence individual outcomes. These datasets underpin research that examines the root causes of poverty, school dropout rates, or health disparities [45], contributing directly to SDG 3 and SDG 4. Without reliable social statistics, the formulation of targeted, equitable social protection programs would be nearly impossible.

Another crucial role of official statistics in the social sciences is in monitoring the effectiveness of public policies and interventions. For instance, evaluations of conditional cash transfers, universal basic income pilots, or affirmative action programs depend on baseline and follow-up data to determine impact [46]. This enables a feedback loop where evidence guides policy revision and innovation, strengthening data-driven governance and supporting all SDGs that hinge on inclusive social policies.

In human geography and urban studies, spatially disaggregated data such as neighborhood-level census information or geotagged household surveys enable research on urban inequality, segregation, and access to infrastructure [47]. These insights are key to achieving SDG 11, as cities strive to become more inclusive, safe, and sustainable. For

example, identifying urban areas with high poverty concentration or limited access to sanitation and transport helps city planners prioritize investments and monitor urban transformation [48].

In essence, official statistics empower the social sciences to translate human experiences into quantifiable patterns, which in turn influence policies that shape the everyday lives of people. As social structures continue to evolve due to globalization, technological change, and environmental stressors, the role of official statistics will only grow in importance. Strengthening data literacy among social scientists and deepening collaboration with statistical agencies will be vital to ensuring that future development remains equitable, inclusive, and responsive to the needs of diverse populations.

Economics, Econometrics & Finance

Economics, econometrics, and finance form the analytical core of understanding resource allocation, market behavior, and financial stability, all of which are crucial for sustainable development. Official statistics provide the quantitative foundation that enables economists and financial analysts to assess macroeconomic performance, model economic growth, and evaluate the fiscal sustainability of public policies. Key indicators such as GDP, inflation rates, employment data, trade balances, and government debt are routinely compiled by NSOs and international bodies. These metrics support SDG 8, SDG 9, and SDG 17, among others.

One of the principal uses of official statistics in this scope is for monitoring economic stability and inclusive growth. GDP per capita, income distribution, and sectoral productivity statistics help measure how wealth is generated and distributed. These indicators are essential for assessing the inclusiveness of growth and whether economic expansion is reducing poverty and inequality (SDG 1 and SDG 10) [49]. Moreover, data disaggregated by region, gender, and age allow for detailed policy targeting, such as promoting youth employment or reducing regional economic disparities [50].

Econometric models, which are central to both academic research and policymaking, rely on high-quality time series and cross-sectional data from official sources. These models enable researchers to identify causal relationships between economic variables, simulate the effects of policy interventions, and forecast future economic trends. For example, using labor force survey data, analysts can predict how minimum wage changes might affect employment or consumption patterns, directly informing labor and welfare policies [51] that contribute to SDG 3 and SDG 8.

In finance, official statistics are vital for assessing financial markets, fiscal discipline, and monetary policy effectiveness. Indicators such as interest rates, inflation expectations, and government budget balances help central banks and financial regulators maintain macroeconomic stability. Data on financial inclusion, such as access to banking services or credit, supports efforts to promote inclusive finance [52], a key enabler of SDG 1, SDG 5, and SDG 9. Furthermore, finance-related statistics play an increasing role in sustainable finance initiatives, such as green bonds and ESG (Environmental, Social, Governance) disclosures [53].

Trade and investment statistics are another cornerstone of sustainability in this field. Balance of payments, foreign direct investment (FDI) flows, and import/export data inform decisions on international trade, regional integration, and supply chain resilience.

These statistics contribute to SDG 17 by supporting global partnerships and sustainable trade practices. For developing countries, understanding trade patterns and dependency is vital to strategizing economic diversification and resilience in the face of global shocks [54].

One emerging area in sustainability economics is the integration of environmental and natural capital accounting, such as through the UN System of Environmental-Economic Accounting [55]. These statistics enable economists to account for the depletion of natural resources, emissions, and ecosystem services alongside traditional economic indicators. Incorporating these data shifts the focus from short-term GDP growth to long-term economic resilience and sustainability, directly contributing to SDG 13, SDG 14 (Life Below Water), and SDG 15.

The rise of digital financial services and informal economies has also prompted statisticians and economists to seek new ways of capturing economic activity. Satellite imagery, mobile transaction data, and big data sources are being explored to complement official statistics and uncover underreported financial information [56]. This innovation is crucial for ensuring that economic statistics reflect the full scope of economic life, particularly in developing countries where informal labor plays a significant role in livelihoods and sustainability outcomes.

Overall, the synergy between economics, finance, and official statistics is essential for designing sound, equitable, and forward-looking policies. As the global economy becomes more complex and sustainability transitions accelerate, enhanced economic statistics will remain central to informed decision-making. Strengthening the statistical capacity of nations, especially in data-poor contexts, is therefore a strategic imperative for achieving the full range of SDGs.

Business, Management, & Accounting

Business, management, and accounting play a pivotal role in operationalizing sustainability principles within organizations, industries, and supply chains. Official statistics serve as vital inputs for strategic planning, market analysis, sustainability reporting, and risk management. These data help businesses align their practices with societal goals, regulatory frameworks, and consumer expectations [57]. The scope naturally connects with SDG 8, SDG 9, SDG 12, and SDG 17.

In management, official statistics are used to guide strategic decision-making and performance benchmarking. Data on labor markets, productivity, education levels, and consumer behavior allow managers to assess market conditions, plan workforce needs, and position their organizations competitively [58]. National and regional indicators also help businesses identify emerging risks and opportunities tied to sustainability trends such as resource scarcity, demographic shifts, or environmental regulation encouraging them to innovate and adapt sustainably [59], [60].

From an accounting perspective, there is a growing push toward integrated and sustainability reporting, which involves disclosing financial and non-financial metrics such as carbon emissions, gender equality, water use, and waste management. Official statistics provide reference points, classification systems, and national baselines against which companies can compare their performance. For example, data from national

greenhouse gas inventories can contextualize a company's emissions, while demographic statistics can guide equity and diversity goals [61].

Moreover, in supply chain and operations management, businesses depend on official trade and logistics data to map supply chain resilience and sustainability risks. Customs data, transportation statistics, and infrastructure availability indicators support decisions on supplier selection, sourcing strategies, and logistics optimization [62]. This becomes critical when pursuing SDG 12 and SDG 13 (Climate Action), especially in light of growing demand for carbon-neutral and ethically sourced products. Robust statistics may help in tracing supply chain impacts and ensuring compliance with international standards and due diligence regulations.

In the realm of entrepreneurship and small-medium enterprises (SMEs) development, official statistics identify gaps and barriers in access to finance, market entry, and innovation capacity. Data on business demographics, access to credit, digital penetration, and R&D investment levels help shape support programs for small businesses and startups, critical engines of sustainable innovation and local economic development [63]. These efforts closely link with SDG 8 and SDG 9, promoting inclusive growth and industrial upgrading.

Public-private partnerships and corporate social responsibility (CSR) initiatives also rely on reliable statistical data to identify societal needs and measure social impact. Official statistics on poverty, health outcomes, education access, and gender inequality inform business-led development programs [64]. By aligning CSR strategies with national and global development indicators, companies contribute meaningfully to the SDGs while enhancing their social license to operate. The increasing importance of ESG (Environmental, Social, and Governance) performance in investment decisions has further increased demand for robust, comparable data. Investors now expect companies to report not only financial returns but also social and environmental impacts [65]. Here, official statistics provide credible reference frameworks, such as those found in the SDG indicators or the Global Reporting Initiative (GRI), ensuring transparency, comparability, and accountability in corporate sustainability practices.

In summary, the intersection between official statistics and business disciplines is instrumental in embedding sustainability into organizational culture, strategies, and reporting. As sustainability becomes a business imperative rather than a peripheral concern, access to high-quality, disaggregated, and timely official data is critical. It empowers businesses to become proactive agents of sustainable development, contributing not only to profit but also to people and the planet.

Engineering

Engineering serves as a critical discipline in translating sustainability principles into practical infrastructure, systems, and technologies that support human well-being and environmental stewardship. Official statistics provide essential input for engineering design, planning, risk assessment, and innovation, particularly when aligning projects with sustainability goals. Within this scope, key links can be made to SDG 7, SDG 9, SDG 11, and SDG 13.

In civil and infrastructure engineering, statistics on population growth, urbanization rates, housing conditions, and transportation use help determine the scale, location, and

type of infrastructure investments required. For example, census and household surveys support the design of urban housing projects, while transportation statistics inform decisions about sustainable mobility systems such as mass transit, pedestrian networks, and cycling infrastructure [66]. Official data ensure that engineering interventions meet present needs without compromising the capacity of future generations.

In energy and environmental engineering, official statistics underpin renewable energy planning and environmental impact assessments. National energy balances, emissions inventories, and climate data guide engineers in designing energy-efficient systems, renewable energy grids, and climate-resilient infrastructure [67]. These data-driven decisions help countries transition toward clean energy systems in alignment with SDG 7 and SDG 13. Accurate geospatial and meteorological data, often from national statistical or meteorological agencies, are particularly vital for siting wind, hydro, and solar energy installations [68].

In industrial and manufacturing engineering, data on material flows, industrial emissions, and resource efficiency allow engineers to optimize production processes for sustainability. The principles of circular economy, such as waste minimization, recycling, and remanufacturing, rely on material and waste statistics to identify inefficiencies and design more sustainable industrial systems [69]. This directly contributes to SDG 12 and supports industries in reducing their environmental footprint.

Disaster risk reduction and resilience engineering also benefit significantly from official statistics, including historical records on floods, earthquakes, and other hazards, as well as social vulnerability data [70]. These inform the design of resilient infrastructure, early warning systems, and emergency preparedness plans, particularly in climate-sensitive and disaster-prone regions. In this sense, engineering interventions are guided by statistical risk modeling and predictive analytics that protect both infrastructure and human lives.

Ultimately, the integration of official statistics into engineering processes ensures that technical solutions are contextually appropriate, socially equitable, and environmentally responsible. By grounding design and planning in verified, standardized data, engineers can effectively contribute to the achievement of the SDGs, especially in areas where infrastructure and innovation are pivotal for sustainable development. The synergy between engineering and official statistics is thus fundamental to building a resilient and inclusive future.

Environmental Sciences

Environmental sciences examine the interactions between human activities and natural ecosystems, emphasizing the need for sustainable management of natural resources. Within this context, official statistics offer a foundational basis for monitoring environmental changes, identifying degradation trends, and shaping policies that mitigate human impacts on the environment. These statistics directly support progress toward SDG 6, SDG 13, SDG 14, and SDG 15.

One of the most significant contributions of official statistics in this field is in the tracking of environmental indicators such as greenhouse gas emissions, deforestation rates, air and water quality, and biodiversity loss [71], [72]. These data are typically compiled through national environmental accounts, land use surveys, and monitoring systems

managed by statistical agencies or environmental ministries. For example, the UN Framework for the Development of Environment Statistics (FDES) guides countries in collecting harmonized environmental data, ensuring that national reporting aligns with global sustainability frameworks.

Water resource management is another area where environmental statistics play a pivotal role. Official data on water availability, consumption patterns, pollution levels, and sanitation coverage inform both local interventions and national water policies [73]. These statistics guide efforts to ensure equitable access to clean water and prevent ecosystem degradation caused by overextraction or contamination, aligning directly with SDG 6. Additionally, hydrological and meteorological statistics contribute to the planning and management of water infrastructure and drought mitigation strategies [74].

Official statistics also enable governments to track and address the impacts of climate change. Long-term datasets on temperature, precipitation, sea level rise, and extreme weather events support scientific assessments and policy responses under SDG 13. These data are vital for climate modeling, adaptation planning, and national communications submitted to the UNFCCC. For instance, integrated climate databases allow researchers and decision-makers to understand regional vulnerabilities and implement evidence-based adaptation and mitigation strategies [75].

Moreover, environmental statistics contribute to ecosystem and biodiversity conservation, which are central to SDG 14 and SDG 15. Data on forest cover, marine protected areas, threatened species, and land degradation help in monitoring ecosystem health and the effectiveness of conservation programs [76], [77]. These statistics support environmental impact assessments and land-use planning, promoting balanced development that maintains ecological integrity.

In sum, official statistics serve as the empirical backbone of environmental science, linking empirical observation with policy formulation and implementation. By offering standardized, reliable, and time-series data, these statistics empower environmental scientists, governments, and communities to make informed decisions that safeguard the planet's ecological balance. The integration of environmental statistics into sustainability governance is not only beneficial but essential to the realization of a more resilient and biodiverse future.

Earth & Planetary Sciences

Earth and planetary sciences explore the physical processes and structures of the Earth and other celestial bodies, playing a crucial role in understanding natural hazards, resource availability, and global environmental systems. In the sustainability context, official statistics derived from geophysical, geological, and atmospheric data provide critical insights for disaster risk reduction, climate monitoring, and resource conservation. These contributions align closely with SDG 11, SDG 13, and SDG 15.

Official statistics in this field often include data from national geological surveys, seismic monitoring networks, and remote sensing systems. These statistics help governments and researchers identify and map areas prone to earthquakes, volcanic eruptions, landslides, and other geohazards. Such data inform land-use planning, building codes, and emergency preparedness systems, key elements of resilience-building under SDG 11. For instance,

earthquake hazard maps derived from official seismic data are used to develop zoning regulations in urban planning [78].

In addition, earth science statistics contribute significantly to understanding the planet's changing climate. Long-term records of atmospheric CO₂ concentrations, glacial retreat, sea level rise, and ocean temperatures are foundational to climate models and policy development under SDG 13 [79], [80]. These statistics also support international efforts such as the Intergovernmental Panel on Climate Change (IPCC), which relies on consistent and verifiable data sources for its assessments.

Resource sustainability is another core area where official statistics in Earth sciences are indispensable. Data on mineral reserves, soil composition, and groundwater availability are vital for managing the extraction and use of non-renewable resources. Governments use these statistics to monitor exploitation trends, ensure responsible mining practices, and assess long-term resource sustainability [81], [82], all of which are important for balancing economic development with environmental stewardship.

The monitoring of planetary processes is increasingly relevant for sustainability as the impacts of space weather, atmospheric changes, and satellite-based observations influence Earth systems. For instance, satellite imagery and geospatial data help monitor deforestation, glacial melt, desertification, and other large-scale processes with direct implications for SDG 15 [83]. These statistics also support precision agriculture, environmental forecasting, and early warning systems that aid in sustainable land and water use.

Overall, official statistics within Earth and planetary sciences form a critical infrastructure for sustainable development planning. By offering systematic, high-quality data on geophysical and atmospheric phenomena, these statistics not only enhance scientific understanding but also inform practical actions to protect life, infrastructure, and natural resources. As climate change and natural disasters pose escalating threats, the continued development and application of Earth science statistics will be essential to sustainable and resilient futures.

Medicine

Medicine, as a scientific and applied field, plays a vital role in advancing sustainability by promoting health, preventing disease, and ensuring equitable access to healthcare. Official statistics within the medical domain encompass systematically collected data on morbidity, mortality, healthcare access, disease prevalence, vaccination coverage, and health service utilization. These datasets, often provided by ministries of health, national health institutes, and international organizations such as the WHO, are instrumental in supporting SDG 3, and intersect with SDG 1, SDG 2, and SDG 10.

One of the most critical uses of official medical statistics is in tracking disease burden and identifying health disparities across regions and populations. By collecting reliable data on conditions such as cardiovascular diseases, cancers, respiratory illnesses, and infectious diseases, governments can prioritize public health interventions and allocate resources effectively. For example, surveillance data during the COVID-19 pandemic guided policies on lockdowns, testing, and vaccine distribution, showcasing how vital real-time official statistics are in mitigating public health crises [84], [85].

In addition, official statistics are central to maternal and child health monitoring. Data on maternal mortality ratios, under-five mortality rates, and access to antenatal care enable countries to track progress on SDG 3 [86], [87]. These statistics guide national health strategies and inform global partnerships, such as the Every Woman Every Child initiative, by pinpointing where healthcare systems fall short and where targeted investments are most needed.

Official health statistics also support efforts to strengthen health systems and improve healthcare infrastructure. Indicators such as doctor-to-patient ratios, hospital bed availability, healthcare expenditures, and insurance coverage help assess the efficiency, accessibility, and equity of healthcare systems [88]. These metrics inform reforms aimed at achieving Universal Health Coverage (UHC), a key target under SDG 3, and support evidence-based policymaking that reduces health inequities and improves service delivery across socio-economic groups.

The integration of environmental health into medical statistics is increasingly important as sustainability challenges, such as pollution, climate change, and urbanization, pose growing health risks. Data on respiratory illnesses linked to air pollution, heat-related illnesses, and vector-borne diseases help to connect environmental and health policies [89], [90]. These linkages reinforce SDG 11 and SDG 13, showing how official health statistics serve as a bridge between medicine and broader sustainability goals.

Ultimately, official statistics in medicine are indispensable tools for protecting population health and fostering sustainable development. They provide the empirical foundation for health equity, resilience, and preparedness, while also enabling global comparisons and accountability. In a world facing interconnected challenges such as pandemics, aging populations, and climate-induced health risks, reliable and transparent medical statistics will continue to underpin sustainable health systems and resilient societies.

3.7 Implications of Official Statistics & Recommendations

The findings of this study underscore the centrality of official statistics as both enablers and accelerators of sustainable development. Across diverse disciplines, ranging from social sciences and decision sciences to medicine, engineering, and environmental studies, official statistics serve as the empirical backbone for informed decision-making, accountability, and evidence-based policy formulation. The implications are clear: without robust, accessible, and high-quality official statistics, the global sustainability agenda, including the achievement of the SDGs, risks being guided by incomplete or biased information.

One major implication is the need to strengthen the capacity and autonomy of NSS. Governments, particularly in low- and middle-income countries, should invest in the modernization of statistical infrastructure, including digital tools, geospatial technologies, and real-time data integration. Enhancing statistical capacity not only improves the quality and timeliness of data but also ensures that statistics can keep pace with fast-evolving global challenges such as pandemics, climate change, and technological disruption [91]. In this regard, targeted funding, South-South collaboration, and support from international organizations like the UN, IMF, and World Bank may be essential.

Another critical recommendation involves promoting interdisciplinary collaboration in the production and use of official statistics. The study shows that sustainability is a

complex, interlinked agenda that spans health, environment, economy, infrastructure, and governance. Hence, statistical agencies must engage with domain experts from various sectors, including academic researchers, policy think tanks, civil society, and private sector actors. These collaborations can refine indicator design, improve contextual interpretation, and enhance the practical utility of data for localized and sector-specific sustainability planning.

Moreover, it is imperative to improve data literacy and accessibility among decision-makers and the general public. High-quality statistics have limited impact if they are not understood or trusted [92]. Governments and institutions should prioritize open data initiatives, user-friendly data platforms, and capacity-building programs that demystify statistical information for non-experts. This includes integrating statistical education into formal curricula and professional training programs. Greater data transparency and public engagement will also enhance civic trust and enable communities to monitor development outcomes more effectively [93].

The study also recommends expanding the scope of sustainability-oriented indicators within official statistics. Emerging areas such as digital inclusion, mental health, circular economy, and climate resilience are often underrepresented in traditional statistical frameworks. Adopting innovative data sources (e.g., satellite imagery, administrative data, citizen-generated data) in combination with traditional surveys can provide a more comprehensive picture of sustainability progress. However, such innovation must be balanced with concerns around data ethics, privacy, and equity, requiring the development of robust governance frameworks.

Finally, there is a pressing need for sustained international coordination to standardize, align, and harmonize sustainability-related indicators. As countries move towards localizing the SDGs and developing national development frameworks, standardized methodologies and shared definitions of indicators will facilitate cross-national learning and comparative benchmarking. Global initiatives such as the UN Global Indicator Framework and the Cape Town Global Action Plan for Sustainable Development Data must be continuously supported, reviewed, and adapted to remain relevant in a data-rich but fragmented world.

4. CONCLUSION

This study has demonstrated that official statistics play a pivotal role in achieving sustainability across a wide array of disciplinary domains, including decision sciences, computer sciences, mathematics, social sciences, economics, business, engineering, environmental sciences, earth and planetary sciences, and medicine. Through bibliometric analysis and thematic exploration, it becomes evident that official statistics serve as foundational tools for monitoring progress, informing policy, guiding investment, and ensuring transparency in sustainable development processes. Despite a growing body of literature and increasing institutional awareness, disparities in disciplinary coverage and geographic representation highlight the need for more balanced and inclusive statistical research, especially in technical fields like engineering and environmental sciences where sustainability imperatives are critical.

Based on these findings, the study recommends a set of strategic actions aimed at maximizing the impact of official statistics on sustainability. These include strengthening NSS, encouraging interdisciplinary collaboration, expanding the range of sustainability

indicators, fostering data literacy, and promoting open access to official data. Moreover, global coordination and capacity-building efforts must be sustained to ensure consistency, comparability, and equity in data use and production. By embracing these recommendations, stakeholders across sectors can better leverage official statistics as a strategic asset in steering transformative, evidence-driven progress toward the SDGs.

DAFTAR PUSTAKA

- [1] H. Hassani and S. MacFeely, "Driving excellence in official statistics: Unleashing the potential of comprehensive digital data governance," *Big Data Cogn. Comput.*, vol. 7, no. 3, p. 134, July 2023.
- [2] A. C. Ikegwu, H. F. Nweke, C. V. Anikwe, U. R. Alo, and O. R. Okonkwo, "Big data analytics for data-driven industry: a review of data sources, tools, challenges, solutions, and research directions," *Cluster Comput.*, vol. 25, no. 5, pp. 3343–3387, Oct. 2022.
- [3] Statista, "Big data market size revenue forecast worldwide from 2011 to 2027," *Statista*, 2025. [Online]. Available: <https://www.statista.com/statistics/254266/global-big-data-market-forecast/>. [Accessed: 31-May-2025].
- [4] S. De Broe *et al.*, "Updating the paradigm of official statistics: New quality criteria for integrating new data and methods in official statistics," *Stat. J. IAOS*, vol. 37, no. 1, pp. 343–360, Mar. 2021.
- [5] S. Badiiee, J. Crowell, L. Noe, A. Pittman, C. Rudow, and E. Swanson, "Open data for official statistics: History, principles, and implementation," *Stat. J. IAOS*, vol. 37, no. 1, pp. 139–159, Mar. 2021.
- [6] N. Bachmann, S. Tripathi, M. Brunner, and H. Jodlbauer, "The contribution of data-driven technologies in achieving the Sustainable Development Goals," *Sustainability*, vol. 14, no. 5, p. 2497, Feb. 2022.
- [7] C. Allen, M. Smith, M. Rabiee, and H. Dahmm, "A review of scientific advancements in datasets derived from big data for monitoring the Sustainable Development Goals," *Sustain. Sci.*, vol. 16, no. 5, pp. 1701–1716, Sept. 2021.
- [8] M. Chopra, D. S. K. Singh, A. Gupta, K. Aggarwal, B. B. Gupta, and F. Colace, "Analysis & prognosis of sustainable development goals using big data-based approach during COVID-19 pandemic," *Sustainable Technology and Entrepreneurship*, vol. 1, no. 2, p. 100012, May 2022.
- [9] L. Tamym, L. Benyoucef, A. Nait Sidi Moh, and M. D. El Ouadghiri, "Big Data Analytics-based life cycle sustainability assessment for sustainable manufacturing enterprises evaluation," *J. Big Data*, vol. 10, no. 1, Nov. 2023.
- [10] L. Tamym, L. Benyoucef, A. N. S. Moh, and M. D. E. Ouadghiri, "A big data analytics-based methodology for social sustainability impacts evaluation: A case study," *Procedia Comput. Sci.*, vol. 220, pp. 32–39, 2023.
- [11] W. B. Gunawan, "MSME Sustainability as the Key to Sustainability: Role and Contribution of MSMEs to Sustainability with a Bibliometric Approach and Literature Review," *Equator Journal of Management and Entrepreneur*, vol. 13, no. 1, pp. 1–17, Summer 2025.
- [12] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, Sept. 2021.

- [13] V. K. Singh, P. Singh, M. Karmakar, J. Leta, and P. Mayr, "The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis," *Scientometrics*, vol. 126, no. 6, pp. 5113–5142, June 2021.
- [14] B. Abidoye and E. Orlic, "Localizing the Sustainable Development Goals: A case for investment in data and impact evaluation," *Stat. J. IAOS*, vol. 38, no. 3, pp. 863–878, Sept. 2022.
- [15] Y. Cortés, "Spatial accessibility to local public services in an unequal place: An analysis from patterns of residential segregation in the Metropolitan Area of Santiago, Chile," *Sustainability*, vol. 13, no. 2, p. 442, Jan. 2021.
- [16] R. de la Torre, C. G. Corlu, J. Faulin, B. S. Onggo, and A. A. Juan, "Simulation, optimization, and machine learning in Sustainable Transportation Systems: Models and applications," *Sustainability*, vol. 13, no. 3, p. 1551, Feb. 2021.
- [17] O. A. Nnene, J. W. Joubert, and M. H. P. Zuidgeest, "A simulation-based optimization approach for designing transit networks," *Public Transp.*, Jan. 2023.
- [18] S. M. H. S. Rezvani, M. J. F. Silva, and N. M. de Almeida, "Urban Resilience Index for critical infrastructure: A Scenario-based approach to disaster risk reduction in road networks," *Sustainability*, vol. 16, no. 10, p. 4143, May 2024.
- [19] I. E. Agbehadji, S. Schütte, M. Masinde, J. Botai, and T. Mabhaudhi, "Climate risks resilience development: A bibliometric analysis of climate-related early warning systems in southern Africa," *Climate*, vol. 12, no. 1, p. 3, Dec. 2023.
- [20] S. Anand and M. K. Barua, "Modeling the key factors leading to post-harvest loss and waste of fruits and vegetables in the agri-fresh produce supply chain," *Comput. Electron. Agric.*, vol. 198, no. 106936, p. 106936, July 2022.
- [21] M. Sousa, M. F. Almeida, and R. Calili, "Multiple criteria decision making for the achievement of the UN Sustainable Development Goals: A systematic literature review and a research agenda," *Sustainability*, vol. 13, no. 8, p. 4129, Apr. 2021.
- [22] G. Hirsch Hadorn, "Which methods are useful to justify public policies? An analysis of cost-benefit analysis, multi-criteria decision analysis, and non-aggregate indicator systems," *Z. Allg. Wissenschaftstheor.*, vol. 53, no. 2, pp. 123–141, June 2022.
- [23] A. Usubiaga-Liaño and P. Ekins, "Monitoring the environmental sustainability of countries through the strong environmental sustainability index," *Ecol. Indic.*, vol. 132, no. 108281, p. 108281, Dec. 2021.
- [24] H. Guo *et al.*, "Measuring and evaluating SDG indicators with Big Earth Data," *Sci. Bull. (Beijing)*, vol. 67, no. 17, pp. 1792–1801, Sept. 2022.
- [25] L. Hantrais and A. T. Lenihan, "Social dimensions of evidence-based policy in a digital society," *Contemp. Soc. Sci.*, vol. 16, no. 2, pp. 141–155, Mar. 2021.
- [26] G. Brunet *et al.*, "Advancing weather and climate forecasting for our changing world," *Bull. Am. Meteorol. Soc.*, vol. 104, no. 4, pp. E909–E927, Apr. 2023.
- [27] L. Chen, B. Han, X. Wang, J. Zhao, W. Yang, and Z. Yang, "Machine Learning methods in weather and climate applications: A survey," *Appl. Sci. (Basel)*, vol. 13, no. 21, p. 12019, Nov. 2023.
- [28] M. Ahmad Jan, M. Adil, B. Brik, S. Harous, and S. Abbas, "Making sense of Big Data in intelligent Transportation Systems: Current trends, challenges and future directions," *ACM Comput. Surv.*, vol. 57, no. 8, pp. 1–43, Aug. 2025.
- [29] P. Bellini, S. Bilotta, E. Collini, M. Fanfani, and P. Nesi, "Data sources and models for integrated mobility and transport solutions," *Sensors (Basel)*, vol. 24, no. 2, p. 441, Jan. 2024.

- [30] O. Kharakhash, "Data Visualization: Transforming Complex Data into Actionable Insights," *Automation of Technological and Business Processes*, vol. 15, no. 2, pp. 4–12, June 2023.
- [31] P. Cheung and X. Taojun, *The ASEAN digital economy*. London: Routledge, 2023.
- [32] X. Wang, L. Ma, S. Yan, X. Chen, and A. Growe, "Trade for food security: The stability of global agricultural trade networks," *Foods*, vol. 12, no. 2, p. 271, Jan. 2023.
- [33] T. Wilson, I. Grossman, M. Alexander, P. Rees, and J. Temple, "Methods for small area population forecasts: State-of-the-art and research needs," *Popul. Res. Policy Rev.*, vol. 41, no. 3, pp. 865–898, 2022.
- [34] S. A. Jamatutu, K. Abbass, S. Gawusu, K. E. Yeboah, I. A.-M. Jamatutu, and H. Song, "Quantifying future carbon emissions uncertainties under stochastic modeling and Monte Carlo simulation: Insights for environmental policy consideration for the Belt and Road Initiative Region," *J. Environ. Manage.*, vol. 370, no. 122463, p. 122463, Nov. 2024.
- [35] S. L. Gebre, D. Cattrysse, and J. Van Orshoven, "Multi-criteria decision-making methods to address water allocation problems: A systematic review," *Water (Basel)*, vol. 13, no. 2, p. 125, Jan. 2021.
- [36] X. Yin and İ. E. Büyüktaktakın, "Risk-averse multi-stage stochastic programming to optimizing vaccine allocation and treatment logistics for effective epidemic response," *IIE Trans. Healthc. Syst. Eng.*, vol. 12, no. 1, pp. 52–74, Jan. 2022.
- [37] S. Gawusu and A. Ahmed, "Analyzing variability in urban energy poverty: A stochastic modeling and Monte Carlo simulation approach," *Energy (Oxf.)*, vol. 304, no. 132194, p. 132194, Sept. 2024.
- [38] R. Liang, R. Goto, Y. Okubo, D. H. Rehkopf, and K. Inoue, "Poverty and childhood obesity: Current evidence and methodologies for future research," *Curr. Obes. Rep.*, vol. 14, no. 1, p. 33, Apr. 2025.
- [39] M. Carrillo, "Measuring progress towards sustainability in the European union within the 2030 Agenda framework," *Mathematics*, vol. 10, no. 12, p. 2095, June 2022.
- [40] U. A. Bhatti, H. Tang, A. Khan, Y. Yasin Ghadi, M. A. Bhatti, and K. A. Khan, "Investigating the nexus between energy, socio-economic factors and environmental pollution: A geo-spatial multi regression approach," *Gondwana Res.*, vol. 130, pp. 308–325, June 2024.
- [41] A. S. Mata and S. M. P. Dourado, "Mathematical modeling applied to epidemics: an overview," *São Paulo J. Math. Sci.*, vol. 15, no. 2, pp. 1025–1044, Sept. 2021.
- [42] W. Waheduzzaman and S. Khandaker, "E-participation for combating corruption, increasing voice and accountability, and developing government effectiveness: A cross-country data analysis," *Aust. J. Publ. Adm.*, vol. 81, no. 4, pp. 549–568, Dec. 2022.
- [43] G. Asimakopoulos, H. Antonopoulou, K. Giotopoulos, and C. Halkiopoulos, "Impact of Information and Communication Technologies on democratic processes and citizen participation," *Societies (Basel)*, vol. 15, no. 2, p. 40, Feb. 2025.
- [44] L. Kuanova, A. Bekbossinova, and T. Abdykadyr, "Assessment of the sustainable development of regions: The case of Kazakhstan," *Eurasian Journal of Economic and Business Studies*, vol. 3, no. 67, pp. 122–135, Oct. 2023.
- [45] S. Assari, "Latinos' diminished returns of educational attainment on reducing food insecurity: the role of ethnic disparities in family structure and employment," *Front. Public Health*, vol. 12, p. 1407005, Aug. 2024.

- [46] A. D. Pinto, M. Perri, C. L. Pedersen, T. Aratangy, A. P. Hapsari, and S. W. Hwang, "Exploring different methods to evaluate the impact of basic income interventions: a systematic review," *Int. J. Equity Health*, vol. 20, no. 1, p. 142, June 2021.
- [47] J. Hwang and T. W. McDaniel, "Racialized reshuffling: Urban change and the persistence of segregation in the twenty-first century," *Annu. Rev. Sociol.*, vol. 48, no. 1, pp. 397–419, July 2022.
- [48] B. Giles-Corti *et al.*, "What next? Expanding our view of city planning and global health, and implementing and monitoring evidence-informed policy," *Lancet Glob. Health*, vol. 10, no. 6, pp. e919–e926, June 2022.
- [49] S. MacFeely, P. van de Ven, and A. Peltola, "To GDP and beyond: The past and future history of the world's most powerful statistical indicator," *Stat. J. IAOS*, vol. 40, no. 3, pp. 685–711, Aug. 2024.
- [50] R. Apunyo *et al.*, "Interventions to increase youth employment: An evidence and gap map," *Campbell Syst. Rev.*, vol. 18, no. 1, p. e1216, Mar. 2022.
- [51] D. Berger, K. Herkenhoff, and S. Mongey, "Minimum wages, efficiency, and welfare," *Econometrica*, vol. 93, no. 1, pp. 265–301, 2025.
- [52] L.-Y. Tay, H.-T. Tai, and G.-S. Tan, "Digital financial inclusion: A gateway to sustainable development," *Heliyon*, vol. 8, no. 6, p. e09766, June 2022.
- [53] W. Luo, Z. Tian, S. Zhong, Q. Lyu, and M. Deng, "Global evolution of research on sustainable finance from 2000 to 2021: A bibliometric analysis on WoS database," *Sustainability*, vol. 14, no. 15, p. 9435, Aug. 2022.
- [54] O. Pretorius, E. Drewes, M. van Aswegen, and G. Malan, "A policy approach towards achieving regional economic resilience in developing countries: Evidence from the SADC," *Sustainability*, vol. 13, no. 5, p. 2674, Mar. 2021.
- [55] H. Chen, Y. Shi, and H. He, "A sustainable urban framework based on natural capital and ecosystem services accounting," *Appl. Spat. Anal. Policy*, vol. 18, no. 1, Mar. 2025.
- [56] B. Charoenwong and A. Kwan, "Alternative Data, Big Data, and Applications to Finance," in *Fintech with Artificial Intelligence, Big Data, and Blockchain*, Singapore: Springer Singapore, 2021, pp. 35–105.
- [57] J. C. Ingram *et al.*, "Opportunities for businesses to use and support development of SESA-aligned natural capital accounts," *Ecosyst. Serv.*, vol. 55, no. 101434, p. 101434, June 2022.
- [58] N. Edh Mirzaei, P. Hilletoft, and R. Pal, "Challenges to competitive manufacturing in high-cost environments: checklist and insights from Swedish manufacturing firms," *Oper. Manag. Res.*, vol. 14, no. 3–4, pp. 272–292, Dec. 2021.
- [59] H. Hegab, I. Shaban, M. Jamil, and N. Khanna, "Toward sustainable future: Strategies, indicators, and challenges for implementing sustainable production systems," *Sustain. Mater. Technol.*, vol. 36, no. e00617, p. e00617, July 2023.
- [60] F. Azmat, W. M. Lim, A. Moyeen, R. Voola, and G. Gupta, "Convergence of business, innovation, and sustainability at the tipping point of the sustainable development goals," *J. Bus. Res.*, vol. 167, no. 114170, p. 114170, Nov. 2023.
- [61] M. A. Koseoglu, H. E. Arici, M. B. Saydam, and V. O. Olorunsola, "Environmental, social and governance assets and diversity scores: exploring their relationship to carbon emissions in global companies," *Manag. Decis.*, May 2024.
- [62] Y. Kayikci, "Stream processing data decision model for higher environmental performance and resilience in sustainable logistics infrastructure," *J. Enterp. Inf. Manag.*, vol. 34, no. 1, pp. 140–167, Jan. 2021.

- [63] A. Colombelli, E. Paolucci, E. Raguseo, and G. Elia, "The creation of digital innovative start-ups: the role of digital knowledge spillovers and digital skill endowment," *Small Bus. Econ.*, vol. 62, no. 3, pp. 917–937, Mar. 2024.
- [64] A. Righi, "Measuring social capital: Official statistics initiatives in Italy," *Procedia Soc. Behav. Sci.*, vol. 72, pp. 4–22, Feb. 2013.
- [65] D. Rozkrut, M. Tarczynska-Luniewska, G. A. Singh, and M. Piwowarski, "The use of big data in ESG monitoring and evaluation," in *Contemporary Studies in Economic and Financial Analysis*, Emerald Publishing Limited, 2024, pp. 25–40.
- [66] M. Tran and C. Draeger, "A data-driven complex network approach for planning sustainable and inclusive urban mobility hubs and services," *Environ. Plan. B Urban Anal. City Sci.*, vol. 48, no. 9, pp. 2726–2742, Nov. 2021.
- [67] S. C. Shandiz, B. Rismanchi, G. Foliente, and L. Aye, "A model for energy master planning and resilience assessment of net-zero emissions community," *Sustain. Resilient Infrastruct.*, vol. 8, no. 4, pp. 375–399, July 2023.
- [68] J. R. S. Doorga, J. W. Hall, and N. Eyre, "Geospatial multi-criteria analysis for identifying optimum wind and solar sites in Africa: Towards effective power sector decarbonization," *Renew. Sustain. Energy Rev.*, vol. 158, no. 112107, p. 112107, Apr. 2022.
- [69] L. Topliceanu, P. G. Puiu, C. Drob, and V. V. Topliceanu, "Analysis regarding the implementation of the circular economy in Romania," *Sustainability*, vol. 15, no. 1, p. 333, Dec. 2022.
- [70] F. Chen, Z. Shirazi, and L. Wang, "Building scientific capacity in disaster risk reduction for sustainable development," *Cultures of Science*, vol. 4, no. 1, pp. 40–54, Mar. 2021.
- [71] S. Ivanova, A. Vesnina, N. Fotina, and A. Prosekov, "An overview of carbon footprint of coal mining to curtail greenhouse gas emissions," *Sustainability*, vol. 14, no. 22, p. 15135, Nov. 2022.
- [72] A. Andries, S. Morse, R. J. Murphy, J. Lynch, and E. R. Woolliams, "Using data from earth observation to support sustainable development indicators: An analysis of the literature and challenges for the future," *Sustainability*, vol. 14, no. 3, p. 1191, Jan. 2022.
- [73] J. Abellán and J. A. Alonso, "Promoting global access to water and sanitation: A supply and demand perspective," *Water Resour. Econ.*, vol. 38, no. 100194, p. 100194, Apr. 2022.
- [74] I. R. Orimoloye, J. A. Belle, A. O. Olusola, E. T. Busayo, and O. O. Ololade, "Spatial assessment of drought disasters, vulnerability, severity and water shortages: a potential drought disaster mitigation strategy," *Nat. Hazards (Dordr.)*, vol. 105, no. 3, pp. 2735–2754, Feb. 2021.
- [75] B. Fakhruddin, J. Kirsch-Wood, D. Niyogi, L. Guoqing, V. Murray, and N. Frolova, "Harnessing risk-informed data for disaster and climate resilience," *Prog. Disaster Sci.*, vol. 16, no. 100254, p. 100254, Dec. 2022.
- [76] S. Sarker *et al.*, "Integration of socio-ecological data to prioritize biodiversity hot-spots for Marine Protected Area (MPA) delineation in the coastal zone of Bangladesh," *Reg. Stud. Mar. Sci.*, vol. 77, no. 103622, p. 103622, Dec. 2024.
- [77] S. Abbas *et al.*, "Monitoring of large-scale forest restoration: Evidence of vegetation recovery and reversing chronic ecosystem degradation in the mountain region of Pakistan," *Ecol. Inform.*, vol. 77, no. 102277, p. 102277, Nov. 2023.
- [78] M. Karpouza, K. Chousianitis, G. D. Bathrellos, H. D. Skilodimou, G. Kaviris, and A. Antonarakou, "Hazard zonation mapping of earthquake-induced secondary effects

- using spatial multi-criteria analysis," *Nat. Hazards (Dordr.)*, vol. 109, no. 1, pp. 637–669, Oct. 2021.
- [79] J. Gower and V. Barale, "The rising concern for sea level rise: Altimeter record and Geo-engineering debate," *Remote Sens. (Basel)*, vol. 16, no. 2, p. 262, Jan. 2024.
- [80] E. Hanna *et al.*, "Short- and long-term variability of the Antarctic and Greenland ice sheets," *Nat. Rev. Earth Environ.*, vol. 5, no. 3, pp. 193–210, Feb. 2024.
- [81] S. Wang and L. Yang, "Mineral resource extraction and resource sustainability: Policy initiatives for agriculture, economy, energy, and the environment," *Resour. Policy*, vol. 89, no. 104657, p. 104657, Feb. 2024.
- [82] M. U. Simoni *et al.*, "Mass-balance-consistent geological stock accounting: A new approach toward sustainable management of mineral resources," *Environ. Sci. Technol.*, vol. 58, no. 2, pp. 971–990, Jan. 2024.
- [83] M. A. Wulder *et al.*, "Fifty years of Landsat science and impacts," *Remote Sens. Environ.*, vol. 280, no. 113195, p. 113195, Oct. 2022.
- [84] P. Kostkova *et al.*, "Data and digital solutions to support surveillance strategies in the context of the COVID-19 pandemic," *Front. Digit. Health*, vol. 3, p. 707902, Aug. 2021.
- [85] F. Ros *et al.*, "Addressing the Covid-19 pandemic and future public health challenges through global collaboration and a data-driven systems approach," *Learn. Health Syst.*, vol. 5, no. 1, p. e10253, Jan. 2021.
- [86] Y. Adegoke, J. Mbonigaba, and G. George, "Sustainable development goals (SDGs), public health expenditures, and maternal and child mortality in selected African countries: Forecasting modelling," *Int. J. Environ. Res. Public Health*, vol. 22, no. 4, Mar. 2025.
- [87] A. Kurjak, M. Stanojević, and J. Dudenhausen, "Why maternal mortality in the world remains tragedy in low-income countries and shame for high-income ones: will sustainable development goals (SDG) help?," *J. Perinat. Med.*, vol. 51, no. 2, pp. 170–181, Feb. 2023.
- [88] B. A. Munir, S. Hafeez, S. Rashid, R. Iqbal, and M. A. Javed, "Geospatial assessment of physical accessibility of healthcare and agent-based modeling for system efficacy," *GeoJournal*, vol. 85, no. 3, pp. 665–680, June 2020.
- [89] S. Soomro, J. G. M. Sahito, and F. Gilal, "The link between climate change and human health," in *CSR, Sustainability, Ethics & Governance*, Cham: Springer Nature Switzerland, 2025, pp. 183–208.
- [90] M. C. Fombad, "Knowledge management for climate change in South Africa: A proposed strategy," *IFLA J.*, vol. 50, no. 2, pp. 292–309, June 2024.
- [91] M. Durand and J. R. Suesser, "A fast-evolving landscape for Official Statistics: How to respond to the challenges?1," *Stat. J. IAOS*, vol. 38, no. 2, pp. 345–349, June 2022.
- [92] M. Bohman, "Making a difference through trusted, high-quality research and statistics," *Am. J. Agric. Econ.*, vol. 106, no. 2, pp. 485–495, Mar. 2024.
- [93] A. Sonnenfeld, J. Stevenson, and H. S. Waddington, "Does citizen engagement improve development outcomes? A realist-informed systematic review of participation and accountability mechanisms," *J. Dev. Effect.*, vol. 16, no. 1, pp. 27–60, Jan. 2024.