Sustainable Data Governance: A Systematic Review and a Conceptual Framework

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Abstract

We present a systematic literature review based on bibliometric analysis to clarify the role of data governance in sustainable development. We made a concept-centric review of 35 relevant papers (out of an initial set of 2214) selected from Scopus and Web of Science and classified them into (1) sector-specific, (2) causal relationships and approaches, (3) data accessibility for sustainable development, and (4) smart contexts. Our contribution includes a conceptual framework for sustainable data governance in product lifecycles. Pursuing data-driven sustainability requires actions in structure, processes, and relational mechanisms. Data attributes (e.g., privacy, immutability, permissions, fairness), scope of data to be covered, and supporting technology are increasingly important to reduce all forms of waste while ensuring a long-term strategy to generate sustainable value from data.

Keywords: Data Governance, Sustainability, Systematic Literature Review

1. Introduction

Data governance is the exercise of power and control over data management to maximize data value while minimizing costs and related risks [2]. It is a top priority for organizations worldwide to establish a cross-organizational data agenda, define mechanisms to capitalize on business opportunities, manage data-related risks, comply with regulations, deal with decentralized data scenarios, and improve data quality [2]. Recent data governance frameworks address the challenges of regulations (e.g., GDPR-General Data Protection Regulation), aiming at data consistency, trustworthiness, and decision-making accountability. Nevertheless, the long-term vision of data value is challenging.

Sustainable development "*meets the needs of the present without compromising the ability of future generations to meet their own needs*" [58]. Information systems are well aware of this societal priority, "*but inadequately understood weapon in the arsenal of organizations in their quest for environmental sustainability*" [34]. Moreover, strategies like circular manufacturing "necessitate to monitor and manage data and information concerning the "*product*," the "*processes*" and the "*management*," relying on the adoption of supporting "*technologies/tools*" to "*gather and use them*" [4]. Therefore, data governance can support sustainable development, having contributed to reduce the risks of health data breaches in health programs for vulnerable people [46], the establishment of data cooperatives to facilitate the access of the society to data [11], and the impact on sustainable agriculture [29]. All this leads to the conclusion that sustainability is inseparable from data governance. The research of [45] highlights the importance of deploying data governance mechanisms for sustainable development.

We propose two research objectives. First, to assess how data governance can

contribute to sustainability. Second, to create a framework with essential elements of sustainable data governance. Our research approach was a systematic literature review [35, 52] supported by bibliometric analysis. The result is a conceptual framework.

The remainder of this paper is structured as follows. Section 2 presents the background. Subsequently, we explain the research approach. In Section 4, we reveal the results of the bibliometric analysis, immediately followed by the analysis of 35 papers. We describe the creation of a framework for sustainable data governance in Section 6. The paper closes by stating conclusions, the main limitations of our research, and future work opportunities.

2. Background

2.1. Data Governance

Data is a strategic asset to compete, requiring new governance practices that "*specifies decision rights and accountabilities for an organization's decision-making about its data, (...) data governance formalizes data policies, standards, and procedures and monitors compliance*" [2]. Therefore, it is a priority in a market characterized by an exponential increase in the amount of data. According to IDC, it was expected that ten times more data would be produced in 2020, compared to 2013 [56]. Other difficulties include the need to deal with different sources that may cause inconsistencies [2], the impact of regulatory compliance (e.g., GDPR) [2], and the challenges involved in simultaneously minimizing data-related costs and risks and increasing data value for the organization [2].

Recent frameworks were proposed to assist companies in their data governance. First, the internal and external antecedents must be identified [44]. For the internal antecedents, it is necessary to understand the organizational culture [44], the Information Technology (IT) architecture [44], and the organizational strategy. The external antecedents include the market dynamics [36], the type of industry [36], and regulations [44].

The scope of data governance is equally important [2]. Two main categories can be considered in the data scope: traditional data and big data [2]. The former typically includes master data (e.g., finances, clients, employees), transactional data (e.g., orders, bills), or reference data (e.g., product codes) [37]. Big data is more complex, encompassing highly dynamic and substantial data sets [2]. The organizational scope is concerned with the expansiveness of data governance [2], in which intra-organizational scenarios aim for internal alignment of the organization's business objectives and data, and management of the data quality and integrity of the organization's operations [36]. Conversely, inter-organizational scenarios should exploit environmental opportunities and may need to deal with the loss of control over data [39]. Finally, governance includes the interrelated scope of the data domain that addresses quality, security, lifecycle, metadata, and storage and infrastructure [2]. For example, processes for quality management should be defined, a data quality strategy must be communicated to all stakeholders, and the roles and responsibilities (e.g., appointing a data architect, data manager) should be established [37].

The data governance mechanisms typically span three main types: (1) structural, (2) procedural, and (3) relational [2]. They "*comprise formal structures connecting business, IT, and data management functions, formal processes and procedures for decision-making and monitoring, and practices supporting the active participation of and collaboration*" [2]. The structural mechanisms establish the governance entities, accountability of actions, and reporting, focusing on setting responsibilities (e.g., data owners) [2, 9]. Procedural mechanisms ensure data accuracy, correctness, security, and efficiency [9]. These mechanisms also include the definition of (1) the data strategy, (2) policies, (3) standards, (4) processes, (5) procedures, (6) contractual agreements, (7) performance measurement, (8) compliance monitoring, and (9) issue management [2]. The third category (relational) defines the collaboration among the stakeholders, communication, training, and the coordination of decisions [2, 9].

2.2. Sustainability and Sustainable Development

According to the United Nations (UN)'s Agenda 21 [48] and the Brundtland Report [58], there are three essential pillars for sustainability: (1) economic, (2) social, and (3)

environmental. Economic sustainability is concerned with promoting consumption without jeopardizing future generations and needs [8]. Therefore, organizational growth must protect the limited natural resources, and address the risks of production [8, 58]. Activities such as the use of renewable energy sources and materials are crucial. Environmental sustainability aims to balance the harvesting of resources with their regeneration, and wastes with the environment's capacity to assimilate them [8]. Additionally, organizations are encouraged to establish measures for ecosystem integrity, protect biodiversity, and reduce carbon footprint [24]. Social sustainability supports the efforts of equity, empowerment, institutional stability, participation, and cultural identity [8]. It concerns empowering the preservation of the environment based on alleviating poverty and economic growth [8].

Data is crucial to adopting the Sustainable Development Goals (SDGs) defined by the UN. For example, metrics and indicators (e.g., urban sensors, traffic, gas emissions, geospatial data like satellite imagery) [25] are necessary to plan, monitor, and provide evidence of compliance to third-party institutions. However, security mechanisms must be implemented, and data must be trustable, making its integrity, sharing, and ownership top priorities [25]. The data sources relevant for SDGs are extensive, including satellites with remote sensing for resource management [40], forest [28], or land-use monitoring [28]. Data is essential for social, economic, and environmental sustainability [55].

3. Research Approach

Our systematic literature review followed a concept-centric analysis [52]. The search started in 02/2022 and evolved according to eight steps [35]: "*Purpose of the literature review*," "*Protocol and training*," "*Searching for the literature,*" "*Practical screen,*" "*Quality appraisal,*" "*Data extraction,*" "*Synthesis of studies,*" and "*Writing the review.*"

The first stage included a bibliometric analysis using the VOSviewer [18]. This tool enables the creation, visualization, and analysis of bibliometric data directly extracted from database archives, such as Scopus and Web of Science (WoS). We selected these two influential scientific databases as the primary source of documents for our bibliometric analysis. Initially, we used the keyword "*data governance*" in WoS and Scopus, resulting in a total of 2214 papers (902 - WoS, 1312 - Scopus). Our goal was to obtain an overview of the publications on data governance and understand how the topic was related to other concepts (e.g., sustainability, privacy, specific technologies). For Scopus, the search criteria included the article title, abstracts, and keywords, while for WoS, we selected all fields and restricted the search to its Core Collection database.

We also evaluated the links between data governance and sustainability in the bibliometric networks, using the keyword combination "*data governance*" AND "*sustainability*." We only obtained 85 hits (39 – Scopus, WoS - 46), which we analyzed to detect paper duplications. After this step, 59 research papers remained. We then analyzed the contents of the abstract (e.g., the type of study, the relevance of data governance, the impact on sustainability) and keywords of the remaining papers to verify their correspondence to the theme of data governance and sustainability, which reduced the number of papers of interest to 35 (identified with * in the References section).

The second stage focused on the study synthesis in the sample of 35 articles. Our reflection during the literature analysis provided the foundations for the proposed framework. The following section presents the bibliometric analysis.

4. Insights from the Bibliometric Analysis

4.1. The Networks of Data Governance

Fig. 1 reveals the most relevant topics in the 902 papers obtained for the sample in WoS.

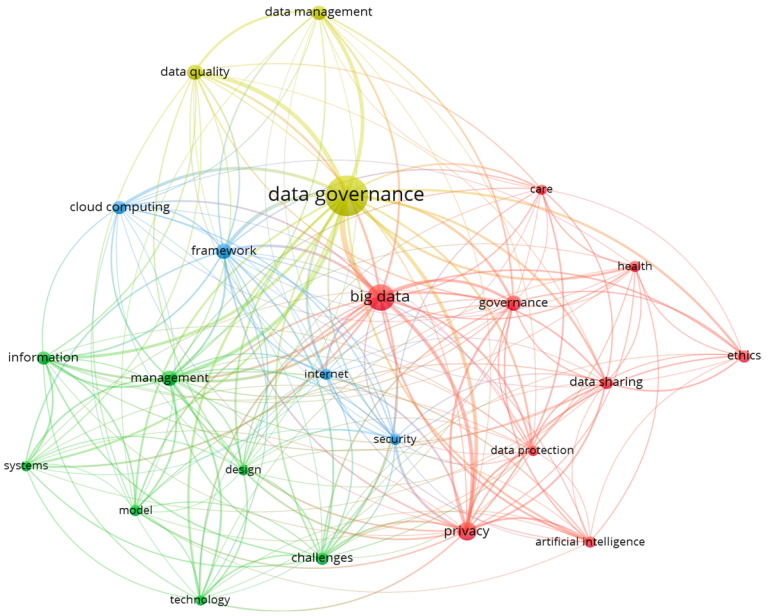

Fig. 1. Bibliometric analysis in WoS: data governance concepts (co-occurrence of all keywords, at least 20 occurrences).

We can identify four main clusters of papers in Fig. 1. The green cluster (on the left) focuses on management concepts, covering systems, information, models, and technologies. The blue (in the center) represents data governance in a cloud computing environment and the internet. Security topics and new frameworks reveal essential links, which is expected due to the amount of data available online and its potential value, as in the case of social networks. The green cluster details data quality and data management aspects. The increase in data sources also raises quality challenges. For example, to support decision-making supported by reliable data or provide consistent evidence in audits. Finally, the red cluster (on the right) includes big data (e.g., ethics, privacy), sector-specific data governance (e.g., healthcare), and regulatory issues. The role of artificial intelligence (AI) is also apparent in this cluster. Fig. 2 represents the Scopus's analysis.

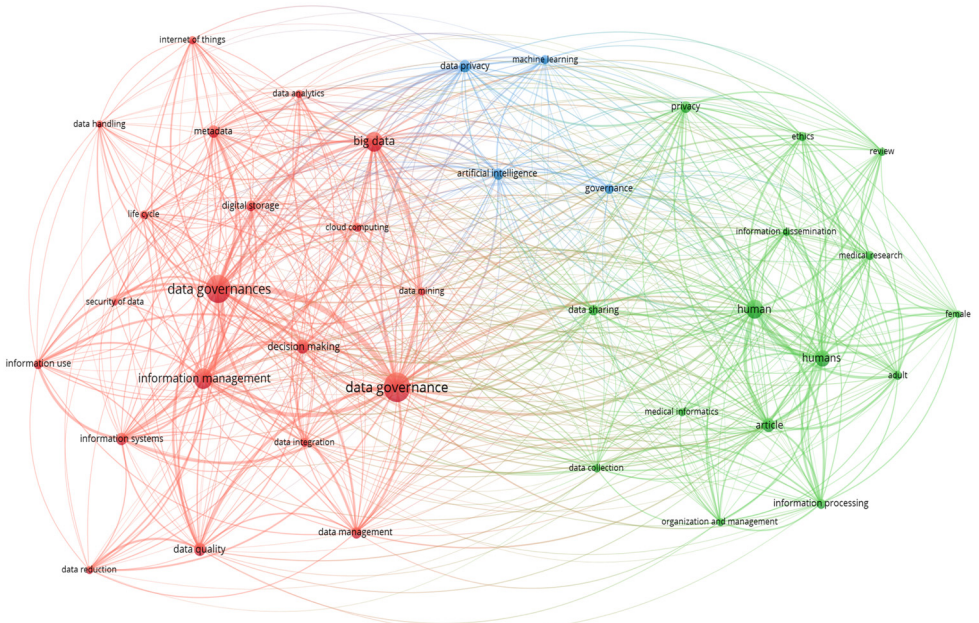

Fig. 2. Bibliometric analysis in Scopus: data governance concepts (at least 30 occurrences).

The bibliometric analysis presented in Fig. 2 includes a larger sample (n=1312) and more complex connections of related terms when compared to WoS. Fig. 2 exposes three

clusters. The red cluster integrates concepts such as data quality, data management, information management, security of data, life-cycle, and big data that are part of the data governance concepts identified by [2]. The blue cluster addresses aspects related to data privacy, AI, machine learning (ML), and governance. Finally, the green cluster points to research on data sharing, data collection, ethics, medical informatics, and people. Nevertheless, there are also touchpoints between the networks obtained for WoS and Scopus, such as the relation between ethics and health-related concepts, as well as a cluster that is concerned with data governance and management activities.

4.2. Disentangling Data Governance and Sustainability

The research presented in previous section revealed the interest of the scientific community in key issues of sustainability, such as ethics, health, data sharing, and information use. Therefore, we decided analyse the intersection of the topics of sustainability and data governance. Fig. 3 introduces the results of the bibliometric analysis of the synergies of data governance and sustainability on the WoS database (46 papers).

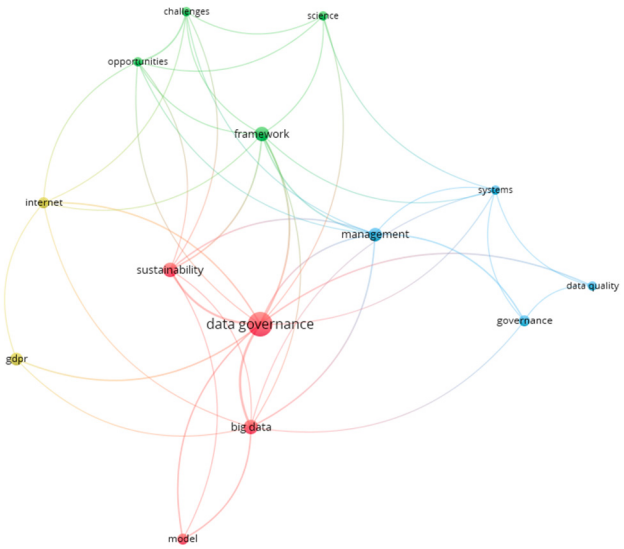

Fig. 3. Bibliometric analysis in WoS: data governance and sustainability concepts (co-occurrence of all keywords, at least three occurrences).

In the center of Fig. 3, the red cluster highlights the importance of big data and model development. The blue cluster covers management, systems, and data quality domains. On the left, the yellow cluster points to the Internet and GDPR. Lastly, the green cluster focuses on the opportunities and challenges in sustainable data governance.

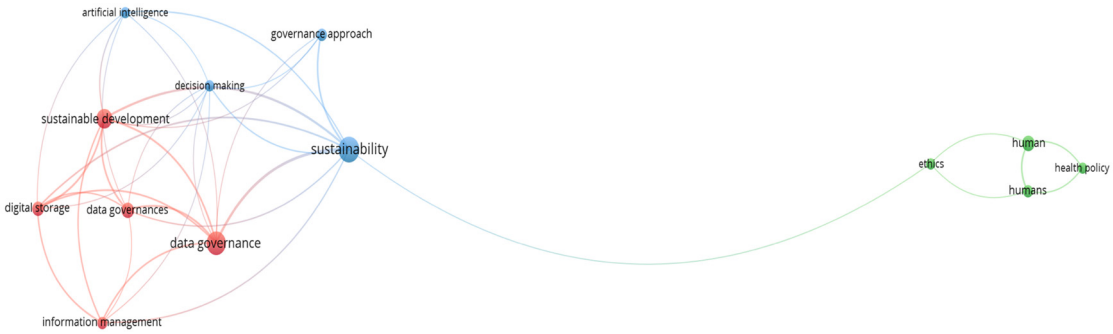

Fig. 4. Bibliometric analysis in Scopus: data governance and sustainability concepts (co-occurrence, at least three occurrences).

The bibliometric analysis of the results for Scopus defines three clusters. The red cluster (on the left) targets the topics close to governance and sustainability. We did not

find mentions of digital storage in the WoS database selection. At the center of Fig. 4, the blue cluster highlights the field of decision-making and AI. Finally, the green cluster (on the right of Fig. 4) highlights the aspects of ethics, humans, and health policy.

This initial analysis reveals that the relationship between data governance and sustainability is underdeveloped. In fact, many relevant topics found in the more ample networks for data governance are scarcely explored from a sustainability perspective. For example, the term "*data quality*" only appears in the WoS sample and only presents links with the data governance node. A similar effect is evident in the network of Fig. 3 for GDPR and Internet (links exclusively with data governance). Fig. 4 also shows a dispersion and social aspects (green cluster) linked with sustainability, missing data governance links. The selected studies does not yet reveal a long-term vision for data governance.

5. Review on Data Governance and Sustainability

This section makes sense of the literature (from WoS and Scopus) according to four leading concepts. The first integrates sector specific situations, such as agriculture (e.g., the use of data to improve productivity [29]) or transportation (e.g., optimizing transport planning [42]). The second concept targets contributions to SDGs (e.g., health records for social sustainability [15]). The third concept addresses the importance of data accessibility (e.g., open data for developing new products [16]) for sustainable development. Lastly, the fourth concept exploits data governance for smart contexts, such as smart cities (e.g., circular products based on data mechanisms [33]).

5.1. Sector Specific

We identified healthcare as a relevant sector in the bibliometric networks. The work of [46] proposes a framework for data governance that aims to reduce the risks of health data breaches in health programs in low- and middle-income countries. In [5], the authors present an overview of the importance of digital technologies in today's operations in health services and the vulnerabilities that cyberattacks reveal, such as inadequate data protection and security (e.g., exposure of clinical data and personal information). These issues will require new data policies, people training, and security measures. The research of [6] deals with rare disease information, which encompasses guidelines for data sharing, data access, data ownership, ethics, and data quality. The work of [47] presents the development of a tool to analyze and establish links about data on consumer food behavior that can help in providing estimates on the progress of society to fulfill the SDGs [57] (e.g., the adherence of the community to a sustainable diet, evaluate environmental footprint).

There are several contributions to the field of agriculture. The survey conducted by [29] reveals the need for data governance mechanisms to extract the maximum contribution of big data, AI, enabling increased agricultural productivity and improved decision-making and compliance. The study performed by [19] concluded that the participants value data sharing but are concerned with the need to establish a mechanism for formal agreements on data exchange, data sharing, integrity, and security. The work of [32] retrieves the opinion of several stakeholders involved in agriculture on sharing farm's biodiversity data, key requirements of tools to support sustainability assessment in agriculture, and their experience on the use of a developed prototype tool for sustainability assessment.

Transportation is another critical sector. The work of [42] proposes applying data governance to transportation data programs (e.g., improving planning efficiency) as well as defining and implementing transportation data business plans (e.g., promoting proactive measures), contributing to environmental sustainability. The research of [54] tries to understand some of the issues of the current smart transportation system, identifying "*poor*" data governance as one of the aspects to address to make these solutions more sustainable: dealing with decentralized data, coordinating multiple sources, and establishing industry standards. The work developed by [7] highlights the need to address sustainable data governance in the paradigm of connected and automated vehicles, considering aspects such as data regulation (e.g., GDPR) and data sharing, among others.

Data governance is essential for sectors, such as agriculture and transportation, under pressure because of their impacts on people and the environment. As seen before, data can be an essential asset for organizations to promote environmentally and socially sustainable agriculture (e.g., increase productivity, early disease detection, monitor land use), health (e.g., reduce health data breaches), and transportation (e.g., reduced emissions).

5.2. The Causal Relationship and Approaches

Some authors established a causal relationship between data governance and sustainable outcomes. The research of [30] introduces the development of a balanced scorecard to address green storage policies that integrate environmental performance in organizational strategy and identify critical issues (e.g., contributor, success factors) for sustainable data governance. The survey conducted by [3] highlights the importance of data governance to build sustainable knowledge, which is of great importance for organizations to promote transparency, innovation, and market and financial performance, contributing to economic and social sustainability. Additionally, the authors propose a set of guidelines for corporate officers to deploy measures that contribute to sustainable knowledge. The survey data from [1] reveals that the quality of financial and accounting information reporting influences firms' decision-making effectiveness. Finally, [31] introduces a combined framework on data governance and sustainability literature models to improve corporate accountability considering their technological shifts and incorporate a sustainability evaluation process. Universities are also responsible for the development of sustainable solutions [17]. For example, implementing a "*Living Lab*" to support the collaboration between several stakeholders in solving sustainable development problems.

Sustainable data governance practices are essential. The work of [15] contributes to these practices in dealing with electronic health records (EHR) by introducing a structured 10-step governance. The approach encompasses elements such as identifying or prioritizing crucial clinical topics, creating and validating draft reference models, calculating gap analyses of EHR, and revising the reference model. The research of [10] suggests measures to be considered by organizations while defining their data governance that can contribute to sustainability, including aspects such as the constant monitoring of data quality defined requirements. Data ownership and sharing in global genetic data repositories require governance mechanisms [49]. For example, to ensure equity in accessing genetic information, the operations' efficiency, and the data's sustainability. These authors improved their findings in [41] for global genetic data repositories governance for sustainability, efficiency, and equity. The work presented by [22] introduces a data governance framework for oil and gas, intending to promote corporate sustainability, regulatory compliance, and new technology implementation.

The implementation of sustainable data governance relies on the definition of a set of mechanisms and frameworks that can support the implementation and monitoring of sustainability practices in organizations, including the definition of sustainability KPIs, the prioritization of organizational goals, and continuous monitoring of data quality.

5.3. Data Accessibility for Sustainable Development

Data accessibility (e.g., by citizens, companies, and non-governmental organizations) supports our society's sustainable development. However, exploiting open data requires solving some challenges. The research of [11] highlights the importance of establishing data cooperatives contributing to social and economic sustainability by creating new job opportunities for the unemployed throughout the pandemic and fighting social inequalities. To achieve this, [11] suggests that organizations will need to change data governance practices that limit the use of data. The research presented in [16] reinforces these arguments stressing the importance of the availability of open data for society, namely due to the possibility of developing new businesses, products, and services. However, "*data ownership*" and regulations may create challenges to open data [11, 16].

More recently, [13] proposes a sustainable development smart cooperative framework

that covers the aspects of a smart economy, smart members, and smart governance. It aims to improve the transformation of the cooperative member's services, management, and governance, contributing to overall sustainable development. The equal access of the community to data is part of sustainable global data governance [43]. Some issues with open data and accessibility are related to audits that depend on data governance, and disclosure practices are only reliable if proper data governance mechanisms exist.

5.4. Smart Contexts

Smart and sustainable cities are only possible with smart data governance. The case study presented by [33] on the creation and deployment of a circular materials bank revealed that data governance would need to be reshaped and deployed to address data monitoring (e.g., intellectual property, commercial value), data availability, and data integrity, contributing to the environmental and economic sustainability of the circular economy.

On the other hand, [26] proposes implementing a framework for the smart city's society, which has data governance (through open data promotion, interoperability, and management) as one of the pillars. It addresses the UN's Development Sustainable Goals, such as health promotion (e.g., smart hospitals, intelligent wearables) and society equality (e.g., an ecosystem of innovation and entrepreneurship through data). The work of [12] proposes the implementation of data ecosystems (implying the deployment of data governance mechanisms) to contribute to social sustainability by protecting the citizens' digital rights in Europe. In [42], the authors propose the FSSDG framework, which aims to capitalize on data governance opportunities, to address the difficulties in balancing technological development, urban planning, and social inclusion.

Data governance mechanisms can address problems related to waterlogging through simulation based on retrieved data, which can help improve the efficiency of operations, maintenance, and emergency management [14]. According to [27], data governance mechanisms are essential to fully exploit technologies such as artificial intelligence (AI) and machine learning (ML) that require the constant use of data to build and train new models. The research of [51] is an example of this, identifying aspects that policymakers and managers must consider to exploit technologies such as AI for sustainable development (e.g., improve the efficiency of operations and resources, predict and prevent cyber-attacks). New frameworks must incorporate ethics in a digital world, as presented by [50] (e.g., using data in AI and ML), including regulations, ethics, and the environment.

The research of [53] proposes a hybrid analytic network process to evaluate government data sustainability, aiming to increase public sector efficiency. The social-ecological data governance of smart cities is the topic selected by [21], highlighting the importance of data governance in evaluating the ideal types of data regulation.

6. A Conceptual Framework for Sustainable Data Governance

The works of [33] and [14] revealed that data governance mechanisms for data monitoring, availability, security, and privacy could contribute to economic and social sustainability. New technologies (e.g., AI) require data governance mechanisms [27] and are essential to developing new sustainable solutions [51]. Data accessibility is also vital for sustainable development, as the example of data cooperatives to exploit new business possibilities and sustainable solutions [11]. On the one hand, data governance guarantees personnel data privacy (e.g., health records case [15]). On the other hand, data governance can be used to promote transparency of entities (e.g., corporate accountability [31]). Data governance mechanisms have also been found to contribute to overall sustainability in sectors relevant to sustainability (e.g., transport [42] or agriculture [29]). The insights gathered from the bibliometric networks, and the concept-centric review provided the foundations for our proposed framework: integrate data governance mechanisms and sustainability goals within product lifecycles (Fig. 5).

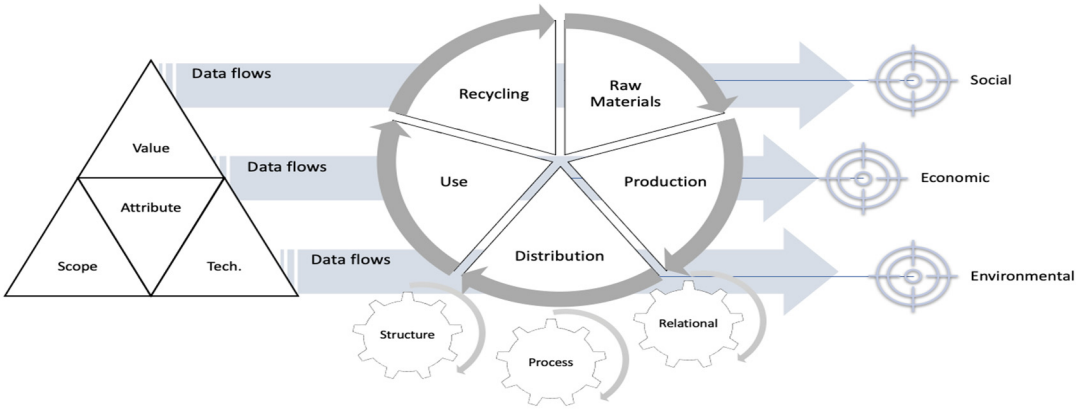

Fig. 5. Data governance compass for sustainability.

According to Fig. 5, data governance must address all product lifecycle stages. Data is a primary input obtained from multiple sources that must be identified and controlled (e.g., internal processes, client feedback), constantly transformed, and augmented during production, use, and end-of-life stages. Similar to the product lifecycle, the data lifecycle of collecting, processing, storing, exploring, and reusing requires formal procedures.

Structural mechanisms include defining roles (e.g., a C-level officer) and responsibilities for data governance activities. Procedural mechanisms integrate sustainability concerns in data strategies [10], requiring a data policy, performance indicators [22], and an explanation of how the organization deals with open data (e.g., accountability, sharing) [16]. Relational mechanisms focus on aspects such as literacy. A long-term vision for data needs to clarify retention and access procedures, a strategy to collect and manage increasing volumes of operational data (e.g., sensor data), and a plan to extract value. For example, creating (or outsourcing) a data science team to support decisions based on evidence (e.g., predictive maintenance to reduce wastes).

Managing the technology portfolio (on the left of Fig. 5) is part of the data value creation process (e.g., blockchain, when required). The most relevant attributes are data accountability, security, integrity, lifecycle, and quality, which organizations will define according to their industry sector, objectives, and specific constraints [2]. They should also consider the scope of data that will be used, including not only the traditional data (e.g., master data, transaction data) and big data (e.g., bibliometric data, sensor data) [2], but also the integration of open data in the organization [11, 16]. Some organizations may also benefit from establishing data cooperatives [11, 13, 16], requiring inter-organizational data governance, with more demanding data exchange procedures, privacy, and accountability.

The social pillar needs data to increase the safety of the community, training actions, and ethical awareness on how to make the best use of data, protect privacy and ensure unbiased data for fair AI [20]. Moreover, data accessibility (e.g., in the recycling stage) is important to promote the development of more employments and new solutions for social equality. The environmental pillar is built in compliance with regulations, using data to minimize resource waste and support auditability. Finally, the economic pillar uses data as a strategic asset, exploiting new business opportunities (e.g., data market). Governance aims to minimize waste within the product lifecycle, using data to support the decisions, prove organization's sustainability efforts, and generate new value for the community.

7. Conclusions

This paper presents a systematic literature review [35, 52] supported by bibliometric analysis on data governance and sustainability. Departing from that work, it proposes a conceptual framework for sustainable data governance.

However, we must discuss some limitations. First, our research included two prominent bibliographic databases, but other options can be explored, including scientific and grey literature. Second, our review considered the analysis of a small number of research papers in detail. Third, our proposed framework is conceptual at this stage, and although supported

by important references, it was not deployed nor tested in a natural environment.

These limitations offer a starting point for future work opportunities, such as expanding the literature review and using the framework to create and audit a data governance policy. Moreover, the proposed framework can be used to create future surveys on this topic, guiding researchers in formulating questions that capture sustainable data governance in more detail. We also hope that our research in sustainable data governance may assist future regulations in to ensure data quality and openness that contribute to UN sustainable goals. Data governance needs to be audited in more intelligent social environments (e.g., smart cities), and our framework could be improved and tested for that purpose.

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