Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 220 (2023) 32–39

Procedia Computer Science

www.elsevier.com/locate/procedia

The 14th International Conference on Ambient Systems, Networks and Technologies (ANT)
March 15-17, 2023, Leuven, Belgium

A Big Data Analytics-Based Methodology For Social Sustainability Impacts Evaluation: A Case Study

Lahcen Tamym[a,c,*], Lyes Benyoucef[a], Ahmed Nait Sidi Moh[b], Moulay Driss El Ouadghiri[c]

[a] *Aix-Marseille University, University of Toulon, CNRS, LIS, Marseille, France*
[b] *Jean Monnet University, Saint Etienne, LASPI, IUT of Roanne, France*
[c] *Moulay Ismail University, IA Laboratory, Meknes, Morocco*

Abstract

Nowadays, Big Data (BD) technology is considered by institutions, enterprises and governments a primary key to addressing sustainability challenges. The business ecosystem is becoming more and more complicated, due to large and strong interactions between the directly involved stakeholders such as suppliers, manufacturers, distributors and customers on one hand, and the indirect stakeholders such as the environment and society on the other hand. Thus, moving toward corporate sustainability requires an accurate understanding of these business partners' impacts on each other. Indeed, enterprises must incorporate the three sustainability dimensions to assess a product, a service, or process performance on environmental, economic, and social aspects. To this end, this paper presents a big data analytics (BDA) based methodology to analyze the social sustainability impacts of enterprises. Besides, a real-life case study from the database proposed by the impact-weighted account project (IWAP) team at Harvard business school, is used to validate the methodology. The obtained results show the added value of using BDA technology to achieve enterprises' social Sustainable Development Goals (SDGs) agenda launched by the United Nations.

© 2023 The Authors. Published by Elsevier B.V.
This is an open access article under the CC BY-NC-ND license (https://creativecommons.org/licenses/by-nc-nd/4.0)
Peer-review under responsibility of the scientific committee of the Conference Program Chairs

Keywords: Big Data Analytics, Social Sustainability; Sustainable Enterprises; Social Impacts; Sustainable Development Goals.

1. Introduction

In the current business, big data (BD) technology has been considered a primary key to dealing with sustainability challenges [1]. The business ecosystem is becoming more and more complicated, due to large interactions between the involved stakeholders such as suppliers, manufacturers, distributors, and customers. As well as the external stakeholders from the environment and society issues. Thus, moving toward corporate sustainability requires an accurate understanding of these business partners' impacts on each other. Indeed, enterprises must incorporate the three sus-

* Corresponding author. Tel.: +33-605-676-973.
E-mail address: lahcen.tamym@lis-lab.fr

1877-0509 © 2023 The Authors. Published by Elsevier B.V.
This is an open access article under the CC BY-NC-ND license (https://creativecommons.org/licenses/by-nc-nd/4.0)
Peer-review under responsibility of the scientific committee of the Conference Program Chairs
10.1016/j.procs.2023.03.007

tainability dimensions to assess a product, service, or process performance on environmental, economic, and social aspects [2]. Furthermore, enterprises must undertake social responsibility (SR) as part of their business activities [3]. SR means benefiting society, not just maximizing shareholders' value. In addition, the enterprises' investments must contribute to the benefit of both environment and society.

Consequently, social issues are universal and related to environmental and economic issues. For instance, high climate exposure will affect natural resources and result in risks associated with climate change, which will significantly increase crime and conflict, as well as fluctuating socioeconomic conditions [4]. In addition, it will also aggravate health problems, especially for those already vulnerable, which will put additional stress and disruption on healthcare due to increased demands. Thus, enterprises must take actions to reduce emissions related to their daily activities.

In today's dynamically changing business environment, enterprises are aware of the relationship between environmental, social, and economic issues and their roles in business strategy. Thus, solving these conflicted issues requires new types of business intelligence. Hence, in order to generate valuable business information, the ability to extract data from reliable sources is nowadays the most considerable factor in gaining a competitive advantage [5]. Furthermore, big data analytics (BDA) technology enables enterprises to provide quality data in the right format by using sophisticated business analytics tools, to offer intriguing solutions that can guide enterprises' sustainability performance and their sustainable supply chains (SC). For instance, it enables tracking which enterprises might be linked to local pollution, human rights abuses, or child labor, to name a few. In addition, it can be used to predict and prevent risks, and develop innovative skills [6]. Moreover, in terms of social issues, BDA plays a vital role in transparency and social development [7]. This can be done only if the best actions are taken by stakeholders including enterprise managers and decision-makers, academic researchers, or policy-makers.

Nevertheless, investigating the benefits of BDA technology in achieving corporate sustainability or sustainability analysis (SA) is still in its early stage. The United Nations developed the called 'sustainable development goals (SDGs)' agenda in 2015, which aims to bring all society stakeholders together to address social, environmental, and economic issues [8]. Moreover, there is little understanding of how effectively and efficiently leverage BDA technology to address social sustainability issues. In addition, enterprises still don't use the new BD ecosystem in ways that benefit people, with a particular focus on society's most vulnerable citizens.

Hence, examining the potential of leveraging BDA technology in analyzing sustainable enterprises' impacts on society, we conduct our research work on corporate environmental impact (CEI), which is a database proposed by the impact-weighted account project (IWAP) team at Harvard business school [9]. The team of this project developed a methodology to calculate monetized measures of environmental impacts from operations of different types of enterprises. Performing these calculations, several established academic database resources have been used (i.e., Bloomberg and Thomson Reuters (ASSET4), Exiobase, Environmental Priority Strategies (EPS), AWARE Model, Waterfund's Global Water Price, Accounting, and Stock Market Data). These measurements are the impacts on "safeguard subjects" which are the critical resources for human health and well-being [10]. The resources concerned by their calculation methodology are human health (working capacity (WC)), crop production capacity (CropPC), meat production capacity (MeatPC), fish production capacity (FishPC), wood production capacity (WoodPC), drinking water and irrigation water (water production capacity (WaterPCDI)), abiotic resources, and biodiversity. Moreover, measurements of the emissions' impacts in terms of United Nations SDGs by mapping each emission's characterization pathways to 17 relevant SDG targets were calculated in this database.

To this end, this paper presents a BDA-based methodology to analyze the social sustainability impacts of enterprises. The rest of the paper is organized as follows: Section 2 reviews some BDA applications on sustainable enterprises' impacts on society. The proposed BDA-based methodology to analyze social issues, as well as, the case study definition, are presented in Section 3. Section 4 discusses the obtained numerical results. Finally, Section 5 concludes the paper with some challenges and future work outlines.

2. Literature Review

A large number of existing studies in the broader literature have examined the sustainability issues of enterprises and their supply chains (SCs). Most of these studies covered how BD technology contributes to enabling enterprises to achieve sustainable development and gain competitive advantages in hotly competitive and dynamic markets. This section reviews the recent contributions of BDA to making enterprises socially sustainable and responsible.

2.1. Big Data and Big Data Analytics

There exist several definitions of BD in the literature. For instance, *BD is large amounts of unstructured and semi-structured data that businesses may create or data that would take too much time, effort, and money to put into a relational database for analysis* [11]. Furthermore, BD has been characterized by five 'Vs' that distinguish it from traditional data. 1) Volume means the significant and exponential increase of BD quantities. 2) Velocity refers to the speed of collecting, processing, and analyzing data in real, or near real-time. 3) Variety means that the data collected in BD contexts could be in structured, semi-structured, or unstructured formats. 4) Veracity refers to the trustworthiness of data sources. 5) Value is the most important characteristic because regardless of BD volume usually it's not useful to be valuable. Thus it's required to convert them into insights to add value to the decision-making process [12].

BDA technology has long been regarded as the primary instrument for processing and analyzing large volumes of data to derive useful insights and assure the reliability of BD sources. Moreover, BDA has been considered the "fourth paradigm of science," a "new paradigm of knowledge assets," or "the next frontier for innovation, competitiveness, and production." Enterprises are now conscious that employing BDA tools to grasp and understand their BD would help them stay competitive in the global market. *BDA is an emerging technology that enables enterprises with the management, processing, and analysis of the BD five Vs* [13, 11]. It will also allow them to better adapt to the present fast-paced and constantly changing market environment. Moreover, it will also enable them to generate relevant ideas for creating long-term value, monitor performance, and develop competitive advantages [14]. BDA applications provide several benefits in SC management, including lower operating costs, more SC agility, and higher customer satisfaction [15]. Last but not least, BDA improves data-driven decision-making and develops new methods to boost corporate efficiency and effectiveness. BDA's goal is to shake up traditional analysis by enabling agility in understanding and addressing issues by processing heterogeneous data simultaneously and in real-time processing and analytics. Finally, machine learning and deep learning technologies, for example, may be used to this end [1]. It's worth mentioning that business intelligence (BI) techniques, such as data visualization and sophisticated analytical approaches like data mining (DM), may be used.

2.2. Big Data Analytics and Sustainable Development

Literature review shows that sustainability and BDA are two buzzwords in the recent business analytics domain. Indeed, several recent studies have been performed to promote the sustainability of enterprises and their SCs [16]. Enterprises are aware of using BDA technology to streamline their operations and manage their SCs thanks to its ability to derive insights from raw data. This will enable them to create green goods or provide sustainable services. Moreover, according to [17], BDA techniques greatly advance economic, environmental, social and ethical, legal, and political benefits. SA is the realization of corporate sustainability and the integration of SR into the business using BDA [3, 18]. As a result, enterprises currently can use the most sophisticated BDA tools and techniques to collect and perform real-time (or near real-time) analysis on massive data that are related to determining sustainability factors, such as energy and resource use, greenhouse gas emissions, and logistics performances, to name a few. Then, they generate the necessary insights to guide their sustainability-related initiatives and improve overall resource efficiency. This scenario analysis will enable them to maintain the linkages between the three pillars of sustainability which are economic, social, and environmental elements. Accordingly, maintaining the intersections between these three elements will influence their future sustainable development strategy and performance, positively. In addition, given the possibilities and opportunities which BD brings to society and business, the United Nations launched in 2017 the BDA for sustainability plan to help achieve the 17 SDGs [19, 8].

2.3. Big Data Analytics Applications for Social Impacts

Environmental sustainability conserves natural resources and protects global ecosystems including health, well-being, and environmentally friendly. Indeed, in addition to environmental concerns, several studies suggest that enterprises must be aware of the interest in considering social sustainability, or SR, due to their huge influence on the whole of society. To this end, in the current business, sustainable enterprises contribute to promoting the living standards of societies, improving working conditions, reducing waste, and using resources effectively. Obviously, many cultures have social difficulties, such as gender equality, child labor, starvation, and working conditions, to name a few [20]. In this regard, there exist some social enterprises in rural regions which started to integrate social sustainability into their sustainable business models [21]. This enables them to expand their value generation to cover the environment and society members, calculate their business impacts, and meet the ”base of the pyramid” and low-income groups, which are often excluded from particular forms of consumption due to price barriers or the nonexistence of markets for these groups [22]. In doing so, these enterprises offer social services, provide common goods, deliver programs to educate people, and offer job opportunities.

Therefore, considered as the most powerful tool in current business analytics, BDA has received great attention lately thanks to its ability to give purpose to data and extract valuable information. Additionally, this will help sustainable enterprise managers to drive the best decision-making and increase their performances by influencing individuals, businesses, and governments that are different members of society [23]. To this end, a large number of existing studies in the broader literature have examined the role of BDA in promoting social sustainability. For instance, [24] argued that sentiment analysis generates information on corporate SR or human rights in the SC networks and logistics fields. Besides, a recent study [25] concluded that healthcare BD analysis allows the best predictions on the future health conditions that enterprises can benefit from to improve their employees’ health conditions. Furthermore, extensive literature has discussed how climate change risks impact social sustainability and the role of BDA in addressing these risks. Thus, [26] showed that climate change is the most pressing concern in food SC safety, such as changes in arable land, crop yields and soil quality changes, livestock production, growth of mycotoxins, residues of pesticides, and pathogens. In addition, the study demonstrated how BDA and web-based decision support systems contribute to improving food safety and securing food SC from farm to consumer. Indeed, enterprises in this regard have to take into consideration sustainable consumption and production concepts [27]. This can be done using BDA to meet the basic needs of social entities, minimize the use of natural resources, toxic materials, and emissions and wastes, improve life quality and ensure economic growth.

From the above literature review, we can conclude that sustainability and BDA are two keywords that we hear all the time. In fact, many methodological innovations were proposed, nevertheless, a few of them have considered the intersections between the three sustainability dimensions. Moreover, addressing sustainability challenges with the efficient use of BDA technologies is seen as a promising topic with several real-life applications, such as engineering, design, manufacturing, and commerce and consumption.

3. Big Data Analytics-Based Methodology

In this section, a BDA-based methodology is presented in order to drive enterprises’ social sustainability using a real database. These enterprises are operating in different sectors to achieve sustainable development. In this regard, a depth analysis is performed to show how the impacts that different enterprises exercise on the economy and environment will affect society.

3.1. Case Study: Corporate Environmental Impact

CEI is a dataset created by the IWAP team at Harvard business school [9]. The team of this project developed a methodology to calculate monetized measures of environmental impacts from operations of different types of enterprises. Performing these calculations, several established academic database resources have been used (i.e., Bloomberg and Thomson Reuters (ASSET4), Exiobase, Environmental Priority Strategies (EPS), AWARE Model, Waterfund’s Global Water Price, Accounting, and Stock Market Data). These measurements are the impacts on ”safeguard subjects”, which are the most critical resources for human health and well-being [10]. The resources concerned by the calculation are human health (i.e., working capacity), CropPC, MeatPC, FishPC, WoodPC, WaterPCDI, abiotic resources, and biodiversity. Moreover, they used characterization pathways, safeguard subjects, and monetary conversion factors from the EPS database [28] to measure the emissions’ impacts in terms of United Nations SDGs, by mapping each emission’s characterization pathways to 17 relevant SDG targets.

Therefore, the measurements concerned by the IWAP show the performances of their methodology. Indeed, they illustrate how various environmental impacts can be calculated and integrated into the decision-making process, management of risks, returns, and impacts, and more efficient and sustainable resource allocation. In doing so, they are able to calculate the total environmental cost impact for over 2500 organizations with data going back to 2010, broken out by the safeguard subjects. Besides, comparing organizations of different sizes, which would reasonably be expected to have different absolute environmental impacts, the total organizational environmental impacts as a percentage of sales and operating income defined as environmental intensity are calculated. This allows them to estimate environmental damage per sales unit or operating income. Within their methodology, they considered the default discount rate of 0%

Table 1. Sample Statistics

Summary	TEC	WC	FishPC	CropPC	MeatPC	WaterPCDI
Count	4136	4136	4136	4136	4136	4136
Mean	-1.4982091721253982E9	-1.003855213736829E9	-310086.93672090216	-1.245727332024189E7	-2789551.3537682267	-4.654193526752256E8
Stddev	6.000031193808253E9	2.8991938047007713E9	824189.7063848815	3.450446119883396E7	7761911.215669795	4.810333329461172E9
Min	-1.36228944661009E11	-3.30592624219893E10	-7958361.29063824	-3.48480714585937E8	-7.78934932986797E7	-1.30597121892545E11
Max	1.57277465251449E10	3.86720080034559E9	155444.919188825	1.08174513802071E8	2.32701455270569E7	2.11511873032397E10

SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG8
4136	4136	4136	4136	4136	4136	4136
-4.015290996439707E8	-2.659472157266567E8	-2.6562817032300606E8	-3114306.6953909346	-3114365.0299417847	-4.332214437519523E7	-5014844.605026698
1.1155910922003942E9	7.024183833706778E8	7.01636079155351E8	8626086.788805913	8626193.61239161	1.140725920022496E8	6.118088521736656E7
-1.11702004162576E10	-6.85387387240512E9	-6.84788779515546E9	-8.71201786464842E7	-8.71201786464842E7	-1.12053698691694E9	-1.37263909821984E9
3.26504894592947E9	2.87052319292295E8	2.8697818801901E8	2.70439238308939E7	2.70396385538954E7	4.5485275113638E7	0.0

Table 2. SDGs definitions forms [9]

SDG	Definition
SDG1	By 2030, *builds the resilience* of the poor and those in vulnerable situations and *reduces their exposure and vulnerability* to climate-related extreme events and other economic, social, and environmental shocks and disasters.
SDG2	By 2030, *ends hunger and ensures access by all people*, particularly the poor and people in vulnerable situations, including infants, to safe, nutritious, and sufficient food all year round.
SDG3	By 2030, *ends all forms of malnutrition*, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under five years of age, and *addresses the nutritional needs* of adolescent girls, pregnant and lactating women, and older persons.
SDG4	By 2030, *doubles the agricultural productivity and incomes of small-scale food producers*, in particular women, indigenous peoples, family farmers, pastoralists, and fishers, including through secure and equal access to land, other productive resources, and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.
SDG5	By 2030, *ensures sustainable food production systems and implements resilient agricultural practices* that increase productivity and production, help maintain ecosystems, strengthen capacity for adaptation to climate change, extreme weather, drought, flooding, and other disasters, and progressively improve land and soil quality.
SDG6	By 2030, *ends the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable diseases.*
SDG8	By 2030, *substantially reduces the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination.*

given the consideration for inter-generational equity, but also they conducted a sensitivity analysis of this assumption by using a 3% discount rate.

3.2. Sample Selection

By using the IWAP database, we conduct our research work on the social impacts that enterprises from different activity sectors have on society. To this end, a sample of 714 enterprises from 10 activity sectors located in 59 countries around the world is selected. This selection is performed using the total environmental cost (TEC) of each activity sector. Besides, the correlations between variables within the database have been studied in order to select the variables that have high correlations between them. The statistics on each variable are shown in table 1, where: 'count' is the number of observations, 'Mean' is the arithmetic average of each variable, 'Stddev' is the standard deviation to measure spread, and variation of values in each variable, and '(Min, Max)' are the minimum and maximum values respectively of each variable. Hence, a high and significant relationship is found indicating that the impact on FishPC, CropPC, MeatPC, and WaterPCDI which are critical resources for human-being are highly related to social SDGs defined in the table 2.

3.3. Big Data Analytics-based Methodology

In this study, Apache Spark (AS) methodology is used due to its advanced execution engine that supports acyclic data flow and in-memory computing. As well as, it uses Resilient Data Dataset (RDD) as a fundamentally different data structure abstraction for distributed collection of data objects that may be operated on different nodes of the cluster in a parallel manner. This gives AS a better computational efficiency than Hadoop MapReduce operations [29]. AS supports interactivity with Scala, Python, and R shells programming languages. Furthermore, AS enables the use of MLlib, which is a powerful tool for building machine-learning applications. The framework shown in figure 1 illustrates the use of AS ecosystem within the developed BDA-based methodology.

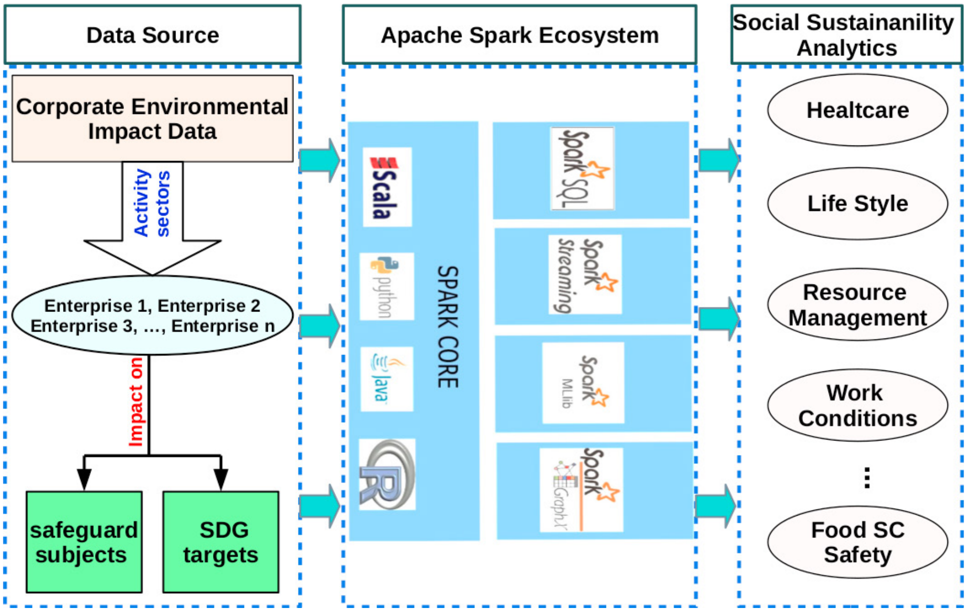

Fig. 1. Apache spark methodology for social sustainability analytics

4. Results and Discussions

The above short review demonstrates that environmental impact is highly related to social impact. Thus, from their daily operations and activities, enterprises are exercising huge impacts on the environment. These enterprises belong to different activity sectors and have different sizes. Within the chosen sample of this study, the total values of TEC that each sector has on the environment are calculated. In our case, the TEC of each sector is the total monetized environmental impact from its operations during a specific year (from 2010 to 2019), as shown in figure 2. The figure shows that the production of electricity and petroleum refinery sectors have the most damage to the environment in terms of environmental impact monetization. This will lead the two activity sectors to have a highly significant impact on society. For instance, the results of the performed analysis highlight that increasing environmental damage intensifies the loss of WC for vulnerable occupations and affects individual labor decisions.

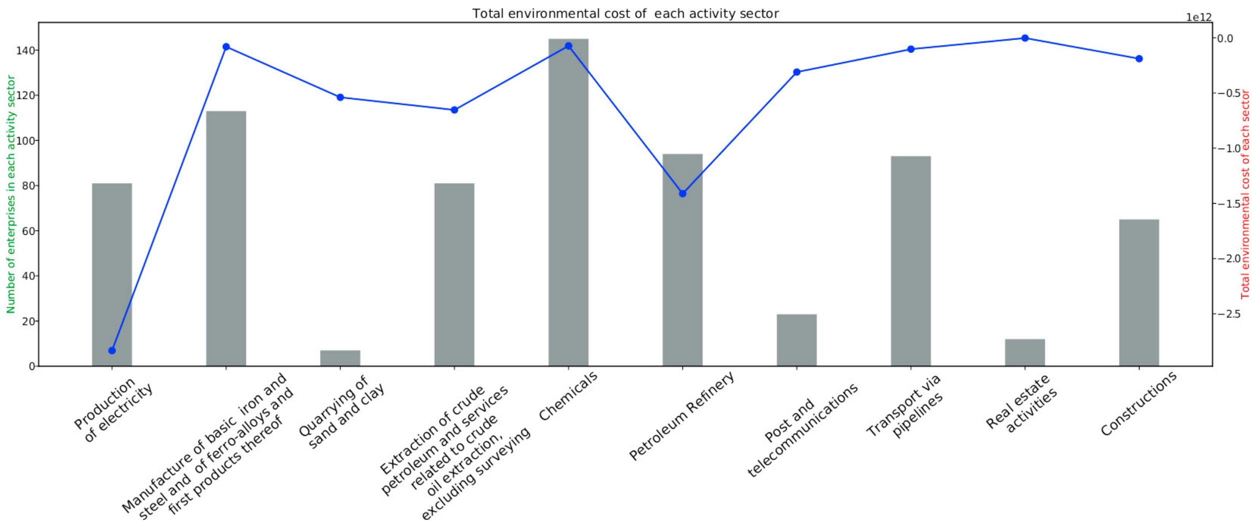

Fig. 2. TEC of each sector

Table 3. Multiple regression linear model measures on the predicted social SDGs

	R^2	MSE	maxIter
SDG1	0.99996	$2.39039e+06$	20
SDG2	0.991115	$6.22115e+07$	20
SDG3	0.995059	$4.92021e+07$	20
SDG4	0.988784	831817	20
SDG5	0.993932	605538	20
SDG6	0.993698	$1.01905e+07$	20
SDG8	0.999966	462468	20

Therefore, our study shows how these enterprises are thinking to be transparent in terms of social impacts, as well as, how they plan to achieve the social SDGs agenda by 2030. According to the IWAP team, there are some enterprises that are working collaboratively to achieve SDGs. In addition, enterprises are aware of the importance of collaboration. Thus, they share creativity, information, actions, resources, risks, duties, and rewards to address urgent societal challenges [13], even if they belong to different sectors or have different identities. In our case, a prediction model is built based on TEC and the safeguard subjects in the selected sample to predict the monetization impacts of the chosen social SDGs. In doing so, multiple regression linear model since the variables in the selected sample are linearly correlated. Hence, in each case, we consider the target (independent variable (Y)) to be predicted as one of the SDGs and the features as TEC and the safeguard subjects (dependent variables). Accordingly, to evaluate the model performances, two metrics are used:

- Mean Squared Error (MSE): it minimizes the loss function between the target value y_i and the predicted value $\hat{y}_i$ given by:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y})^2$$

- R^2: it measures the validity of the regression model given by:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

where $\hat{y}_i$ is the estimated value of the independent value for the ith observation by the regression model, and $\bar{y}$ is the mean of all observations of the independent variable.

After evaluating the model on each selected SDGs, table 3 shows the obtained performances. The model gives the best results in terms of prediction accuracy on validation data for all the selected social SDGs. These best results can be explained as follows:

- the measurements of impact monetization provided by the IWAP are highly accurate and the adopted calculation methodology is efficient;
- in the proposed database some enterprises are working collaboratively to achieve SDGs agenda;
- the impact on the environment which in its turn influences significantly the safeguard of subjects that are critical to human well-being and to the prosperity of societies will trigger many social issues.

Thus, there is a high correlation between all these variables, which enables to have good results in terms of social SDGs predictions.

5. Conclusion and Future Research Directions

In summary, the methodology presented in this paper investigates the potential of BDA technology in achieving corporate sustainability or sustainability analysis, especially social sustainability. In this regard, this may be considered as a promising aspect for enterprises to rethink how they design their business model, by integrating social and environmental stakeholders. Moreover, it will enable them to create economic, environmental, and social sustainable value in order to gain competitive advantages in the current highly vulnerable markets. Thus, BDA has the ability to generate valuable business insights that will help sustainable enterprises to achieve SDGs agenda by 2030, launched by the United Nations. In addition, a real case study was presented in this study based on the corporate environmental impact database from the impact-weighted account project at Harvard business school. The reason behind using this database is that social impacts are hard to measure. Thus, the database provides monetization impacts of enterprises' social impacts. The output of the present study confirmed that BDA can significantly help enterprises of different sizes and activity sectors to achieve social sustainability and social responsibility.

Finally, this study focused on some selected social issues concerned by some activity sectors. Hence, as perspectives, we expect to expand the presented BDA-based methodology to include other tools and techniques, as well as, address other social issues in the analysis process.

References

[1] Tamym, L., Benyoucef, L., Nait Sidi Moh, A., El Ouadghiri, M.D.. "Towards Big Data-based Sustainable Business Models and Sustainable Supply Chain". In: Emerging Trends in Intelligent Systems & Network Security. Springer International Publishing; 2023, p. 464–474.

[2] Hermundsdottir, F., Aspelund, A.. "Sustainability innovations and firm competitiveness: A review". Journal of Cleaner Production 2021;280.

[3] Martin, J., Petty, W., Wallace, J.. "Shareholder Value Maximization-Is There a Role for Corporate Social Responsibility?" Journal of Applied Corporate Finance 2009;21:110–118.

[4] Carter, J.G., Cavan, G., Connelly, A., Guy, S., Handley, J., Kazmierczak, A.. "Climate change and the city: Building capacity for urban adaptation". Progress in Planning 2015;95:1–66.

[5] Bahrami, M., Shokouhyar, S., Seifian, A.. "Big data analytics capability and supply chain performance: the mediating roles of supply chain resilience and innovation". Modern Supply Chain Research and Applications 2022;.

[6] Maheshwari, S., Gautam, P., Jaggi, C.K.. "Role of Big Data Analytics in supply chain management: current trends and future perspectives". International Journal of Production Research 2021;59(6):1875–1900.

[7] Cuquet, M., Vega-gorgojo, G., Lammerant, H., Finn, R., ul Hassan, U.. "Societal impacts of big data: challenges and opportunities in Europe" 2017;.

[8] United Nations, .. "Transforming our world: the 2030 Agenda for Sustainable Development". 2015. URL: https://sdgs.un.org/2030agenda; accessed 20 Sept 2022.

[9] Serafeim, G., Park, D., Freiberg, D., Zochowski, R.. "Corporate Environmental Impact: Measurement, Data and Information". Harvard Business School Working Paper 2020;(20-098).

[10] Bengt, S., Sara, P.. "A selection of safeguard subjects and state indicators for sustainability assessments". The International Journal of Life Cycle Assessment 2016;21.

[11] Fosso Wamba, S., Akter, S., Edwards, A., Chopin, G., Gnanzou, D.. "How 'big data' can make big impact: Findings from a systematic review and a longitudinal case study". International Journal of Production Economics 2015;165:234–246.

[12] Akter, S., Fosso Wamba, S., Gunasekaran, A., Dubey, R., Childe, S.. "How to improve firm performance using big data analytics capability and business strategy alignment?" International Journal of Production Economics 2016;182:113–131.

[13] Tamym, L., Benyoucef, L., Nait Sidi Moh, A., El Ouadghiri, M.D.. "A big data based architecture for collaborative networks: Supply chains mixed-network". Computer Communications 2021;175:102–111.

[14] Wamba, S.F., Gunasekaran, A., Akter, S., fan Ren, S.J., Dubey, R., Childe, S.J.. "Big data analytics and firm performance: Effects of dynamic capabilities". Journal of Business Research 2017;70:356–365.

[15] Nguyen, T., Zhou, L., Spiegler, V., Ieromonachou, P., Lin, Y.. "Big data analytics in supply chain management: A state-of-the-art literature review". Computers & Operations Research 2018;98:254–264.

[16] Lv, Z., Iqbal, R., Chang, V.. "Big data analytics for sustainability". Future Generation Computer Systems 2018;86:1238–1241.

[17] Cuquet, M., Fensel, A.. "The societal impact of big data: A research roadmap for Europe". Technology in Society 2018;54:74–86.

[18] Deloitte, . "Sustainability Analytics, the three-minute guide". Tech. Rep.; Deloitte Development LLC; 2012.

[19] Zhang, D., Pan, S.L., Yu, J., Liu, W.. "Orchestrating big data analytics capability for sustainability: A study of air pollution management in China". Information & Management 2019;:103231.

[20] United Nations, . "Gender equality and sustainable development". Tech. Rep.; The Research and Data section of UN Women; 2014.

[21] Richter, R.. "Rural social enterprises as embedded intermediaries: The innovative power of connecting rural communities with supra-regional networks". Journal of Rural Studies 2019;70:179–187.

[22] Evans Steveand Fernando, L., Yang, M.. "Sustainable Value Creation From Concept Towards Implementation". In: Sustainable Manufacturing: Challenges, Solutions and Implementation Perspectives. 2017, p. 203–220.

[23] Chen, H., Chiang, R.H.L., Storey, V.C.. "Business Intelligence and Analytics: From Big Data to Big Impact". MIS Quarterly 2012;36(4).

[24] Jeble, S., Dubey, R., Childe, S., Papadopoulos, T., Roubaud, D., Prakash, A.. "Impact of big data & predictive analytics capability on supply chain sustainability". The International Journal of Logistics Management 2018;29.

[25] Batko, K., Andrzej, . "The use of Big Data Analytics in healthcare". Journal of Big Data 2022;9.

[26] Talari, G., Cummins, E., McNamara, C., O'Brien, J.. "State of the art review of Big Data and web-based Decision Support Systems (DSS) for food safety risk assessment with respect to climate change". Trends in Food Science & Technology 2022;126:192–204.

[27] Dubey, R., Gunasekaran, A., Childe, S.J., Papadopoulos, T., Wamba, S.F., Song, M.. "Towards a theory of sustainable consumption and production: Constructs and measurement". Resources, Conservation and Recycling 2016;106:78–89.

[28] Steen, B.. A systematic approach to environmental priority strategies in product development (eps). version 2000–general system characteristics. Gothenburg Centre Environ Assess Prod Material Syst 1999;.

[29] Gupta, A., Deokar, A., Iyer, L., Sharda, R., Schrader, D.. "Big Data & Analytics for Societal Impact: Recent Research and Trends". Information Systems Frontiers 2018;20:1–10.