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**Systematic Review of Sustainability Reports for Effective Decarbonization in Supply Chains**

***Revisión sistemática de las memorias de sostenibilidad para una descarbonización efectiva en las cadenas de suministro***

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**Abstract:**

Problem: Businesses in developing countries, like Cuba, face challenges in transitioning to zero emissions due to limited resources and extreme weather conditions. Aims: This research aims to systematize sustainability and decarbonization measures in the chemical and food industries focusing on supply chains. Methodology: A systematic literature analysis of externally certified sustainability reports was conducted to collect empirical data. Measures were categorized according to (Brinken, Trojahn, & Behrendt, 2022) Results andDiscussion: Findings show a strong inclination towards Consistency and Efficiency strategies, mainly at Process and System levels. Sufficiency measures are less emphasized, revealing a potential gap in the transformation. Application level of measures possibly indicates differences in impacts. Conclusions: This research contributes to understanding supply chain decarbonization and offers insights for sustainable decision-making in businesses. While businesses focus on technological solutions and efficiency, Sufficiency strategies are underrepresented.

**Keywords:** Sustainability; Decarbonization; Supply Chain; Corporate Social Responsibility; Reporting; Systemization.

***Palabras Claves:*** Sostenibilidad; Descarbonización; Cadena de Suministro; Responsabilidad Social Corporativa; Informes; Sistematización

**1. Introduction**

The need for businesses in countries of the global south like Cuba to transition towards zero emissions is undeniable, considering limited financial resources and the importance of simpler, cost-effective measures. Limited financial resources pose challenges for implementing extensive sustainability measures (Wang, Hawkins, & Berman, 2014). Additionally, Cuba's geographical location in the Caribbean, with warming temperatures possibly intensified weather conditions (storms, draughts, etc.), emphasizes the importance of transitioning towards sustainability, especially building resilience (IPCC, 2021). This research aims to systematize sustainability and decarbonization measures in supply chains, specifically focusing on the chemical and food industries. These industries are economically significant, intertwined with environmental concerns, and offer opportunities for sustainable practices. Additionally, these sectors are important in Cuba and pose a good leverage point for the transition to sustainability in developing countries.

By conducting a systematic literature analysis of externally certified sustainability reports from global companies in these industries, we collect empirical data to identify and categorize measures within the framework proposed by Brinken et al. (2022). In future the identified measures will be integrated into a simulation model, which allows us to analyze their impact on costs and emissions reduction, supporting decision-making processes. This research contributes to understanding decarbonization in supply chains and provides insights for sustainable decision-making for example in Cuba or other developing countries.

This work is in the context of Green and Sustainable Supply Chain Management (SCM) integrating environmental, social, and economic considerations into supply chain practices (Seuring & Müller, 2008; Srivastava, 2007). Rockström et al emphasize the undeniable need for businesses to transition to zero emissions (Rockström et al., 2017). The relevance is driven by three main aspects: growing awareness on and scope of climate change impacts, customers and stakeholders demanding sustainable practices and legal regulations and policies to promote sustainable operations (Knickel, Schaer, & Sprenger, 2003; Miranda-Ackerman & Azzaro-Pantel, 2017). A vast variety of publications exist on the topic and many focus on multi criteria decision making especially on the firm level (Khan, Yu, Golpira, Sharif, & Mardani, 2021). Selecting and customizing sustainability measures influences the impact, the speed and the cost of decarbonization.

A wide range of measures exists in the literature, covering various sectors and spanning the entire supply chain. A selection of relevant measures has been condensed into an overview table derived from multiple reviews of sustainability measures.

Table 1: Types of decarbonization measures

|  |  |
| --- | --- |
| **Type of measures** | **Explanations/Examples** |
| Circularity and Renewable Materials | Establish circular material flows; use renewable materials; reuse, repair, remanufacture, recycle, etc. |
| Clean Energy and Technology | Generation, use or purchase of renewable, innovative or low-emission energy |
| Improve planning and design | Better or more efficient planning and design; optimization and improvement of processes |
| Research and Education | Innovations, generation and spreading of knowledge |
| Building natural capital | Building or restoring ecosystems or water/natural cycles/processes |
| Management, Organization and Standards | Establishing management systems or structures; CSR governance, strategy development reporting; establishing organizations networks and using/implementing standards |
| Reducing Contamination/ Pollution Risks | Reducing the harm and pollution of activities, by changing technologies, avoiding regions or certain activities; Monitoring etc. |
| Information and Transparency | Collecting information on objects, processes or systems; Monitoring, Tracking and Tracing |

Different approaches can be used to group or cluster these measures, each with its own challenges. The Triple Bottom Line approach is often employed, categorizing measures based on their economic, social, or ecological aspects. Another approach groups the measures by the sections of supply chains and companies, although these vary extremely between different companies and sectors. Assessing the effectiveness and motivation of measures for a structured display poses difficulties when evaluating measures or companies externally. (Brinken et al., 2022)

In logistics and production, the division of Objects, Processes, Systems, and Infrastructure is commonly utilized and applicable to any sector, supply chain, or company (Schmidtke, Glistau, & Behrendt, 2019). In the field of sustainability science, improvement strategies focus on the following basic functionalities:

* Sufficiency: Reducing negative impacts by renunciation/dispensing
* Consistency: Using technologies that are not harmful but circular and regenerative
* Efficiency: Enhancing the ratio between benefits and ecological expenses through improved resource utilization.

**2. Methodology**

To systematize sustainability and decarbonization measures in supply chains, a method based on the systematization framework is proposed (Brinken et al., 2022). This involves collecting empirical data through a systematic literature analysis of sustainability/CSR reports. The collected measures are then sorted into the proposed framework, as a base for the analysis and discussion.

To systematically analyze sustainability and Corporate Social Responsibility (CSR) reports from the companies with the biggest revenue in the chemical and food industries are selected. An approach based on several publications on systematic literature reviews is adapted to review CSR reports from companies operating in the target industries (Kitchenham et al., 2007; Moher, Liberati, Tetzlaff, & Altman, 2010). The reports are taken from the companies’ websites and screened. If they meet the inclusion criteria, first the bibliometric data is extracted (Table 2). As the companies publish the reports about their own activities, incomplete information or “Green Washing” of their company image can be a problem. Therefore only reports which are compiled using internationally renowned standards, for example published by (Global Sustainability Standards Board, 2018), and reports certified by an external certification body, are included.

Table 2: Inclusion criteria for reports and extracted data

|  |  |
| --- | --- |
| **Inclusion criteria** | **Data collection** |
| * The report must be a sustainability or CSR report. * The report must be externally certified by a recognized certification body. * The report must be from a company operating in the chemical or food industry sector * The two companies with the highest revenue in their sector are selected * The report must be for the year 2022 | * Company: Name of the company producing the sustainability or CSR report. * Year: Publication year of the report. * Title: Title or name of the report. * Used Standard: The sustainability standard or framework employed in the report. * Certification: The name of the certification body that externally certified the report. * Number of Pages: Total number of pages in the report. * Industry Sector: The specific industry sector to which the company belongs (chemical or food). * Country |

First the collected reports will be systematically analyzed to identify and collect sustainability and decarbonization measures listed in the reports. For every measure found, following information will be extracted: Name/Description of the measure, page, their thematic areas (Table 1), if the measure´s impact is just qualitatively described or even quantitatively calculated and what the financial or time efforts invested in the measure are (if listed in the report). Afterwards the measures are assorted to the sustainability strategy (efficiency, sufficiency, consistency, compensation, resilience, unclear/other) and the application level (Object, Process, System, Infrastructure, Unclear). The criteria for the assertion are given in the Table 3.

Table 3: Assertion criteria for sustainability strategies and application level

|  |  |  |  |
| --- | --- | --- | --- |
| **Sustainability Strategy** | | **Application Level** | |
| Sufficiency | To regulate/ dispense/ forgo/ waive materials, resources, suppliers or processes | Object | Adaption of product/service, like its material, design, attributes, packaging |
| Consistency | Using processes or materials who do not cause ecological harm (recycling, renewable materials or energies, etc.) | Process | Activities in production, logistics, controlling |
| Efficiency | Improving existing objects/process in terms of resource utilization | System | Workers, machines, factories, information and management systems |
| Compensation | Restoring ecosystem, sequestering CO² | Infrastructure | Resources and systems, which are generally available (like transport way, energy supply, land) |
| Resilience | Increase robustness and flexibility to respond to possible crisis/ disruptions | Unclear | None or multiple of the above levels |
| Unclear/Other | None or multiple of the above levels |  |  |

Quantitative and qualitative techniques are employed to gain insights into the prevalence, significance, and effectiveness of the identified measures. This analysis will provide a comprehensive overview of the sustainability practices undertaken by companies in these industries and support decision-makers in understanding the range of available options for achieving decarbonization and sustainability goals in the two sectors.

**3. Results and Discussion**

The four sustainability reports from 2022 (Table 3) have been selected according to the inclusion criteria, they include companies from Europe, the United States and China. The reports consist of 51 – 116 pages (in average 36000 words), which are filled with text, images, data, diagrams and interviews. They provide an overview of the most relevant and presentable sustainability related issues and activities. All reports a filed using standards (most often the GRI standard) and certified by global auditing and certification companies. Due to the extensive length of the reports, only a small number of four reports could be analyzed in depth for this study.

Table 4: Sustainability reports studied

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sector** | **Company** | **Title** | **Year/ Pages** | **Standards** | **Cert. body** |
| Chemical | BASF | Nachhaltigkeit entlang der Wertschöpfungskette | 2022/  51 | GRI | KPMG |
| Chemical | Sinopec | 2022 Sinopec Corp. Sustainability Report | 2022/ 116 | HKEX ESG; UNGC; TCFD | KPMG |
| Food | Nestle | Creating Shared Value and Sustainability Report | 2022/  63 | GRI; SASB | Bureau Veritas; EY |
| Food | Archer Daniels Midland | Scaling Impact | 2022/  62 | GRI; SASB; TCFD | APEX |

In total a number of 162 of different decarbonization measures have been analyzed. The diagram (Figure 1) shows that 65% of the reported measures can be grouped in the areas of Management, Organization and Standards, Circularity and Renewable Materials, Clean Energy and Technology and Improve planning and design. The sectoral differences can be seen in the colors red and green: the diagram shows that the food sector is focusing more strongly on Circularity and renewable materials, but in general is reporting on less measures than the chemical sector. 80% of the measures found are described in a qualitative way, in just 40% of the cases a quantification of their impact is stated in the reports. For the overwhelming majority (96%) of the measures the time effort, financial or other resources needed are not stated in the reports.

Figure 1: Types and numbers of sustainability measures found

**3.1 Strategies and application levels of the measures**

The following diagrams present the outcomes of the activity assessment, categorized by sustainability strategy and application level. Notably, 35% of the measures are centered on consistency, while 25% revolve around efficiency. Conversely, strategies based on sufficiency account for a mere 3% of the reported measures. This could be due to companies focusing on technological advancements and process optimization, linked to consistency and efficiency. These avenues enable technological innovation and economic growth, potentially overshadowing sufficiency-oriented approaches that involve self-restraint for sustainability. Approximately a quarter of the measures could not be definitively attributed to a single strategy, either due to the absence of discernible decarbonization impact or because the activities equally embraced multiple strategies. This is due to the complexity and multifaceted impacts of sustainability measure, where a single action often effects different dimensions of the problem (i.e. an improved packaging might be using renewable (consistent) materials and (efficiently) use less material.

Among the 41 efficiency measures, the majority were aligned with "Improve planning and design" (14 measures) and "Clean Energy and Technology" (11 measures). This is highly expectable, as the efficiency strategy is closely related to enhancement or optimization. Also, clean and renewable energies are often more efficient, as they do not need inefficient combustion. The 57 consistency measures predominantly fell within the domains of "Circularity and Renewable Materials" (21 measures), "Clean Energy and Technology" (12 measures), and "Improve planning and design," along with "Management, Organization, and Standards" (both 7 measures). Among consistency measures, the prominence of "Circularity and Renewable Materials" underscores a substantial effort towards creating closed-loop material systems and reducing waste through recycling and renewability. Only four sufficiency measures were identified, encompassing initiatives like a "Code of Conduct for Suppliers," "Palm Sourcing Policy,"

"Removal of Unnecessary Plastic," and the "Avoidance of Eco-Sensitive Areas for Construction Projects." However, this area requires more attention, considering the potential impact of these measures, which often do not need expensive technology investments.

Figure 2: Strategies and application levels

At the application level, the distribution is less concentrated. System-level measures are the most frequent (32%), while object-level measures are the least common (17%). System-level actions frequently correspond to "Management, Organization, and Standards" (19 measures), "Clean Energy and Technology" (10 measures), and, to a slightly lesser extent, "Improve planning and design" (7 measures) and "Information and Transparency" (6 measures). Object-level measures predominantly focus on "Circularity and Renewable Materials" (12 measures) and "Improve planning and design" (8 measures).While the system measures include many different aspects (management systems, factories, and machines), it becomes obvious that many improvements can be found here. On the other hand, it is not easy to change the object or product a company is selling, as this might be either a change of design or material or otherwise need an adaption of the whole business model. Infrastructure sustainability measures primarily align with "Building Natural Capital" (17 measures) and "Clean Energy and Technology" (10 measures), so they focus either on the green and blue infrastructure or the energy supply. Among process measures, "Circularity and Renewable Materials" and "Management, Organization, and Standards" are the most prevalent. Companies are closing material loops in their processes, or are at least defining what minimal requirements are (setting standards). Other measures are often "Improve planning and design" (6 measures), use "Clean Energy and Technology," increase "Research and Education," or "Reducing Contamination/Pollution Risks" (5 measures each).

**3.2 Systematization of the measures**

The provided table has been analyzed using the proposed systematization framework. For enhanced clarity, the table includes columns and rows displaying the sums of each row and column, along with their respective percentages. Additionally, cells are color-coded from yellow (indicating lower values) to green (indicating higher values). Notably, a consistent pattern emerges across the food and chemical sectors. Both sectors prioritize consistency and efficiency measures over sufficiency measures. Infrastructure measures are less frequent in comparison to measures undertaken on other application levels. It's important to note that, unlike Figure 2, this table excludes compensation, resilience, and unclear measures from the calculation. Consequently, a minor shift is observed: the majority of measures within both sectors are oriented towards process-level changes, indicating a preference for altering operational methods rather than addressing overarching systems.

Table 5: Systematization framework to compare sectors

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Chemical** | Object | Process | System | Infrastructure | SUM | in % |
| Sufficiency | 0 | 1 | 1 | 1 | 3 | 5% |
| Consistency | 9 | 7 | 10 | 6 | 32 | 55% |
| Efficiency | 4 | 12 | 6 | 1 | 23 | 40% |
| SUM | 13 | 20 | 17 | 8 | 58 |  |
| in % | 22% | 34% | 29% | 14% |  | 100% |
| **Food** | Object | Process | System | Infrastructure | SUM | % |
| Sufficiency | 1 | 0 | 0 | 0 | 1 | 2% |
| Consistency | 7 | 6 | 5 | 7 | 25 | 60% |
| Efficiency | 3 | 7 | 6 | 0 | 16 | 38% |
| SUM | 11 | 13 | 11 | 7 | 42 |  |
| in % | 26% | 31% | 26% | 17% |  | 100% |

Broadly, a significant emphasis appears to lie in the quadrant of Consistency & Efficiency strategies and Process & System levels. This is evident as approximately 60% (for the food sector) and 80% (for the chemical sector) of measures are concentrated within just one-third of the cells. The lack of sufficiency measures has been discussed before.

So, this focus in that area could stem from varying impacts associated with measures across different application levels. Consequently, an analysis was conducted to determine the proportion of each application level that lacked reported qualitative or quantitative impacts. The findings, depicted in Table 5, reveal a nuanced scenario. The Infrastructure level presents the most comprehensive qualitative impact description, closely followed by Object and System levels. In contrast, the qualitative impact description for Process level appears to be relatively deficient. Regarding quantification of impact, the Infrastructure level is the most frequently quantified, with the other three levels being quantified less frequently. Intriguingly, the Process level sees a higher frequency of quantitative impact descriptions compared to the Object or System levels. This variance underscores the complex dynamics between different application levels and the assessment of impacts, which can significantly influence the strategic direction of sustainability measures within an organization.

Table 6: Impact of measures on different application levels

|  |  |  |
| --- | --- | --- |
|  | Impact not stated | |
|  | Qualitatively | Quantitatively |
| Object | 17% | 63% |
| Process | 27% | 52% |
| System | 18% | 68% |
| Infrastructure | 13% | 33% |

Unfortunately, an analysis of the costs of the measure in relation to strategy or application level could not be done, as just 7 of the 162 measures are reported together with the time or resource efforts.

**4. Conclusions**

Through a systematic approach and the integration of real-world data, this study significantly enhances our understanding of making supply chains more sustainable. It offers valuable insights for businesses striving towards eco-friendly decisions and a greener future. The study's findings indicate a clear preference for strategies that enhance consistency and efficiency, particularly when focusing on the process and system levels. However, it's evident that not enough attention is being given to sufficiency measures, which are crucial for driving fundamental changes that conserve resources. Understanding the impacts of these measures across different levels of application remains somewhat unclear, suggesting varied effects depending on where they are implemented.

The method employed here is well-suited for gaining a broad understanding of sustainability efforts in the sectors. It could serve as an inspiration for other companies and particularly benefit businesses in developing nations that might face resource limitations. Yet, while this research provides insights into the types and levels of measures, details about their impacts and costs are relatively scarce. The attempt to categorize consistently and neutrally is noticeable, even though some level of subjectivity persists.

It's important to acknowledge that the study's scope was limited by available resources, restricting the number of reports analyzed. Future research should aim for a broader sample to ensure a more comprehensive evaluation. In terms of future research, exploring the costs and impacts of various groups of measures while considering their application levels and strategies could yield valuable insights. Engaging in discussions with sustainability officers across different companies might provide a clearer understanding of why sufficiency measures are less prominent and how this situation could be transformed.

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