UNIVERSIDADE FEDERAL DE SÃO CARLOS

CENTRO DE CIÊNCIAS EM GESTÃO E TECNOLOGIA

PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO DO *CAMPUS* SOROCABA

Maquele Antunes de Oliveira

EVALUATION OF REVERSE LOGISTICS CONTRIBUTIONS AND IMPACTS ON SUSTAINABLE DEVELOPMENT

Sorocaba

2023

UNIVERSIDADE FEDERAL DE SÃO CARLOS

CENTRO DE CIÊNCIAS EM GESTÃO E TECNOLOGIA

PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO DO *CAMPUS* SOROCABA

Maquele Antunes de Oliveira

EVALUATION OF REVERSE LOGISTICS CONTRIBUTIONS AND IMPACTS ON SUSTAINABLE DEVELOPMENT

Dissertação apresentada ao Programa de Pós-Graduação em Engenharia de Produção de Sorocaba para obtenção do título de Mestre em Engenharia de Produção.

Orientação: Prof. Dr. Juliana Veiga Mendes

Co-orientação: Prof. Dr. Luis Antonio de Santa-Eulalia

Financiamento: CAPES DS

Sorocaba

2023

Modelo de ficha catalográfica
Ficha Catalográfica — Biblioteca Campus Sorocaba - B-So UFSCar

MAQUELE ANTUNES DE OLIVEIRA

EVALUATION OF REVERSE LOGISTICS CONTRIBUTIONS AND IMPACTS ON SUSTAINABLE DEVELOPMENT

Dissertação apresentada ao Programa de Pós-Graduação em Engenharia de Produção para obtenção do título de Mestre em Engenharia de Produção. Sorocaba, 11 de Maio de 2023.

Orientador(a)

____

Dr. (a) Juliana Veiga Mendes

UFSCar - So

Co-Orientador(a)

____

Dr. (a) Luis Antonio de Santa-Eulalia

Université de Sherbrooke

Examinador(a)

____

Dr. (a) Claudia Mattos

FEI

Examinador(a)

____

Dr.(a) Virginia Aparecida da Silva Moris

UFSCar-So

Dedico

A todos os professores que passaram pela minha vida e me cederam seus ombros para que eu pudesse enxergar adiante.

AGRADECIMENTO

Agradeço primeiramente à minha família – Hevelson Rosario, Zelda e Salem – pelo apoio, companhia, carinho e paciência nessa curta jornada – que foi curta em tempo, mas gigantesca em valor (e em trabalho!).

Agradeço também à professora Dra. Juliana Veiga Mendes por ter me aceitado como sua orientanda, pela dedicação durante a orientação dessa pesquisa, pelo respeito e simpatia de sempre e por ser uma inspiração para mim – como pessoa, como pesquisadora e como educadora. Agradeço também ao meu coorientador, professor Dr. Luis Antonio de Santa-Eulalia, por todo o suporte, disponibilidade, competência, bom-humor, pelas fantásticas dicas e ensinamentos e pelas correções a qualquer momento (com direito a “Feliz ano novo” no dia 31/12!). Faço esses agradecimentos aqui com a esperança de que um dia eu possa me tornar uma professora tão excelente quanto vocês são.v

Agradeço especialmente ao Programa de Pós-Graduação em Engenharia de Produção da UFSCar Sorocaba (PPGEP-So), pela oportunidade de me desenvolver enquanto acadêmica e cidadã. Também faço esses agradecimentos na esperança de que, daqui para frente, eu possa retribuir para a sociedade todo o aprendizado que tive o privilégio de adquirir durante esses anos de mestrado.

Por final, agradeço:

À CAPES pela bolsa concedida.

Ao Grupo de Pesquisa em Engenharia da Sustentabilidade por todo o conhecimento compartilhado e pelas colaborações em publicações.

E ao corpo docente e discente e à equipe administrativa do PPGEP-So, que me auxiliaram e contribuíram de forma inestimável para que essa pesquisa se tornasse viável.

"We are at the very beginning of time for the human race. It is not unreasonable that we grapple with problems. But there are tens of thousands of years in the future. Our responsibility is to do what we can, learn what we can, improve the solutions, and pass them on."

Richard P. Feynman

RESUMO

OLIVEIRA, Maquele Antunes. Evaluation of reverse logistics contributions and impacts on sustainable development. 2023. Dissertação (Mestrado em Engenharia de Produção) – Universidade Federal de São Carlos, Sorocaba, 2023.

A preocupação mundial com o desenvolvimento sustentável tem aumentado e práticas produtivas que podem contribuir têm ganhado destaque – sendo a logística reversa (LR) uma dessas práticas. No entanto, o tema ainda é emergente e requer novos esforços. A definição de quais contribuições a LR pode trazer para a sustentabilidade ainda é incerta. Sendo assim, o objetivo da pesquisa é ampliar o entendimento sobre os impactos sustentáveis que a LR pode gerar econômica, ambiental e socialmente e definir quais ODS (Objetivos de Desenvolvimento Sustentável) são mais impactados pela adoção da LR. Além disso, pretende-se: contribuir para a produção de conhecimento relacionando a LR e sustentabilidade em suas três dimensões, onde há carência de estudos que o façam; demonstrar às empresas interessadas em aumentar sua adesão ao pacto global dos ODS como a adoção da LR pode beneficiá-las; identificar os principais impactos da LR para o desenvolvimento sustentável e elucidar como a adoção da LR pode ajudar no cumprimento dos ODS. Para esses fins, a pesquisa foi dividida em dois artigos, faz uso, respectivamente, de: (i) uma revisão sistemática da literatura para reunir as evidências empíricas sobre os impactos da LR na sustentabilidade, (ii) *expert elicitation* por meio do protocolo IDEA para avaliar a relação entre a LR e os ODS e (iii) VIKOR para análise e definição de quais ODS são os mais impactados pela adoção da LR. Concluiu-se através da literatura que: o pilar "ambiental" da sustentabilidade é o que tem mais impactos reportados; o pilar social ainda apresenta poucos impactos relatados na literatura – mesmo com as grandes contribuições sociais apontadas para o bem-estar humano – e o impacto de RL mais citado na literatura foi "melhorar lucro e economia de custos". Através da *expert elicitation* e VIKOR também constatou-se que o ODS 12 é o que mais se beneficia da adoção da RL e o ODS 1 é o que menos tem o seu cumprimento impulsionado pela RL. Diversas sugestões para pesquisas futuras são também apontadas.

Palavras-chave: logística reversa, sustentabilidade, ODS, economia circular, VIKOR, *expert elicitation*.

ABSTRACT

Global concern around sustainable development has increased and production practices that can contribute to this have gained prominence – with reverse logistics (RL) being one of these. However, the topic is still emerging and requires new efforts. The definition of which contributions reverse logistics can bring to sustainability is still inexact. The research aim is to extend the understanding of the sustainable impacts that RL can generate economically, environmentally and socially and to define which SDGs (Sustainable Development Goals) are the most impacted by RL adoption. In addition, it is intended to contribute to the production of knowledge related to RL and sustainability in its three dimensions – where there is a lack of studies –; demonstrate to companies interested in increasing their adherence to the global SDG pact how the adoption of RL can benefit them; identify the main impacts of RL for sustainable development and elucidate how RL adoption can help the achievement of the SDGs. For these purposes, the research will make use of: (i) a systematic literature review in order to gather the empirical evidence of RL impacts on sustainability, (ii) expert elicitation through the IDEA protocol to evaluate the relation between RL and the SDGs and (iii) VIKOR to the analysis and to define which SDGs are the most impacted by the adoption of RL practices. It was found in literature that: the environmental pillar of sustainability is the one with more impacts reported; the social pillar still has minimum impacts reported – even with the great social contributions pointed for human welfare – and the RL impact most cited in literature was “improve profit and cost savings”. After the analysis in the second article presented in this dissertation, it was found that SDG 12 has the greatest contribution from RL adoption and SDG 1 is the one which has its accomplishment least driven by RL. At the end, instructions for further research are given.

Keywords: reverse logistics, sustainability, SDG, circular economy, VIKOR, expert elicitation.

SUMÁRIO

CHAPTER I: RESEARCH OVERVIEW

1 GENERAL INTRODUCTION

The unconscious extraction of natural resources for production has increased the amount of waste we produce and put future generations at risk (Guarnieri, 2014). Our demand for natural resources currently exceeds the Earth's ability to regenerate (Earth Overshoot Day, 2020), which demonstrates the sustainability deficit of our current production model.

This current scenario risen considerably the interest in the environmental impact of organizational activities (Hervani, Sarkis and Helms, 2017) and in improving their sustainable performance (Nosratabadi *et al.*, 2019). Sustainability is the integration of environmental, social and economic aspects, which requires drastic changes across a broad range of sectors and there is still a lot of work to be done on sustainability research (Köhler *et al.*, 2019). However, there is a lack in the conceptualisation of sustainability – partly due to the nature of the sustainability discourse arising from broadly different schools of thought historically, which the absence of a theoretically solid conception frustrates approaches towards a theoretically rigorous operationalisation of sustainability (Purvis, Mao and Robinson, 2019).

Despite this absence, the United Nations has presented 17 goals and 169 targets for sustainable development – they are called Sustainable Development Goals (SDGs). The SDGs have encouraging targets and indicators (Purvis, Mao and Robinson, 2019), which are integrated, indivisible and balance the three dimensions of sustainable development (Nations, 2015). The companies participation in the SDGs achievement is crucial; for this reason, the United Nations also created the Global Compact, which the strategy is driving business awareness and action in support of achieving the SDGs by 2030 (Nations, 2015). The SDGs made sustainable development gain increased attention in the academic, governance, planning and development space (Mensah, 2019; Nosratabadi *et al.*, 2019). The concept of 'sustainable development' centres around the three pillars of sustainability interconnecting them; which increases the need for practicioners' awareness of their relationships, complementarities, and trade-offs (Mensah, 2019; Peña-Montoya *et al.*, 2020).

The SDGs are: (SDG 1) No Poverty; (SDG 2) Zero Hunger; (SDG 3) Good Health and Well-being; (SDG 4) Quality Education; (SDG 5) Gender Equality; (SDG 6) Clean Water and Sanitation; (SDG 7) Affordable and Clean Energy; (SDG 8) Decent Work and Economic Growth; (SDG 9) Industry, Innovation and Infrastructure; (SDG 10) Reduced Inequality; (SDG 11) Sustainable Cities and Communities; (SDG 12) Responsible Consumption and Production;

(SDG 13) Climate Action; (SDG 14) Life Below Water; (SDG 15) Life on Land; (SDG 16) Peace and Justice Strong Institutions; and (SDG 17) Partnerships to achieve the Goal (Nations, 2015).

Among these SDGs, there is one goal quite specific for manufacturing: SDG 12. However, production systems and other companies can potentially contribute to a far wider range of SDGs (Leurent and Abbosh, 2018). Circular economy practices in the industry and related business models can help achieve several of the SDGs, specially linked with SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land) (Schroeder, Anggraeni and Weber, 2019). In this way, supply chain management is important for sustainability (Koberg and Longoni, 2019) and operations management can and should contribute to this. It is necessary to maximize product recovery and reuse, reducing the harmful effects on the environment of waste disposal, extraction of raw materials, transport and distribution – and may also increase profits as a consequence (Kleindorfer, Singhal and Wassenhove, 2005).

In the literature, reverse logistics (RL) is considered a sustainable practice (Sellitto, Camfield and Buzuku, 2020; Trujillo-Gallego, Sarache and Sellitto, 2021), part of sustainable development (Brito and Dekker, 2004) and is described as an emerging area of research with opportunities to achieve considerable impacts on society, environment and economy (Sarkis, Helms and Hervani, 2010; Frei, Jack and Brown, 2020). RL is a strategy that operationalizes the return of products and aims to enable economic and sustainable development. It can be characterized by the flow from customers to companies receiving post-consumer products (Guarnieri, 2014); or, in a broadly way, as the process from end user to recovery (or to a new user) (Brito and Dekker, 2004). In many companies, some reverse logistics practices already happen even informally, due to the need to dispose of waste (Guarnieri, 2014).

Recycling management, including RL management, has come to the attention of most manufacturing and service organizations in recent years (Govindan and Gholizadeh, 2021), together with the ascending interest in sustainable development (Mensah, 2019). The motivations for adopting RL are varied, being oriented mostly to the market and to the desire to keep costs low (Brito and Dekker, 2004; Sorkun and Onay, 2018). However, the growing need to make development more sustainable has forced many companies not only to adopt reverse logistics but also to make it increasingly efficient and effective (Agrawal, Singh and Murtaza, 2015). Investing in sustainability through RL is also a way to gain market share by promoting a strong environmental reputation, and expanding the reach among customers who value sustainable performance (Toffel and Toffel, 2004).

Regarding the three pillars of sustainability, the recovery of products at the end of their useful life through reverse logistics has become significant for organizations due to environmental and economic issues, however attention to social sustainability is still rudimentary (Sarkis, Helms and Hervani, 2010; Banihashemi, Fei and Chen, 2019).

Sustainability is key in linking RL to performance, but still requires detailed examination and confirmatory work to examine how sustainability and RL relate (Morgan *et al.*, 2018) – which could fill literature gaps and help practitioners see how the adoption of RL through their companies can help their path on sustainability and increase their commitment to implement universal sustainability principles established by United Nations SDGs and Global Compact. However, there is still a limited number of papers studying RL as a practice for sustainability (Aitken and Harrison, 2013; Piyathanavong *et al.*, 2019). Sustainable approaches related to RL are generally discussed in the literature, thus more efforts are necessary in this direction (Banihashemi, Fei and Chen, 2019). Additionally, to the best of our knowledge, following a systematic literature review, no articles were found that methodically gather the sustainable impacts of RL and relate them to the SDGs – despite some recommendations to use SDGs as measures of sustainability (Maurice, 2016).

In this context, the following general research question arises: Can RL contribute to sustainable development? To answer this question in a structured way, it was separated into four specific questions: (i) What are the specific sustainable impacts generated by RL? (ii) Which dimensions (environmental, social and economic) of sustainability are the most impacted? (iii) If RL really has sustainable impacts, which SDGs are the most impacted by the RL adoption? (iv) And how it can contribute to sustainable development? These research questions led the dissertation to some research objectives, as discussed next.

1.1 Research objectives

The research questions previously stated in the last subsection were unfolded into specific objectives with defined methodologies to achieve them. All these were organized into **two articles** and the details about each one can be seen in Table 1.

Table 1. Articles summary.

Chapter	Article	RQ	Main objectives

2.	Article #1: Towards reverse logistics impacts on sustainability: a review of evidence from empirical studies	(RQ1) What are the sustainable impacts generated by RL according to the literature?	Collect the empirical impacts of RL adoption and practices.
		(RQ2) Which dimensions (environmental, social and economic) of sustainability are the most impacted by RL according to the literature?	Define which dimensions of sustainability are most impacted by RL.
3.	Article #2: Connecting reverse logistics impacts and the Sustainable Development Goals	(RQ3) Which SDGs are the most impacted by RL adoption?	Relate RL impacts with the achievement of SDGs.
		(RQ4) How RL can contribute to sustainable development?	Define which SDGs are more impacted by RL.

As shown in Table 1, first, systematic literature was conducted to gather systematically all empirical RL sustainable impacts reported by literature (in Article #1). In the end, the results obtained in the systematic review in Article #1 were used as input to construct a questionnaire and conduct an expert elicitation, in order to understand the relation between RL impacts and how it can contribute to the accomplishment of the SDGs (in Article #2).

Through completion of the objectives, the main contributions of this study are:

(1) For practitioners, the adoption of RL can increase profits and cost savings and improve the image of their organizations. Plus, it can also generate jobs and benefit the

community and stakeholders. Even if the social dimension of sustainability is not a primary concern for companies, the results presented in this dissertation give a glimpse into the importance of measuring this aspect and consolidating it as a sustainability dimension of equal importance.

(2) The results can also help practitioners target their investments in RL and have a clear vision of how the adoption of RL by their companies can help in the achievement of SDGs.

(3) For policy-makers, it can help evaluate reverse logistics initiatives and facilitate subsidy distributions in a more effective way.

(4) For scholars, the paper fills the gap in literature connecting reverse logistics with the SDGs and provides a future research agenda as described in the next paragraphs.

More details about the contributions and the relevance of this study can be found in the last sections of this dissertation (see Chapter IV).

1.2 Dissertation structure

This study is organized as follows: after this introduction (which covers the general perspective of the dissertation, including aspects that are addressed in more detail within the specific articles), Chapter II contains the article called "*Towards reverse logistics impacts on sustainability: a review of evidence from empirical studies*" and Chapter III contains the article *"Connecting reverse logistics impacts and the Sustainable Development Goals"*; Finally, Chapter IV presents the general conclusions, briefly bringing the results from the articles and its insights. The details of the structure can be seen in Figure 1.

INTEGRATED DISSERTATION OVERVIEW: *Evaluation of reverse logistics contributions and its impacts on sustainable development*		
	CHAPTER I: RESEARCH OVERVIEW	1 General introduction
	CHAPTER II: ARTICLE #1 *Towards reverse logistics impacts on sustainability: a review of evidence from empirical studies*	Abstract and keywords 1 Introduction 2 Research design 3 Results 4 Discussion 5 Conclusion
	CHAPTER III: ARTICLE #2 *Connecting reverse logistics impacts and the Sustainable Development Goals*	Abstract and keywords 1 Intruduction 2 Literature background 3 Research design 4 Results 5 Discussion 6 Conclusion
	CHAPTER IV: RESEARCH CLOSURE	1 Introduction 2 General discussions 3 General conclusions

Fig. 1. Integrated dissertation overview.

Both articles (Article #1 and Article #2) will be submitted to journals after the dissertation defence.

1.3 General methodology

This section describes the process employed to obtain the results described in the present study.

The choice of research methods used in this dissertation was associated with the scientific research development process and the detailing of each of the methods chosen is provided in the next chapters, which are organized in the form of articles. Was chose the format of articles to speed up the process of publishing the contents and results obtained in this study.

This study is exploratory, but its fundamental characteristic is the interest in the application, use and practical knowledge (Gil, 2008), focusing on investigating RL practices and how their adoption contributes to the achievement of SDGs. According to Gil (2008), the study level is descriptive, because of its aims of establishing relationships between RL and sustainable development.

This study used mixed methods, combining qualitative and quantitative research. The qualitative approach was used to explore the current state-of-art and develop the set of impacts of RL. After, a quantitative approach was used to turn the concepts measurable and create linkages between the previous findings and the SDGs, applying descriptive statistics and classification.

The general flow of this research methodology, objectives, methods and tools and sections are summarized in Table 2.

Table 2. Methodology flow.

	Objectives	**Methods and tools**	**Section**
Data collection process	Collect the empirical impacts of RL adoption and practices.	Systematic literature review through PRISMA protocol.	Chapter II - Article #1: Towards reverse logistics impacts on sustainability: a review of evidence from empirical studies
Data analysis process	Define which dimensions of sustainability are most impacted by RL.	Content and descriptive statistical analysis.	

Data collection process	Relate RL impacts with the accomplishment of SDGs.	Expert elicitation using IDEA protocol. As a tool, a structured questionnaire – with a Likert scale and in four-step question format – was applied.	Chapter III - Article #2: Connecting reverse logistics impacts and the Sustainable Development Goals
Data analysis process	Define which SDGs are more impacted by RL.	Descriptive statistical analysis and rank up the SDGs using the best guesses.	

In the next sub-sections (1.3.1 and 1.3.2) the details about the literature review and expert elicitation are provided.

1.3.1 Systematic literature review

The literature review is an important part of any research since all research needs to be informed by existing knowledge in a subject area (Rowley and Slack, 2004). Traditional reviews frequently lack thoroughness and in many cases are not undertaken as genuine pieces of investigatory science (Tranfield, Denyer and Smart, 2003). A meaningful literature review is much more than that (Levy and Ellis, 2006).

A systematic literature review approach can reduce bias and increase rigours and verifiability. The process of systematic review has been developed over the last decade and now plays a major role in evidence-based practices (Tranfield, Denyer and Smart, 2003). An increasing number of applied disciplines use evidence-based frameworks to review and disseminate the effectiveness of management and policy interventions – the medical systematic review methodology, for example, is developing rapidly with new techniques to handle the variable levels of data quality (Pullin and Stewart, 2006).

According to Levy and Ellis (2006), the systematic review is a process of helping the researcher understand the existing body of knowledge, providing a solid theoretical foundation, substantiating the presence of the research problem, justifying the proposed study and framing the valid research methodologies, approach, goals and research questions for the proposed study.

In this dissertation, the systematic literature view was adopted in the first article and more details about its application can be found on the next chapter. For scholars, the reviewing process increases methodological rigour. For practitioners/managers, a systematic review helps develop a reliable knowledge base by accumulating knowledge from a range of studies (Tranfield, Denyer and Smart, 2003).

Since the medical systematic methodology is a reference for systematic reviews, the approach chosen for the first article was PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Moher *et al.*, 2009). The PRISMA statement focuses on giving directions to a review with clearly formulated questions, explicit methods to identify, select and critically appraise relevant research and collect and analyse data from the studies that are included in the review (Moher *et al.*, 2009).

1.3.2 Expert elicitation

Expert elicitation is a structured process to elicit subjective judgements from experts (Refsgaard *et al.*, 2007) and extract expert knowledge about some unknown quantity. However, elicitation is not a simple task, and practitioners need to be aware of a wide range of research findings in order to elicit expert judgements accurately and reliably (O’Hagan *et al.*, 2006).

According to Martin *et al.* (2012), in general, an expert-elicitation approach consists of five steps:

I) Deciding how the information will be used,

II) Determining what to elicit,

III) Designing the elicitation process,

IV) Performing the elicitation, and

V) Translating the elicited information into quantitative statements that can be used in a model or directly to make decisions.

The limitations are linked to the subjectivity of the results that are sensitive to the selection of experts (Refsgaard *et al.*, 2007). Just as the reliability of empirical data depends on the rigor with which it was acquired so too does that of expert knowledge (Martin *et al.*, 2012).

Several elicitation protocols have been developed and have the potential to make use of all available knowledge that cannot easily be formalised otherwise (Refsgaard *et al.*, 2007). Expert elicitation should build on and use the best available research and analysis and be undertaken only when, given those, the state of knowledge will remain insufficient to support timely informed assessment and decision-making. Draft protocols should be pilot tested with quasi-experts to assure that question formulations are workable and can be understood. And the elicitation protocols must be developed through careful iterative refinement (Morgan, 2014).

For this master´s thesis, the expert elicitation was adopted in the second article and more details about its application can be found in Chapter III.

Since a structured protocol for expert elicitation is essential to mitigate biases and improve the accuracy and transparency of the resulting judgements, the one chosen was the IDEA protocol. The IDEA includes several key steps that may look familiar, such as the four-step elicitation and a modified Delphi procedure (Hemming *et al.*, 2018).

Expert elicitation has ethical requirements, as it involves humans. Therefore, the questionnaire that was applied to the experts was previously submitted to the ethics committee. All documentation can be found in the Annex section of this dissertation; it is organised as follows:

- Annex A - Proof of submission to the ethics committee.
- Annex B - Proof of receipt from the ethics committee.
- Annex C - Basic project information submitted to the ethics committee.
- Annex D - Detailed project submitted to the ethics committee.
- Annex E - Term of Free Consent and Clarification (*Termo de Consentimento Livre e Esclarecimento* or TCLE).
- Annex F - Embodied opinion of the ethics committee.

CHAPTER II: ARTICLE #1 TOWARDS REVERSE LOGISTICS IMPACTS ON SUSTAINABILITY: A REVIEW OF EVIDENCE FROM EMPIRICAL STUDIES

ABSTRACT: Reverse logistics has been gaining prominence when it regards sustainable development, but the literature does not clearly state how it can impact and help sustainability from the Triple Bottom Line perspective. The relationship between its three perspectives (economic, environmental, and social) may look intuitive, but there is still an empirical gap in linking both. Therefore, this study aims to extend the understanding of the contributions of reverse logistics practices to sustainability. Firstly, a systematic literature review was conducted through the PRISMA approach to determine which are the most important sustainable impacts of reverse logistics studied in the scientific literature employing empirical methods. Secondly, the surveyed impacts were classified into the dimensions of sustainability. It was found 35 impacts of reverse logistics on sustainability, of which 17 are related to environmental aspects, 12 are economic impacts, while only 6 are related to social aspects. Surprisingly, the largest number of citations are related to the economic aspects and the most cited impact was "improve profit and cost savings". The social dimension of sustainability on RL is not a major font of concern in the literature. Future studies may seek to identify more social impacts from RL adoption as well as to better balance the three perspectives, furthermore, future studies should use the impacts to link the RL adoption with the Environmental, Social, and Corporate Governance (ESG) approach and the Sustainable Development Goals (SDGs).

KEYWORDS: Reverse logistics, sustainable development, triple bottom line, TBL.

1 INTRODUCTION

The concept of sustainability, sustainable development and several associated terms have gained prominence and there is a convergence that it can be defined by the performance in three main dimensions: social responsibility, environmental sustainability and economic viability (Jamali, 2006; UNIDO, 2015). This concept of sustainability is also known as Triple Bottom Line (TBL) – a term introduced by Elkington (1998) – or just as the three sustainability pillars (Purvis, Mao and Robinson, 2019). And, according to the Brundtland report – Our Common Future –, sustainable development should "meet the necessities of the present generation without harming the future generation's capacity to meet their own" (Keeble, 1988).

The unconscious extraction of natural resources for production increased the amount of waste we produce and puts future generations at risk (Guarnieri, 2014). According to the Earth Overshoot Day organized by the Global Footprint Network, our demand for natural resources currently exceeds the Earth's capacity to regenerate (Earth Overshoot Day, 2020). Therefore, inclusive and sustainable industrial development (ISID) “makes a critical contribution towards addressing the economic, social and environmental dimensions of development in a systemic and holistic manner” (UNIDO, 2015).

Some practices in the industry, such as the circular economy and related business models and practices, can help to promote sustainable development (Schroeder, Anggraeni and Weber, 2019). In particular, reverse logistics (RL) is considered a sustainable practice (Trujillo-Gallego, Sarache and Sellitto, 2021; Sellitto, Camfield and Buzuku, 2020; Sirisawat and Kiatcharoenpol, 2019). It stands for the process of planning and returning products to the supply chain (Mafini and Loury-Okoumba, 2018), described as an emerging area of research with opportunities to achieve considerable impact on society, the environment and the economy (Frei, Jack and Brown, 2020; Sarkis, Helms and Hervani, 2010).

Despite the growing volume of the literature concerning RL, the attention given to the sustainable impacts of RL practices is overlooked in general (Banihashemi, Fei and Chen, 2019); just a few studies relate RL with operational environmental sustainability approaches (Piyathanavong *et al.*, 2019). Especially the interest in the social dimension of sustainability in RL is rudimentary (Banihashemi, Fei and Chen, 2019; Sarkis, Helms and Hervani, 2010). RL has not been a major source of investigation within the sustainable supply chain field (Sarkis, Helms and Hervani, 2010) and more investigation to explore the relationship between RL and sustainability is necessary (Trujillo-Gallego, Sarache and Sellitto, 2021; Mafini and Loury-Okoumba, 2018, Sarkis, Helms and Hervani, 2010), mainly related to the understanding of the impacts of RL in the three dimensions of sustainability (Mafini and Loury-Okoumba, 2018). Furthermore, some authors (Morgan *et al.*, 2018) call for confirmatory work to examine how sustainability and RL impact extant supply chain performance study results. Additionally, to the best of our knowledge, no articles were found that systematically gather the sustainable impacts of RL, mainly from the empirical perspective.

In this context, this study aims to extend the understanding of the contributions of RL practices to sustainability in the three dimensions (environmental, social and economic) by first identifying and mapping the scientific literature covering empirical studies only, then proposing a conceptual framework to organise the results. To this end, the systematic literature review approach was adopted, to answer the following two research questions (RQ):

- RQ1: What are the sustainable impacts generated by RL from an empirical perspective?
- RQ2: Which dimensions of sustainability are the most impacted by RL?

It is important to highlight that this paper comprises empirical results only, which has been playing a major role when it comes to evidence-based practices and which, for practitioners and managers, helps develop a reliable knowledge base by accumulating knowledge from a range of studies (Tranfield, Denyer and Smart, 2003).

This paper is organized as follows: after this introduction, Section 2 presents the research design employed to perform the systematic literature review and the corresponding analysis; Section 3 depicts the results, while Section 4 discusses them; finally, Section 5 outlines some conclusions and proposes directions for future research.

2 RESEARCH DESIGN

This systematic literature review follows the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) approach (Moher *et al.*, 2009). An increasing number of applied disciplines are utilizing evidence-based frameworks (Pullin and Stewart, 2006), but traditional 'narrative' reviews frequently lack thoroughness and can be biased, although the systematic review differs from the traditional by adopting a "replicable, scientific and transparent process" (Tranfield, Denyer and Smart, 2003). The PRISMA's checklist provides guidelines to conduct a consistent systematic review (e.g., title, abstract, method, results, discussion) and the PRISMA flow chart describes the information flow through the different phases of the systematic review (i.e., identification, screening, eligibility, inclusion) (Moher *et al.*, 2009).

The first phase was identification, consisting of the definition of relevant research questions and appropriated search protocol (Table 1) and removing duplicates using the Mendeley Desktop software. In the screening phase, the title and abstract were analysed by applying the exclusion criteria. In the eligibility phase, full-text articles in the sample were assessed for qualification. Finally, for the included phase, data extraction and cross-search through snowballing were done to identify papers that had not been captured by the search protocol. The phases are shown in Figure 1 and will be detailed in the following paragraphs.

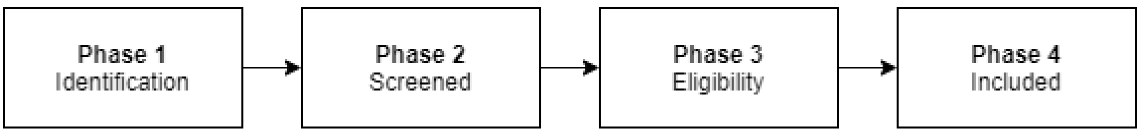


Fig. 1. Systematic literature review phases.

To answer the RQ1 and RQ2 and based on the objectives of the research, in the identification phase the search protocol was defined and a search string was constructed. The electronic data sources selected were Web of Science (WoS) and Scopus for their vast coverage of papers on Operations Management and Engineering (Mongeon and Paul-Hus, 2016). Four eligibility criteria were applied: (1) period: the search period ranges from the beginning of 2015, with the emergence of the Sustainable Development Goals (SDGs) (Nations, 2015), to September, 2021; (2) Search fields: title and abstract; (3) Document types: only journal articles were included as they were considered more reliable owing to the rigour of the evaluation process; (4) Language: only studies published in English. This search returned 416 records from both sources – WoS and Scopus. After duplicate removal, the sample was reduced to 288 articles.

Table 1. Search protocol.

Data source	Web of Science and Scopus
Search string	("reverse logistics" AND "sustain*") AND ("impact" OR "performance")
Search fields	Title and abstract
Period	From 2015 to September 30, 2021
Language	English
Document	Journal articles

The screening phase consisted of analysing the title and abstract in the sample, and applying the exclusion criteria (Table 2). The first exclusion criterion (E1) aimed to filter articles does not fit the research scope, excluding studies focused on areas other than RL (e.g., education, healthcare, chemistry); the second exclusion criteria (E2) aimed to filter studies which are not empirical – were included studies as case study, survey and action research.

In the eligibility phase, the remaining articles were fully read for qualification and those matching the inclusion criteria (Table 2) were accepted in the sample. After this stage, the 41 articles of the systematic review were included.

Table 2. Inclusion and exclusion criteria.

Criteria	Description	Total occurrences

	E1: Does not fit with the scope of the research.	8
Exclusion (E)	E2: It is not an empirical study.	165
Inclusion (I)	I1: The paper analyses or review the sustainability in RL.	41

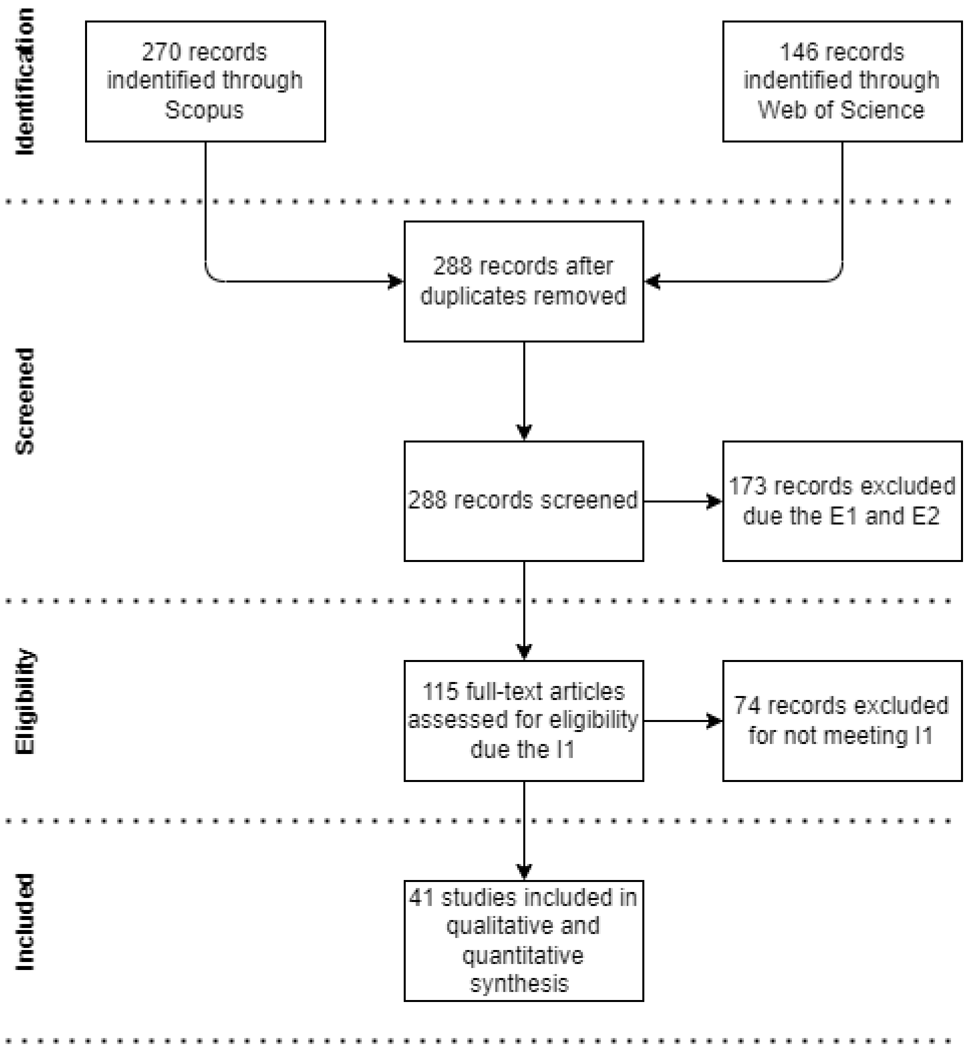


Fig. 2. Study selection flow.

Figure 2 shows the complete study selection flow and the results obtained in each phase. Most records were generated by Scopus (270). Phase 1 initially resulted in 416 articles. After duplicate removal, the sample was reduced to 288 articles. The titles, abstracts and keywords were thereafter analysed and exclusion criteria E1 and E2 set out in Table 2 were applied, reducing the sample to 115 articles. At this stage, 8 articles were excluded due to E1 – because they focused on other areas (e.g., education, healthcare, chemistry) – and 165 were excluded due to E2 – because they do not present empirical results (e.g., literature review, model proposal). After assessing the full text of the articles, the other 74 articles were excluded due to the fact they do not present any analysis or review of RL sustainable impacts (I1), also were excluded those which the full text could not be accessed. Hence, a total of 41 articles were included in the final sample.

For the quantitative and qualitative analyses of the articles included in the review, two approaches were used: bibliometric and content analyses, respectively.

The bibliometric method introduces objectivity into the evaluation of scientific literature, increases rigour and mitigates researcher bias (Zupic and Čater, 2015). The steps for the bibliometric analysis were conducted as the workflow proposed by Zupic and Čater (2015), summarized in Figure 3.

Fig. 3. Bibliometric analysis workflow.

Steps 1 and 2 were the same as the systematic review, leading to the bibliometric analysis of the final 41 articles. For step 3 and to prepare data for visualization (Step 4) VOSviewer was the software chosen given the coverage of different highlights – data, visualization and technique (VOSviewer, 2021).

For the interpretation and content analysis, the final sample of 41 articles was analysed to extract the sustainable impacts of RL they describe. The impacts were classified according to the three pillars of sustainability – environmental, economic and social. Next, descriptive statistical analysis was performed to help enhance the content analysis.

The environmental dimension of sustainability consists of aspects of quality of air, water and soil and responsible extraction of raw material and consumption. The social dimension addresses issues related to humanity and its welfare. And the economic pillar of sustainability is associated with the wealth of companies, organisations or individuals.

All results are reported in the next section.

3 RESULTS

The 41 articles were analysed to identify and extract the reported sustainable impacts of RL. First, the quantitative bibliometric analysis was conducted to find relevant patterns and information from metadata. Second, qualitative analysis was adopted to identify the impacts and categorize them into the TBL. All the results are reported in detail in the following sections.

3.1 Quantitative bibliometric analysis

The sample size of the selection comprises 41 journal articles, used for both quantitative and qualitative analysis (see Table 3). Most articles were published in 2021 (Figure 4), even though this study covered publications util September 2021, which demonstrates how recent the topic is. In total, 2019, 2020 and 2021 have 64,92% of the total publications.

Table 3. Articles sample.

Item	Title	Authors	Year	Journal	Methodology	Where was the research applied?
1	Green supply chains: A perspective from an emerging economy	Jayaram, J., Avittathur, B.	2015	International Journal of Production Economics	Delphi	Emerging economy contexts such as Brazil, China, India and other countries.
2	Reverse logistics in humanitarian operations: challenges and opportunities	Peretti, U., Tatham, P., Wu, Y., Sgarbossa, F.	2015	Journal of Humanitarian Logistics and Supply Chain Management	Informal discussions	Humanitarian operations
3	Triple bottom line performance evaluation of reverse logistics	Agrawal, S., Singh, R.K., Murtaza, Q.	2016	Competitiveness Review	Fuzzy analytical hierarchy process, extent analysis approach and case study	Electronic companies
4	Reverse logistics in manufacturing waste management: The missing link between environmental commitment and operational performance	Fernando, Y., Tew, M.-M.	2016	International Journal of Integrated Supply Management	Variance-based structural equation modelling (SEM) with the partial least squares (PLS) method	Electronics and electrical (E&E) manufacturing firms
5	The use of reverse logistics for waste management in a Brazilian grocery retailer	Dias, K.T.S., Braga, S.S., Jr.	2016	Waste Management and Research	Case study	Brazilian grocery retailer

6	Strategic orientations, sustainable supply chain initiatives, and reverse logistics: Empirical evidence from an emerging market	Hsu, C.-C., Tan, K.-C., Mohamad Zailani, S.H.	2016	International Journal of Operations and Production Management	Survey	Malaysia – among all EMS ISO 14001–certified firms
7	Reverse logistics in household recycling and waste systems: a symbiosis perspective	A Jalil, E.E., Grant, D.B., Nicholson, J.D., Deutz, P.	2016	Supply Chain Management	Surveys and quantitative approached coupled to the functionalist paradigm and interviews and qualitative approaches coupled to the interpretivist paradigm	Two English local authorities and their respective consumers or households
8	Reverse logistics and informal valorisation at the Base of the Pyramid: A case study on sustainability synergies and trade-offs	Brix-Asala, C., Hahn, R., Seuring, S.	2016	European Management Journal	Case study	RL chain for water sachets in the African state of Ghana
9	The effects of reverse logistics on cost control abilities: An insight into manufacturing companies in Malaysia	Fernando, Y, Sharon, S.S.T., Wahyuni-Td, I.S., Tundys, B.	2017	International Journal of Value Chain Management	Survey	Manufacturing firms registered under the Federation of Malaysia Manufacturers (FMM)
10	Resource commitment and sustainability: a reverse logistics performance process model	Morgan, T.R., Tokman, M., Richey, R.G., Defee, C.	2018	International Journal of Physical Distribution	Survey methods and structural equation modeling	Data from 180 supply chain professionals

				and Logistics Management		
11	A framework for evaluating the performance of sustainable service supply chain management under uncertainty	Tseng, M.-L., Lim, M.K., Wong, W.-P., Chen, Y.-C., Zhan, Y.	2018	International Journal of Production Economics	Fuzzy Delphi Method and Analytical Network Process	Expert group
12	A disclosure of social and environmental results/economy resulting from the implementation of reverse logistics and final disposal of the post-consumption product: The case of computer peripherals industry	Slomski, V., Slomski, V.G., Valim, G.G., Vasconcelos, A.L.F.D.S.	2018	Environmental Quality Management	Case study	Multinational manufacturer of computer peripherals in the city of São Paulo, Brazil
13	Carbon footprint model for reverse logistics of waste disposal in interior design industry	Liang, C.-C., Lee, J.-P.	2018	Asia Pacific Journal of Marketing and Logistics	Case study	Disposing interior design waste in Taiwan
14	Reverse logistic strategy for the management of tire waste in Mexico and Russia: Review and conceptual model	Uriarte-Miranda, M.-L., Caballero-Morales, S.-O., Martinez-Flores, J.-L., Cano-Olivos, P., Akulova, A.-A.	2018	Sustainability (Switzerland)	Applied modeling	Management of Tire Waste in Mexico and Russia
15	Impacts of collaboration networks, operational performance and reverse logistics determinants on the performance outcomes of the auto parts industry	Phoosawad, P., Fongsuwan, W., Chamsuk, W., Takala, J.	2019	Management and Production Engineering Review	Survey	Thailand’s auto parts industry

16	Market dynamics and reverse logistics for sustainability in the Indian Pharmaceuticals industry	Narayana, S.A., Pati, R.K., Padhi, S.S.	2019	Journal of Cleaner Production	Base causal loop model and semi-structured personal/telephonic interviews (sometimes site visits)	Pharmaceutical industry in India
17	Assessing the cost structure of component reuse in a product family for remanufacturing	Wang, W., Mo, D.Y., Wang, Y., Tseng, M.M.	2019	Journal of Intelligent Manufacturing	Case study	Bulldozer remanufacturing
18	Green Supply Chain Management (GSCM) practices for sustainability performance: An empirical evidence of Malaysian SMEs	Rasit, Z.A., Zakaria, M., Hashim, M., Ramli, A., Mohamed, M.	2019	International Journal of Financial Research	Case study	Small and medium enterprises
19	The adoption of operational environmental sustainability approaches in the Thai manufacturing sector	Piyathanavong, V., Garza-Reyes, J.A., Kumar, V., Maldonado-Guzmán, G., Mangla, S.K.	2019	Journal of Cleaner Production	Survey	Manufacturing sector of Thailand
20	Analyzing disposition decisions for sustainable reverse logistics: Triple Bottom Line approach	Agrawal, S., Singh, R.K.	2019	Resources, Conservation and Recycling	Survey	Indian electronics industry
21	Correlation of Reverse Logistics Performance to Solutions Using Structural Equation Modeling	Sirisawat, P., Kiatcharoenpol, T.	2019	Journal of Advanced Manufacturing Systems	Case study	Electronics industry in Thailand

22	Determinants of sustainable supply chain management: A case study from the oil and gas supply chain	Gardas, BB (Gardas, Bhaskar B.); Raut, RD (Raut, Rakesh D.); Narkhede, B (Narkhede, Balkrishna)	2019	Sustainable Production and Consumption	Case study	Oil and gas supply chain
23	Examining the effect of green human capital availability in adoption of reverse logistics and remanufacturing operations performance	Bag, S., Gupta, S.	2020	International Journal of Manpower	Survey	Automotive manufacturing firms operating in an emerging economy (South Africa)
24	Managing eco-design for reverse logistics	Khor, K.-S., Ramayah, T., Fouladgaran, H.R.P.	2020	International Journal of Environment and Waste Management	Survey	89 electrical and electronic (E&E) manufacturing firms that received IS014001 certification
25	Reverse logistics practices in Indian pharmaceutical supply chains: A study of manufacturers	Abbas, H., Farooquie, J.A.	2020	International Journal of Logistics Systems and Management	Survey	Indian pharmaceutical supply chains
26	The mediating role of sustainable supply chain in the relationship between ECO-strategic orientation and the reverse logistic in Thai electronic industry	Kerdpitak, C., Chakphet, T., Maneechay, S., Jaepho, S.	2020	International Journal of Supply Chain Management	Variance-based structural equation modelling (SEM) with the partial least squares (PLS) method	Thai Electronic Industry

27	External supply chain management factors and social performance in Thai manufacturing industry: Moderating role of green human resource practices	Sittisom, W., Mekhum, W.	2020	International Journal of Supply Chain Management	Questionnaires	Thai Manufacturing Industry
28	Spoilt - Ocean Cleanup: Alternative logistics chains to accommodate plastic waste recycling: An economic evaluation	van Giezen, A., Wiegmans, B.	2020	Transportation Research Interdisciplinary Perspectives	Case study and applied modeling	Different geographical locations
29	The effect of collaboration and IT competency on reverse logistics competency - Evidence from Brazilian supply chain executives	Campos, E.A.R.D., Paula, I.C.D., Caten, C.S.T., Maçada, A.C.G., Marôco, J., Ziegelmann, P.K.	2020	Environmental Impact Assessment Review	Survey	Brazilian supply chain executives
30	Reverse logistics system analysis of a Brazilian beverage company: An exploratory study	Beiler, B.C., Ignácio, P.S.D.A., Pacagnella Júnior, A.C., Anholon, R., Rampasso, I.S.	2020	Journal of Cleaner Production	Exploratory study	Brazilian beverage company
31	Strategic Decision Making in Construction Supply Chains: A Comparison of Reverse Logistics Strategies	Pushpamali, N.N.C., Agdas, D., Rose, T.M.	2020	Frontiers in Built Environment	Case study	Construction sector
32	Exploring disposition decision for sustainable reverse logistics in the era of a circular economy: Applying the	Javed H., Firdousi S.F., Murad M., Jiatong W., Abrar M.	2021	International Journal of Supply and Operations Management	Survey	Pakistan textile manufacturing industry

	triple bottom line approach in the manufacturing industry					
33	Relationship among reverse logistics, corporate image and social impact in medical device industry	Hong S.-Q., Huang Y.-J.	2021	Revista de Cercetare si Interventie Sociala	Survey	Medical device industry Fujian Province
34	Green and reverse logistics in conditions of sustainable development in enterprises in Slovakia	Richnák P., Gubová K.	2021	Sustainability (Switzerland)	Survey	Enterprises in Slovakia
35	Examining the Interconnections Between Sustainable Logistics Practices, Environmental Reputation and Financial Performance: A Mediation Approach	Baah C., Amponsah K.T., Issau K., Ofori D., Acquah I.S.K., Agyeman D.O.	2021	Vision	Partial least square structural equation modelling	Logistics firms operational in the Ghanaian setting; most of these firms were small and medium-sized enterprises
36	Robust network design for sustainable-resilient reverse logistics network using big data: A case study of end-of-life vehicles	Govindan K., Gholizadeh H.	2021	Transportation Research Part E: Logistics and Transportation Review	Case study	End-of-life vehicles in Iran.
37	Synergizing environmental, social, and economic sustainability factors for refuse derived fuel use in cement industry: A case study in Espirito Santo, Brazil	de Lorena Diniz Chaves G., Siman R.R., Ribeiro G.M., Chang N.-B.	2021	Journal of Environmental Management	Case study	Waste management in Espirito Santo, Brazil

38	Production decisions of a closed-loop supply chain considering remanufacturing and refurbishing under government subsidy	Feng D., Shen C., Pei Z.	2021	Sustainable Production and Consumption	Stackelberg and Cournot duopoly game models	Auto parts market
39	Identification of practices that facilitate manufacturing companies' environmental collaboration and their influence on sustainable production	Trujillo-Gallego M., Sarache W., Sellitto M.A.	2021	Sustainable Production and Consumption	Survey	Colombian manufacturing companies
40	Circularity of Brazilian silk: Promoting a circular bioeconomy in the production of silk cocoons	Barcelos S.M.B.D., Salvador R., Barros M.V., de Francisco A.C., Guedes G.	2021	Journal of Environmental Management	Case study	Production of silk cocoons in Brazil
41	Robust global reverse logistics network redesign for high-grade plastic wastes recycling	Xu, ZT., Elomri, A., Liu, WJ., Liu, H., Li, M.	2021	Waste Management	Case study	Plastic waste recycling between China and Belgium

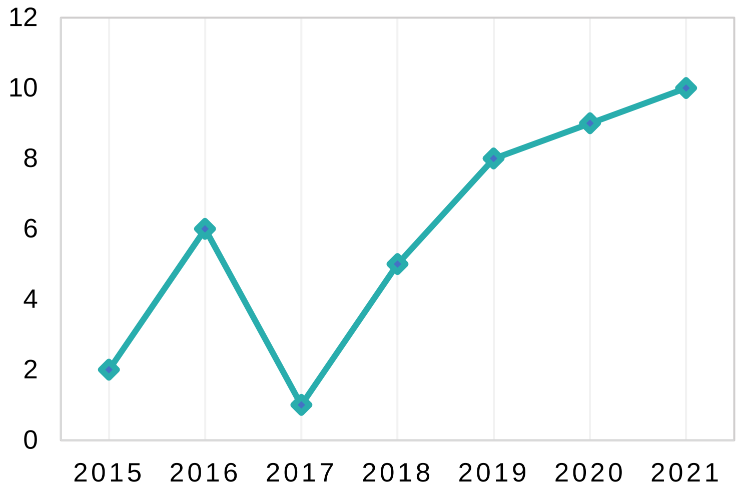


Fig. 4. Distribution of the articles over time.

The geographical distribution of the publications is presented in Figure 5. All countries with more than 1 publication were considered. In total, the 41 articles were distributed in 30 different countries.

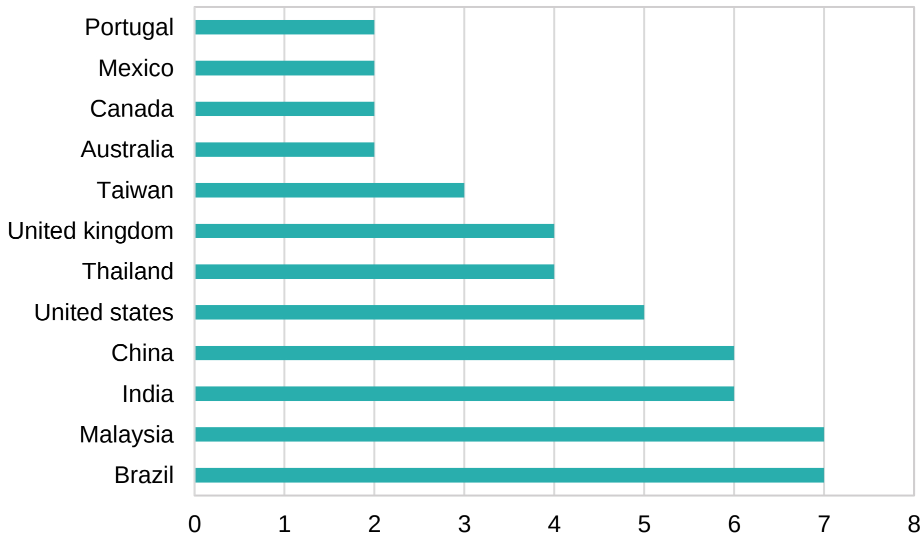


Fig. 5. Number of articles per country.

The occurrence of Brazil as one of the countries which more publications is also supported by the analysis of keywords. In Table 4 is possible to see all the keywords from the articles which a minimum of 5 occurrences; and the ninth word is "Brazil".

Table 4. Keyword occurrence.

Keyword	Occurrences
Reverse logistics	25
Sustainable development	17

Sustainability	15
Logistics	12
Supply chain management	8
Recycling	6
Structural equation modelling	6
Waste management	6
Brazil	5
Circular economy	5
Environmental management	5
Remanufacturing	5
Supply chains	5

Among the articles included in this systematic review (Table 3), 139 authors were included. Only 3 authors appear more than once: Agrawal S., Fernando Y. and Singh R. K. – which one with 2 occurrences. However, together they only own 6,74% of citations. The authors with more citations are Avittathur B. and Jayaram J. – owing 121 citations which corresponds to 16,2% of all citations.

3.2 Qualitative analysis

The selected articles were summarized and categorized following the dimension of sustainability which is cited: environmental, social and economic. Since operations are positively related to economic sustainability (Hami, Muhamad and Ebrahim, 2015), therefore it is classified as economic.

Table 5. Articles analysis and classification by sustainability pillar.

Item	Authors	Environmental	Social	Economic
1	Jayaram and Avittathur, 2015	x		
2	Peretti *et al.*, 2015	x		

3	Agrawal, Singh and Murtaza, 2016	x	x	x
4	Fernando and Tew, 2016	x		x
5	Dias and Braga, 2016	x		x
6	Hsu *et al.*, 2016	x		x
7	Jalil *et al.*, 2016	x		
8	Brix-Asala, Hahn and Seuring, 2016	x	x	
9	Fernando *et al.*, 2017			x
10	Morgan *et al.*, 2018	x		x
11	Tseng *et al.*, 2018	x		x
12	Slomski *et al.*, 2018	x	x	x
13	Liang and Lee, 2018	x		
14	Uriarte-Miranda *et al.*, 2018	x		x
15	Phoosawad *et al.*, 2019			x
16	Narayana, Pati and Padhi, 2019	x		
17	Wang *et al.*, 2019			x
18	Rasit *et al.*, 2019			
19	Piyathanavong *et al.*, 2019	x		
20	Agrawal and Singh, 2019	x		
21	Bag and Gupta, 2020			x
22	Sirisawat and Kiatcharoenpol, 2019			x
23	Khor, Ramayah and Fouladgaran, 2020	x		x
24	Abbas and Farooquie, 2020			x

25	Kerdpitak *et al.*, 2020	x		
26	Sittisom and Mekhum, 2020		x	
27	van Giezen and Wiegmans, 2020	x		
28	Campos *et al.*, 2020	x	x	x
29	Beiler *et al.*, 2020	x	x	
30	Pushpamali, Agdas and Rose, 2020	x	x	
31	Gardas, Raut and Narkhede, 2019			x
32	Javed *et al.*, 2021	x	x	x
33	Hong and Huang, 2021		x	x
34	Richnák and Gubová, 2021			x
35	Baah *et al.*, 2021			x
36	Govindan and Gholizadeh, 2021			x
37	de Lorena Diniz Chaves *et al.*, 2021		x	x
38	Feng, Shen and Pei, 2021		x	x
39	Trujillo-Gallego, Sarache and Sellitto, 2021			
40	Barcelos *et al.*, 2021	x	x	x
41	Xu *et al.*, 2021	x		x
Total		25	12	26
Percentage		39,68%	19,05%	41,27%

From the sample, 26 articles are concerned with the economic dimension of sustainability, of which 8 are operational-related. And 25 articles presented environmental impacts. The dimension with fewer articles reporting impacts is the social (12 articles identified). These results are supported by the current literature which suggests a lack of attention to the social impacts of reverse logistics (Banihashemi, Fei and Chen, 2019; Sarkis, Helms and Hervani, 2010; Agrawal, Singh and Murtaza, 2016).

RL can be employed in many areas beyond manufacturing industries. Peretti et al. (2015) proposal is to apply commercial RL practices in a humanitarian operation context in order to “do no harm” and improve their activities to reduce the environmental footprint, as well as improve the social and economic impacts of their supply chain activities. Dias and Braga (2016) applied RL in a grocery retailed and found economics and environmental impacts improving the company’s image and reducing the amount of waste and the impact generated by the disposal of materials in landfills. With the active participation of the government, RL can also be an alternative even for cleaning the oceans (van Giezen and Wiegmans, 2020). But it is necessary to plan and design adequate RL strategies to be implemented, and analysing which is the best option for each sector or company in order to make an accurate decision (Pushpamali, Agdas and Rose, 2020).

Jalil et al. (2016) emphasize the impacts of RL to reduce the environmental footprint, natural resources and landfill disposal, adding it can help to decrease general pollution levels and improve recycling. Liang and Lee (2018) also bring the carbon footprint perspective – which also can be associated with the air pollution concern – as impacted by RL. Piyathanavong et al. (2019) show a tendency of responses towards pollution prevention, waste reduction and waste management. In another way, Narayana, Pati and Padhi (2019) advocate delays in the returns processes cause a detrimental impact on the environment and society – such as soil, water, and air pollution. Another author suggests RL is positively associated with general environmental outcomes (Khor, Ramayah and Fouladgaran, 2020). For Agrawal, Singh and Murtaza (2016) minimum energy consumption, optimum use of raw material, and transport optimization are the performance measures which have higher indexes from environmental performance perspectives. In social performance, community complaints and customer health and safety have higher performance indexes

Hong and Huang (2021) validate the RL relationship with social impacts and corporate image. Some studies pointed to job generation as having an impact on the social dimension (Brix-Asala, Hahn and Seuring, 2016; Slomski et al., 2018; Beiler *et al.*, 2020). Even in the informal sphere, RL provides income for value pickers (Brix-Asala, Hahn and Seuring, 2016; Beiler *et al.*, 2020). The general social performance is positively affected by RL (Sittisom and Mekhum, 2020; Hong and Huang, 2021) which is also connected with green human resources practices (Sittisom and Mekhum, 2020). However, the inclusion of waste pickers cooperatives, even partial, not only presents economic advantages and social sustainability for the network but also an increase in the revenue of the waste pickers cooperatives involved in this network (de Lorena Diniz Chaves *et al.*, 2021).

RL impacts the strategic and decision level as well (Agrawal and Singh, 2019), impacting positively strategies oriented by eco-reputation and eco-innovation (Hsu et al., 2016; Kerdpitak *et al.*, 2020) and the top management in general (Sirisawat and Kiatcharoenpol, 2019). Strategies environmentally driven are beneficial for RL and other green supply chain practices (Jayaram and Avittathur, 2015). According to Abbas and Farooquie (2020), a major driver for RL adoption is increased customer satisfaction and, consequently, it has as a perceived performance indicator the improvement of corporate image. This improvement in the corporate image also can lead the company to increase market competitiveness (Campos *et al.*, 2020) and financial performance (Baah *et al.*, 2021). Otherwise, research conducted by Richnák and Gubová (2021) in Slovakia shows the lowest percentage of analysed enterprises (6.7%) utilise green and reverse logistics to improve their image; most of the companies (35,2%) uses green logistics and reverse logistics to improve customer–supplier relationship, followed by the improvement of relations with government (31,5%).

RL can influence profits (Fernando *et al.*, 2017; Slomski *et al.*, 2018; Uriarte-Miranda *et al.*, 2018; Wang *et al.*, 2019; Khor, Ramayah and Fouladgaran, 2020) and economic and operational performance (Fernando and Tew, 2016; Morgan et al., 2018; Phoosawad et al., 2019; Gardas, Raut and Narkhede, 2019; Bag and Gupta, 2020; Baah *et al.*, 2021), RL also contribute to cost control (Brix-Asala, Hahn and Seuring, 2016; Fernando et al., 2017; Wang et al., 2019; Govindan and Gholizadeh, 2021), improve customer service (Tseng *et al.*, 2018; Richnák and Gubová, 2021), meet environmental pressures (Tseng *et al.*, 2018) and legal requirements (Sirisawat and Kiatcharoenpol, 2019; Richnák and Gubová, 2021), increase the return rate of used products (Wang et al., 2019), in the adoption of technological solutions (Sirisawat and Kiatcharoenpol, 2019) and improve the capacity utilization, delivery and product quality (Fernando and Tew, 2016; Morgan et al., 2018). Uriarte-Miranda et al. (2018) analyses the management of tire waste and found economic and environmental impacts as savings in energy and the re-manufacturing process.

Just two studies indicate no sustainable impact from RL (Rasit et al., 2019; Trujillo-Gallego, Sarache and Sellitto, 2021). According to Rasit *et al.* (2019) *"[...] Malaysian SMEs adopt GSCM practices mostly through eco-design and robust cooperation among departments* *in dealing with environmental issues. Green practices and reverse logistics practices are still new for SMEs and do not contribute to achieving better performance.".* For Trujillo-Gallego, Sarache and Sellitto (2021) *"The lack of support regarding the effect of reverse logistics on environmental collaboration can be explained by reverse logistics' status as an emerging environmental practice in developing countries".*

3.3 RL sustainable impacts classification

The impacts of RL on sustainability identified in the literature were structured following the three pillars as well (see Appendix A). In total, 35 impacts were extracted from the article sample: 17 environmental impacts, 12 economic impacts and 6 social impacts.

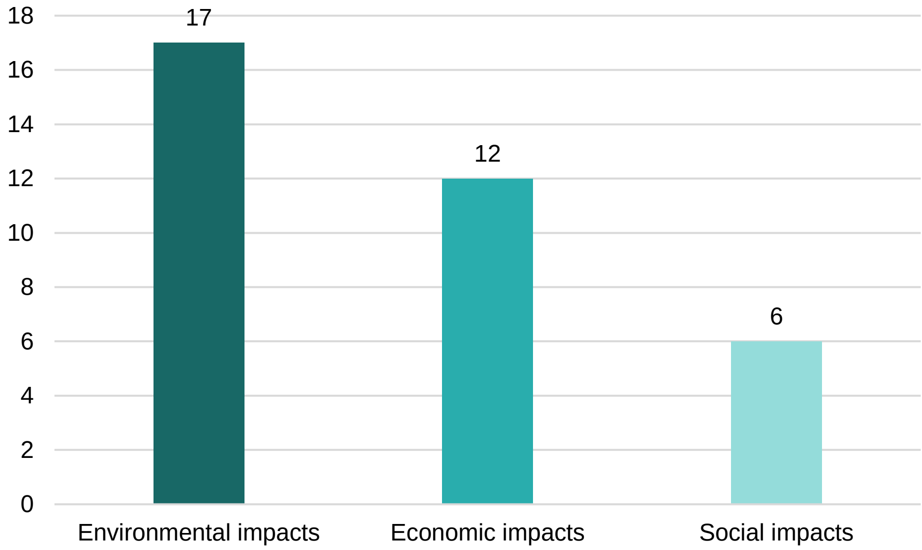


Fig. 6. Number of impacts per sustainability pillar.

It is important to notice although most articles cite economic impacts, some impacts are duplicated (appearing more than once in different articles). The environmental pillar of sustainability is the one with more distinct impacts identified (17 environmental impacts). As found in the first analyse, the social aspect is the least discussed; once again supported by the current literature which suggests a lack of attention to the social impacts of reverse logistics (Banihashemi, Fei and Chen, 2019; Sarkis, Helms and Hervani, 2010; Agrawal, Singh and Murtaza, 2016).

The impacts more cited is "improve profit and cost saving", followed by "improve the company's image and reputation", both from the economic pillar of sustainability as can be seen in Figure 8. The economic impacts had 43 citations in total, environmental impacts had 43 and social impacts had 17 (see Appendix A).

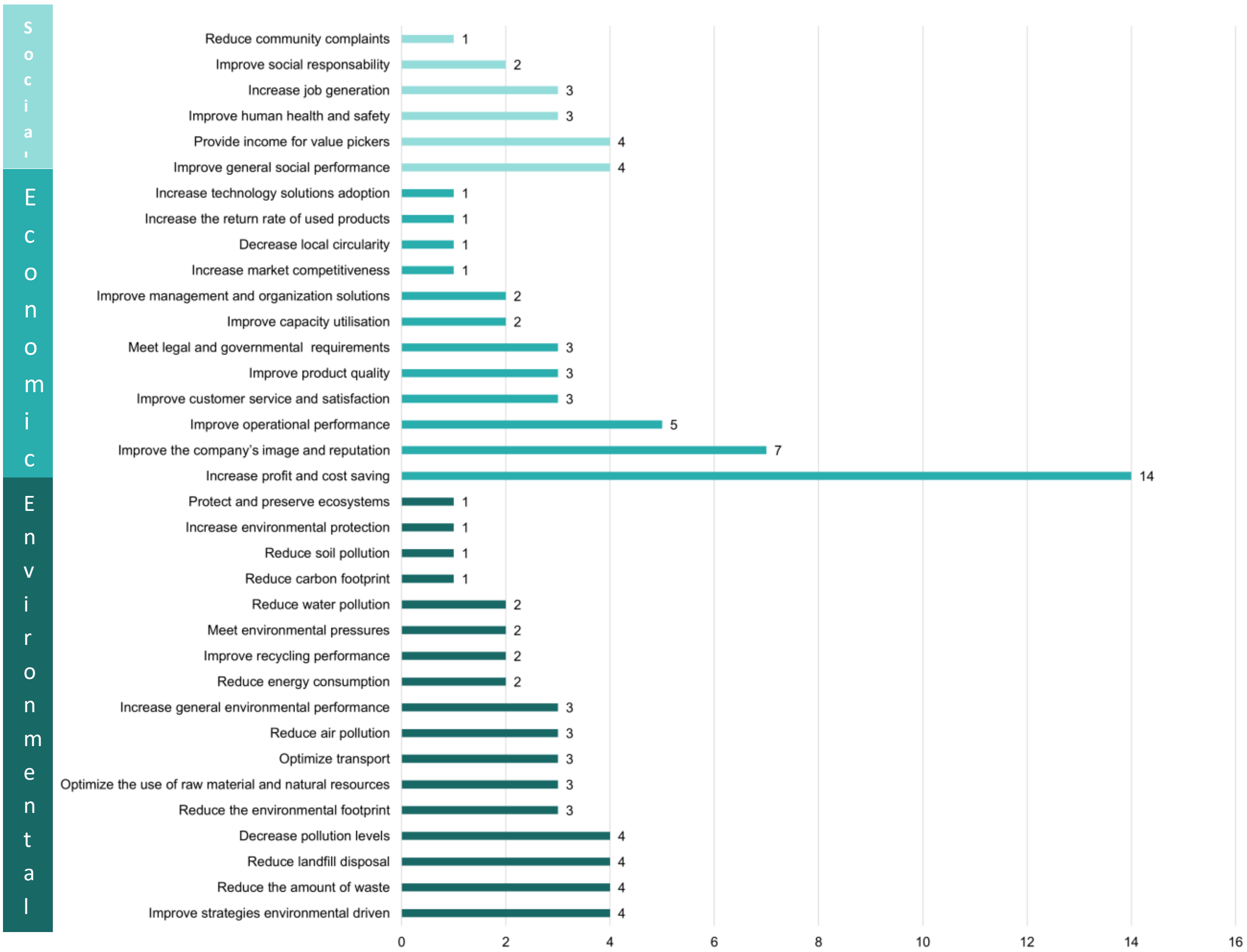


Fig. 7. RL impacts on sustainability.

The impacts were split into the three pillars and then the Pareto principle was applied, using the ‘frequency of citations occurrence of which impact. The Pareto principle or, more commonly, “the 80/20 rule”, states that for many events, roughly 80% of the effects come from 20% of the causes (Kiremire, 2011).

Figure 8 demonstrates all impacts according to the number of citations. 20 impacts (59% of the total of impacts) correspond to 80% of the total of citations. From these 20 impacts (*Increase profit and cost saving, Improve the company's image and reputation, Improve operational performance, Improve strategies environmentally driven, Reduce the amount of waste, Reduce landfill disposal, Decrease pollution levels, Improve general social performance, Provide income for value pickers, Reduce the environmental footprint, Optimize the use of raw material and natural resources, Optimize transport, Reduce air pollution, Increase general environmental performance, Improve customer service and satisfaction, Improve product quality, Meet legal and governmental requirements, Improve human health and safety, Increase job generation, Reduce energy consumption*), 10 are environmental, 6 are economic and 4 are social impacts.

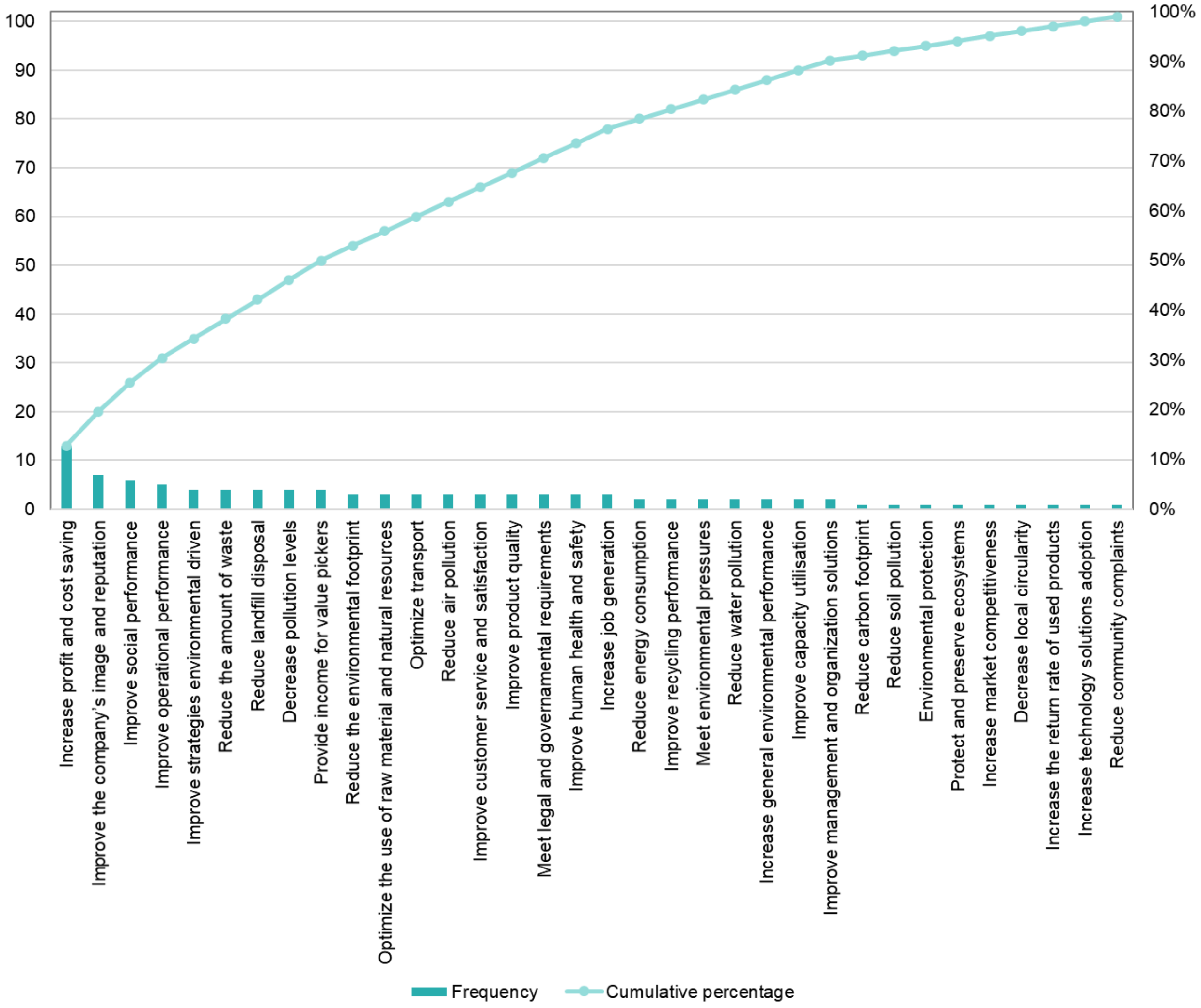


Fig. 8. RL impacts on sustainability.

In Figure 9 elucidate that *Improve strategies environmentally driven* is the major environmental impact of RL according to the number of citations. The first 11 impacts (65% of the total of environmental impacts) correspond to 81% of the total citations.

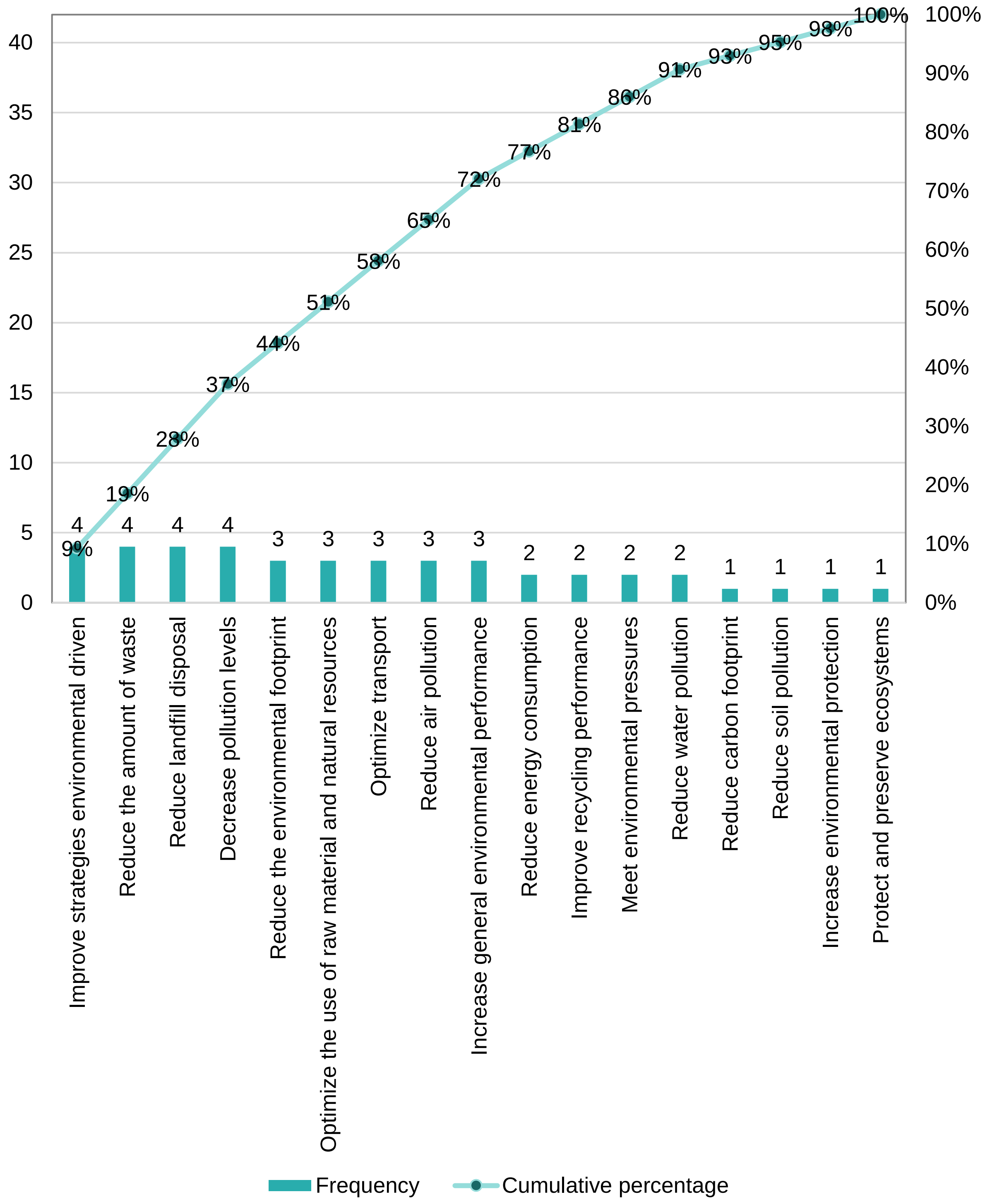


Fig. 9. RL environmental impacts on sustainability.

In Figure 10 is possible to see that Improve general social performance and Provide income for the value pickers are the major social impacts of RL according to the number of citations. And 4 impacts (66.66% of the total impacts) correspond to 82% of the total citations.

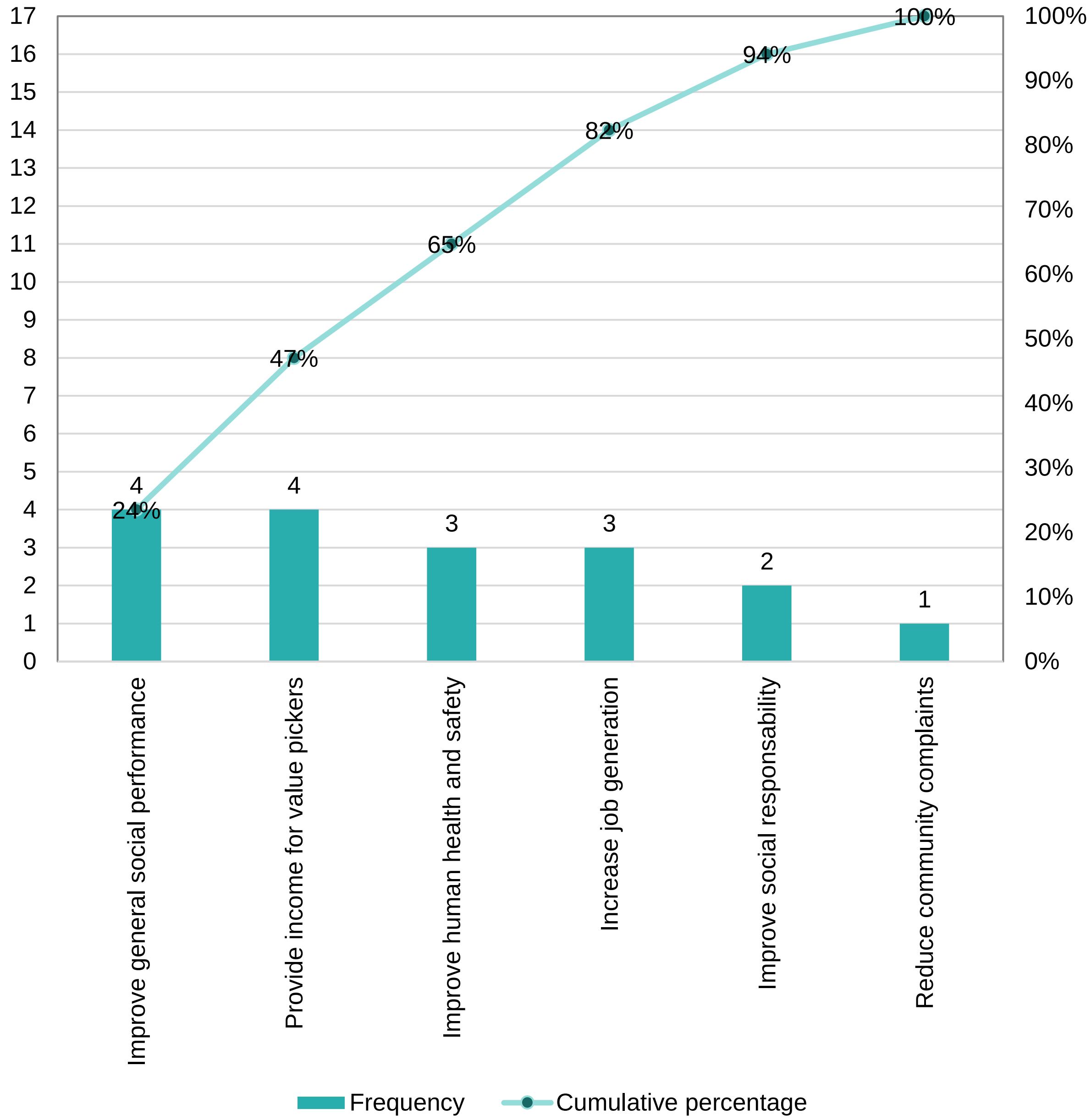


Fig. 10. RL social impacts on sustainability.

In Figure 11, Profit and cost saving is the major economic impact of RL according to the number of citations. 6 impacts (50% of the total of impacts) correspond to 81% of the total of citations.

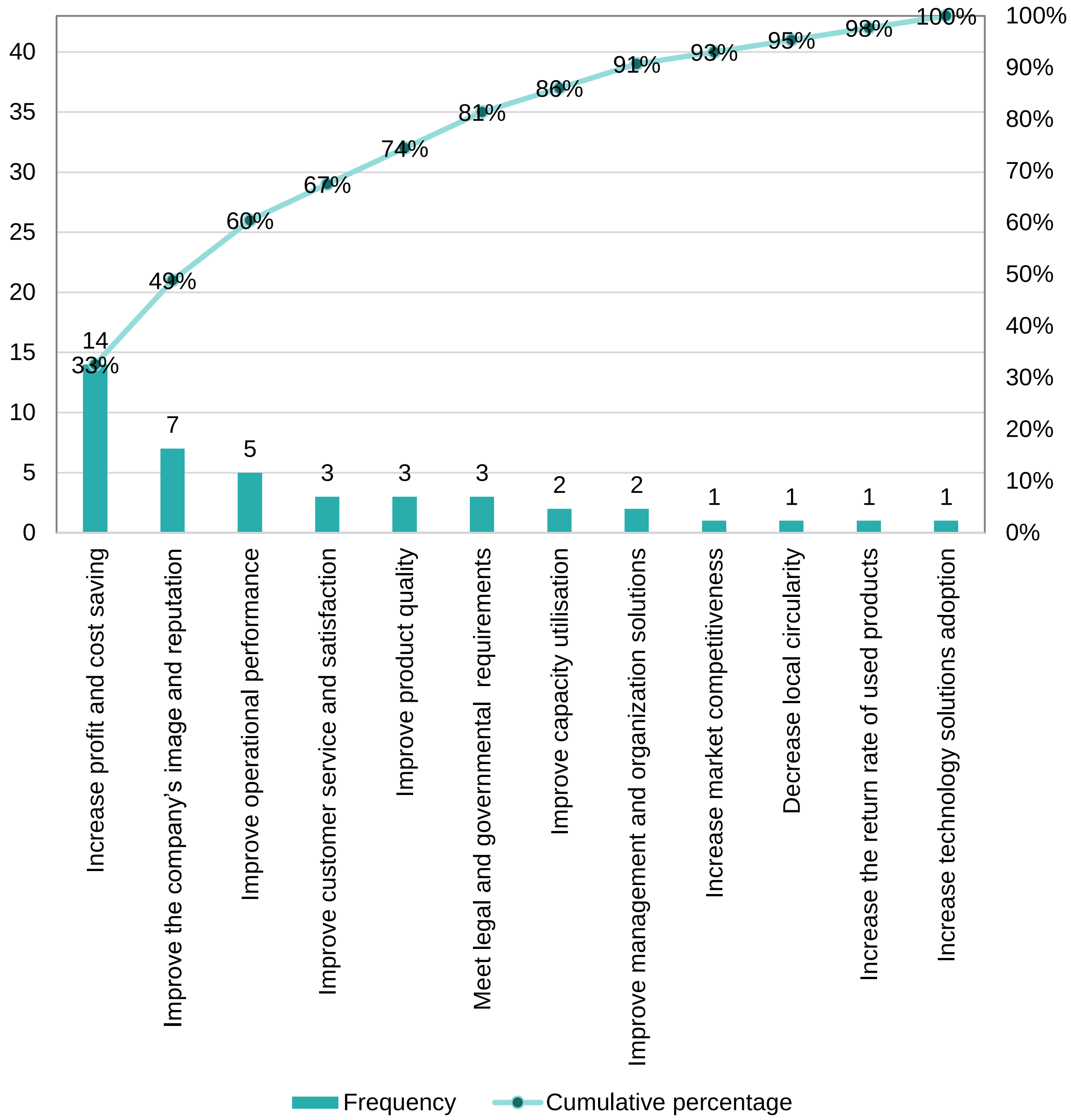


Fig. 11. RL economic impacts on sustainability.

4 DISCUSSIONS

RL can be employed and bring benefits for many areas, beyond manufacturing industries. Several studies (Peretti *et al.*, 2015; Dias and Braga, 2016; van Giezen and Wiegmans, 2020) reported sustainable contributions in diverse industries, such as humanitarian operations, grocery retail and in government actions to clean the oceans. It demonstrates how RL has a broad application and can improve sustainability in many ways. The sustainable impacts gathered and presented in this article are the result of different applications of RL and show that its adoption can increase the sustainable performance of different companies, organisations and governments.

During the bibliometric analysis, Brazil appears multiple times in the results, it is possible to relate it to the fact that the country has a National Solid Waste Policy – result of 21 years of discussions on the topic in the National Congress that address reverse logistics resolutions for supply chains (IBAMA, 2016). It demonstrates that the government has an important role in the adoption of RL and, consequently, in sustainable development.

For a better e deeper analysis, all the impacts found in the literature were split into the three pillars of sustainability and then the Pareto (Kiremire, 2011) was applied showing that 20 impacts (59% of the total of impacts) correspond to 80% of the total of citations. Of these 20 impacts, 10 are environmental, 6 are economic and 4 are social impacts. Besides the number of environmental impacts found, the economic aspect of sustainability still plays a major role having 42% of the total citations.

According to the number of citations, *Profit and cost saving*, *Improve strategies environmental driven* and *Improve general social performance* together with *Provide income for the value pickers* are the major economic, environmental and social impacts of RL, respectively. It is important to notice the most cited environmental impact is driven by organisational strategies and it could be related to the economic dimension as well, since its main concern is the benefit for the company in the first place. This demonstrates the growing usage of sustainability to increase profits.

There is a trend pointing towards a greater interest concerning the economic impacts of RL adoption. It can be a signal of the current increase in greenwashing, where companies adopt "green practices" – as RL – but do not act for real sustainable causes, just use those practices as a way to increase profits and improve the company image, as a new form of marketing (Astakhova, Reznikova and Astakhova, 2020).

As elucidated by previous research (Banihashemi, Fei and Chen, 2019; Sarkis, Helms and Hervani, 2010), the social dimension of sustainability is still not extensively explored in the literature. The impacts found are minimum if compared with other sustainability dimensions and the most cited social impact is general. The sustainability definition in RL is still an ongoing effort and that is possibly why social impacts are not so investigated in RL as the other two aspects. But actions such as the definition of the Sustainable Development Goals (SDGs) by the United Nations (Nations, 2015) bringing social goals in its core is a clear indication of evolution in this way. Besides that, some authors indicate the social performance is positively affected by RL (Sittisom and Mekhum, 2020; Hong and Huang, 2021), but the full incorporation of the social sustainability aspect could be an obstacle due to the high financial incentive required.

Just two studies found indicate no sustainable impact from RL (Rasit et al., 2019; Trujillo-Gallego, Sarache and Sellitto, 2021). But both explain that RL is still a new practice in some contexts, such as in SMEs and in developing countries. In other words, the positive impacts for sustainability through RL adoption, besides being many, still depend on how mature the context of the application is.

5 CONCLUSIONS

This paper mapped the impacts of RL on sustainability, collaborating with the knowledge construction about sustainable practices in supply chain management. The content analysis of the articles in this systematic review showed that there is a significant number of RL impacts reported by literature. The environmental pillar of sustainability is still the one with more impact found. However, when it comes to the number of citations, the economic pillar plays a major role. The social impacts reported by literature are still minimum, even with the great social contributions pointed to human welfare.

Regarding the initial RQ (RQ1: "What are the sustainable impacts generated by RL?" and "RQ2: Which dimensions of sustainability are the most impacted by RL?"), it was found 35 impacts of RL on sustainability, of which 17 are environmental impacts, 12 are economic impacts and 6 are social impacts. But, besides that, the largest number of citations are about the economic impacts. Taking into account all three dimensions, the most cited impact was "improve profit and cost savings".

The Pareto analysis showed that 20 impacts (59% of the total impacts found) correspond to 80% of the total citations. These 20 impacts are: *Increase profit and cost saving, Improve the company's image and reputation, Improve operational performance, Improve strategies environmentally driven, Reduce the amount of waste, Reduce landfill disposal, Decrease pollution levels, Improve general social performance, Provide income for value pickers, Reduce the environmental footprint, Optimize the use of raw material and natural resources, Optimize transport, Reduce air pollution, Increase general environmental performance, Improve customer service and satisfaction, Improve product quality, Meet legal and governmental requirements, Improve human health and safety, Increase job generation, Reduce energy consumption*. Of these impacts that represent 80% of citations, 10 are environmental, 6 are economic and 4 are social impacts; but the economic pillar of sustainability still has the most citations.

The results indicate that RL has great positive impacts on all three dimensions of sustainability. Besides the intuitive impacts of RL on the environment; for practitioners, the adoption of RL can increase profits and cost savings. Plus, it can also generate jobs and benefit the community and stakeholders. Even if the social pillar of sustainability is not a primary concern for companies, it is necessary to incentive the measuring of this aspect and consolidate it as a sustainability dimension of equal importance.

Future studies may seek to focus on the social dimension of sustainability to identify more RL impacts. It can be achieved by adopting methodologies such as social life cycle assessment (SLCA); to have more empirical evidence and contribute to the knowledge in social sustainability, since RL can have important benefits to this dimension, and, consequently, to the entire society as well.

REFERENCES

Abbas, H. and Farooquie, J. A. (2020) 'Reverse logistics practices in Indian pharmaceutical supply chains: A study of manufacturers', *International Journal of Logistics Systems and Management*, 35(1), pp. 72–89. doi: 10.1504/IJLSM.2020.103863.

Agrawal, S. and Singh, R. K. (2019) 'Analyzing disposition decisions for sustainable reverse logistics: Triple Bottom Line approach', *Resources, Conservation and Recycling*, 150(August), p. 104448. doi: 10.1016/j.resconrec.2019.104448.

Agrawal, S., Singh, R. K. and Murtaza, Q. (2016) 'Triple bottom line performance evaluation of reverse logistics', *Competitiveness Review*, 26(3), pp. 289–310. doi: 10.1108/CR-04-2015-0029.

Astakhova, I., Reznikova, T. and Astakhova, E. (2020) 'Greenwashing as a form of modern eco-marketing', *Acta Innovations*, 34(5), pp. 5–12.

Baah, C. *et al.* (2021) 'Examining the Interconnections Between Sustainable Logistics Practices, Environmental Reputation and Financial Performance: A Mediation Approach', *Vision*, 25(1), pp. 47–64. doi: 10.1177/0972262920988805.

Bag, S. and Gupta, S. (2020) 'Examining the effect of green human capital availability in adoption of reverse logistics and remanufacturing operations performance', *International Journal of Manpower*, 41(7), pp. 1097–1117. doi: 10.1108/IJM-07-2019-0349.

Banihashemi, T. A., Fei, J. and Chen, P. S.-L. (2019) 'Exploring the relationship between reverse logistics and sustainability performance', *Modern Supply Chain Research and Applications*, 1(1), pp. 2–27. doi: 10.1108/mscra-03-2019-0009.

Barcelos, S. M. B. D. *et al.* (2021) 'Circularity of Brazilian silk: Promoting a circular bioeconomy in the production of silk cocoons', *Journal of Environmental Management*, 296(April), p. 113373. doi: 10.1016/j.jenvman.2021.113373.

Beiler, B. C. *et al.* (2020) 'Reverse logistics system analysis of a Brazilian beverage company: An exploratory study', *Journal of Cleaner Production*, 274. doi: 10.1016/j.jclepro.2020.122624.

Brix-Asala, C., Hahn, R. and Seuring, S. (2016) 'Reverse logistics and informal valorisation at the Base of the Pyramid: A case study on sustainability synergies and trade-offs', *European Management Journal*, 34(4), pp. 414–423. doi: 10.1016/j.emj.2016.01.004.

Campos, E. A. R. de *et al.* (2020) 'The effect of collaboration and IT competency on reverse logistics competency - Evidence from Brazilian supply chain executives', *Environmental Impact Assessment Review*, 84(March), p. 106433. doi: 10.1016/j.eiar.2020.106433.

Dias, K. T. S. and Braga, S. S. (2016) ‘The use of reverse logistics for waste management in a Brazilian grocery retailer’, *Waste Management and Research*, 34(1), pp. 22–29. doi: 10.1177/0734242X15615696.

Earth Overshoot Day (2020) *About Earth Overshoot Day*. Available at: https://www.overshootday.org/about-earth-overshoot-day/.

Elkington, J. (1998) ‘Partnerships from Cannibals with Forks: The Triple Bottom line of 21st - Century Business’, *Environmental Quality Management*, 8(1), pp. 37–51.

Feng, D., Shen, C. and Pei, Z. (2021) ‘Production decisions of a closed-loop supply chain considering remanufacturing and refurbishing under government subsidy’, *Sustainable Production and Consumption*, 27, pp. 2058–2074. doi: 10.1016/j.spc.2021.04.034.

Fernando, Y. *et al.* (2017) ‘The effects of reverse logistics on cost control abilities: An insight into manufacturing companies in Malaysia’, *International Journal of Value Chain Management*, 8(4), pp. 285–306. doi: 10.1504/IJVCM.2017.089377.

Fernando, Y. and Tew, M. M. (2016) ‘Reverse logistics in manufacturing waste management: The missing link between environmental commitment and operational performance’, *International Journal of Integrated Supply Management*, 10(3–4), pp. 264–282. doi: 10.1504/IJISM.2016.081273.

Frei, R., Jack, L. and Brown, S. (2020) ‘Product returns: a growing problem for business, society and environment’, *International Journal of Operations and Production Management*, 40(10), pp. 1613–1621. doi: 10.1108/IJOPM-02-2020-0083.

Gardas, B. B., Raut, R. D. and Narkhede, B. (2019) ‘Determinants of sustainable supply chain management: A case study from the oil and gas supply chain’, *Sustainable Production and Consumption*, 17, pp. 241–253. doi: 10.1016/j.spc.2018.11.005.

van Giezen, A. and Wiegmans, B. (2020) ‘Spoilt - Ocean Cleanup: Alternative logistics chains to accommodate plastic waste recycling: An economic evaluation’, *Transportation Research Interdisciplinary Perspectives*, 5, p. 100115. doi: 10.1016/j.trip.2020.100115.

Govindan, K. and Gholizadeh, H. (2021) ‘Robust network design for sustainable-resilient reverse logistics network using big data: A case study of end-of-life vehicles’, *Transportation Research Part E: Logistics and Transportation Review*, 149(February), p. 102279. doi: 10.1016/j.tre.2021.102279.

Guarnieri, P. (2014) *Logística Reversa*. Clube de Autores (managed).

Hami, N., Muhamad, M. R. and Ebrahim, Z. (2015) ‘The impact of sustainable manufacturing practices and innovation performance on economic sustainability’, *Procedia CIRP*, 26, pp.

190–195. doi: 10.1016/j.procir.2014.07.167.

Hong, S. Q. and Huang, Y. J. (2021) 'Relationship among reverse logistics, corporate image and social impact in medical device industry', *Revista de Cercetare si Interventie Sociala*, 72, pp. 109–121. doi: 10.33788/rcis.72.7.

Hsu, C.-C. *et al.* (2016) 'Strategic orientations, sustainable supply chain initiatives, and reverse logistics: Empirical evidence from an emerging market', *International Journal of Operations & Production Management*, 36(1), p. 360. Available at: https://www.emeraldinsight.com/doi/pdfplus/10.1108/IJOPM-06-2014-0252.

IBAMA (2016) *Política Nacional de Resíduos Sólidos (PNRS)*. Available at: http://www.ibama.gov.br/residuos/controle-de-residuos/politica-nacional-de-residuos-solidos-pnrs.

Jalil, E. E. A. *et al.* (2016) 'Reverse logistics in household recycling and waste systems: a symbiosis perspective', *Supply Chain Management: An International Journal*, 21(2). Available at: https://doi.org/10.1108/13598540910954539.

Jamali, D. (2006) 'Insights into triple bottom line integration from a learning organization perspective', *Business Process Management Journal*, 12(6), pp. 809–821. doi: 10.1108/14637150610710945.

Javed, H. *et al.* (2021) 'Exploring disposition decision for sustainable reverse logistics in the era of a circular economy: Applying the triple bottom line approach in the manufacturing industry', *International Journal of Supply and Operations Management*, 8(1), pp. 53–68. doi: 10.22034/IJSOM.2021.1.5.

Jayaram, J. and Avittathur, B. (2015) 'Green supply chains: A perspective from an emerging economy', *International Journal of Production Economics*, 164, pp. 234–244. doi: 10.1016/j.ijpe.2014.12.003.

Keeble, B. R. (1988) 'The Brundtland Report: "Our Common Future"', *Medicine and War*, 4(1), pp. 17–25. doi: 10.1080/07488008808408783.

Kerdpitak, C. *et al.* (2020) 'The mediating role of sustainable supply chain in the relationship between ECO-strategic orientation and the reverse logistic in Thai electronic industry', *International Journal of Supply Chain Management*, 9(1), pp. 10–18.

Khor, K.-S., Ramayah, T. and Fouladgaran, H. R. P. (2020) 'Managing eco-design for reverse logistics Thurasamy Ramayah Hamid Reza Panjeh Fouladgaran', *International Journal of Environment and Waste Management*, 26(2), pp. 125–146.

Kiremire, A. R. (2011) 'The application of the pareto principle in software engineering',

Consulted January, 13, p. 2016.
Liang, C. C. and Lee, J. P. (2018) 'Carbon footprint model for reverse logistics of waste disposal in interior design industry', *Asia Pacific Journal of Marketing and Logistics*, 30(4), pp. 889–906. doi: 10.1108/APJML-01-2018-0035.
de Lorena Diniz Chaves, G. *et al.* (2021) 'Synergizing environmental, social, and economic sustainability factors for refuse derived fuel use in cement industry: A case study in Espirito Santo, Brazil', *Journal of Environmental Management*, 288(February), p. 112401. doi: 10.1016/j.jenvman.2021.112401.
Mafini, C. and Loury-Okoumba, W. V. (2018) 'Extending green supply chain management activities to manufacturing small and medium enterprises in a developing economy', *South African Journal of Economic and Management Sciences*. doi: 10.4102/sajems.v21i1.1996.
Moher, D. *et al.* (2009) 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement', *PLoS Med*.
Mongeon, P. and Paul-Hus, A. (2016) 'The journal coverage of Web of Science and Scopus: a comparative analysis', *Scientometrics*, 106(1), pp. 213–228. doi: 10.1007/s11192-015-1765-5.
Morgan, T. R. *et al.* (2018) 'Resource commitment and sustainability: a reverse logistics performance process model', *International Journal of Physical Distribution and Logistics Management*, 48(2), pp. 164–182. doi: 10.1108/IJPDLM-02-2017-0068.
Narayana, S. A., Pati, R. K. and Padhi, S. S. (2019) 'Market dynamics and reverse logistics for sustainability in the Indian Pharmaceuticals industry', *Journal of Cleaner Production*, 208, pp. 968–987. doi: 10.1016/j.jclepro.2018.10.171.
Nations, U. (2015) *The 17 Goals*. Available at: https://sdgs.un.org/goals.
Peretti, U. *et al.* (2015) 'Reverse logistics in humanitarian operations: challenges and opportunities', *Journal of Humanitarian Logistics and Supply Chain Management*, 5(2), pp. 253–274.
Phoosawad, P. *et al.* (2019) 'Impacts of collaboration networks, operational performance and reverse logistics determinants on the performance outcomes of the auto parts industry', *Management and Production Engineering Review*, 10(3), pp. 61–72. doi: 10.24425/mper.2019.129599.
Piyathanavong, V. *et al.* (2019) 'The adoption of operational environmental sustainability approaches in the Thai manufacturing sector', *Journal of Cleaner Production*, 220, pp. 507–528. doi: 10.1016/j.jclepro.2019.02.093.
Pullin, A. S. and Stewart, G. B. (2006) 'Guidelines for systematic review in conservation and

environmental management', *Conservation Biology*, 20(6), pp. 1647–1656. doi: 10.1111/j.1523-1739.2006.00485.x.

Purvis, B., Mao, Y. and Robinson, D. (2019) 'Three pillars of sustainability: in search of conceptual origins', *Sustainability Science*, 14(3), pp. 681–695. doi: 10.1007/s11625-018-0627-5.

Pushpamali, N. N. C., Agdas, D. and Rose, T. M. (2020) 'Strategic Decision Making in Construction Supply Chains: A Comparison of Reverse Logistics Strategies', *Frontiers in Built Environment*, 6(December). doi: 10.3389/fbuil.2020.593372.

Rasit, Z. A. *et al.* (2019) 'Green Supply Chain Management (GSCM) practices for sustainability performance: An empirical evidence of Malaysian SMEs', *International Journal of Financial Research*, 10(3), pp. 371–379. doi: 10.5430/ijfr.v10n3p371.

Richnák, P. and Gubová, K. (2021) 'Green and reverse logistics in conditions of sustainable development in enterprises in Slovakia', *Sustainability (Switzerland)*, 13(2), pp. 1–23. doi: 10.3390/su13020581.

Sarkis, J., Helms, M. M. and Hervani, A. A. (2010) 'Reverse Logistics and Social Sustainability', *Corporate Social Responsibility and Environmental Management*, 354(January), pp. 337–354.

Schroeder, P., Anggraeni, K. and Weber, U. (2019) 'The Relevance of Circular Economy Practices to the Sustainable Development Goals', *Journal of Industrial Ecology*, 23(1), pp. 77–95. doi: 10.1111/jiec.12732.

Sellitto, M. A., Camfield, C. G. and Buzuku, S. (2020) 'Green innovation and competitive advantages in a furniture industrial cluster: A survey and structural model', *Sustainable Production and Consumption*, 23, pp. 94–104. doi: 10.1016/j.spc.2020.04.007.

Sirisawat, P. and Kiatcharoenpol, T. (2019) 'Correlation of Reverse Logistics Performance to Solutions Using Structural Equation Modeling', *Journal of Advanced Manufacturing Systems*, 18(4), pp. 511–525. doi: 10.1142/S0219686719500276.

Sittisom, W. and Mekhum, W. (2020) 'External supply chain management factors and social performance in Thai manufacturing industry: Moderating role of green human resource practices', *International Journal of Supply Chain Management*, 9(1), pp. 190–198.

Slomski, V. *et al.* (2018) 'A disclosure of social and environmental results/economy resulting from the implementation of reverse logistics and final disposal of the post-consumption product: The case of computer peripherals industry', *Environmental Quality Management*, 27(3), pp. 73–87. doi: 10.1002/tqem.21530.

Tranfield, D., Denyer, D. and Smart, P. (2003) ‘Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review’, *British Journal of Management*, 14, pp. 207–222.

Trujillo-Gallego, M., Sarache, W. and Sellitto, M. A. (2021) ‘Identification of practices that facilitate manufacturing companies’ environmental collaboration and their influence on sustainable production’, *Sustainable Production and Consumption*, 27, pp. 1372–1391. doi: 10.1016/j.spc.2021.03.009.

Tseng, M. L. *et al.* (2018) ‘A framework for evaluating the performance of sustainable service supply chain management under uncertainty’, *International Journal of Production Economics*, 195, pp. 359–372. doi: 10.1016/j.ijpe.2016.09.002.

UNIDO (2015) ‘The 2030 Agenda for Sustainable Development: Achieving the industry-related goals and targets’, *Sustainable Development Knowledge Platform*. Available at: https://sustainabledevelopment.un.org/?menu=1300.

Uriarte-Miranda, M. L. *et al.* (2018) ‘Reverse logistic strategy for the management of tire waste in Mexico and Russia: Review and conceptual model’, *Sustainability (Switzerland)*, 10(10). doi: 10.3390/su10103398.

VOSviewer (2021) *VOSviewer*. Available at: https://www.vosviewer.com/.

Wang, W. *et al.* (2019) ‘Assessing the cost structure of component reuse in a product family for remanufacturing’, *Journal of Intelligent Manufacturing*, 30(2), pp. 575–587. doi: 10.1007/s10845-016-1267-1.

Xu, Z. *et al.* (2021) ‘Robust global reverse logistics network redesign for high-grade plastic wastes recycling’, *Waste Management*, 134(October 2020), pp. 251–262. doi: 10.1016/j.wasman.2021.08.024.

Zupic, I. and Čater, T. (2015) ‘Bibliometric Methods in Management and Organization’, *Organizational Research Methods*, 18(3), pp. 429–472. doi: 10.1177/1094428114562629.

APPENDIX

Appendix A

	Improve strategies environmental driven	Reduce the environmental footprint	Reduce the amount of waste	Reduce energy consumption	Optimize the use of raw material and natural resources	Optimize transport	Improve recycling performance	Reduce landfill disposal	Decrease pollution levels	Meet environmental pressures	Reduce carbon footprint	Reduce soil pollution	Reduce air pollution	Reduce water pollution	Increase environmental protection	Protect and preserve ecosystems	Increase general environmental performance	Decrease local circularity	Improve the company's image and reputation	Improve customer service and satisfaction	Increase profit and cost saving	Increase the return rate of used products	Improve operational performance	Improve product quality	Improve capacity utilisation	Improve management and organization solutions	Meet legal and governmental requirements	Increase technology solutions adoption	Increase market competitiveness	Reduce community complaints	Improve human health and safety	Provide income for value pickers	Increase job generation	Improve general social performance	Improve social responsability
Jayaram and Avittathur, 2015	x																																		
Peretti *et al.* , 2015		x																																	
Agrawal, Singh and Murtaza, 2016				x	x	x															x									x	x				
Fernando and Tew, 2016			x			x																	x	x	x										
Dias and Braga, 2016			x					x											x		x					x									
Hsu *et al.* , 2016	x																		x																
Jalil *et al.* , 2016		x			x		x	x	x																										
Brix-Asala, Hahn and Seuring, 2016		x																														x	x		
Fernando *et al.* , 2017																					x														
Morgan *et al.* , 2018						x																	x	x	x										
Tseng *et al.* , 2018										x										x															
Slomski *et al.* , 2018								x													x											x	x		
Liang and Lee, 2018									x		x		x																						
Uriarte-Miranda *et al.* , 2018			x	x																	x			x											
Phoosawad *et al.* , 2019																							x												
Narayana, Pati and Padhi, 2019												x	x	x																					
Wang *et al.* , 2019																					x	x													
Rasit *et al.* , 2019																																			
Piyathanavong *et al.* , 2019			x						x																										
Agrawal and Singh, 2019	x																																		
Bag and Gupta, 2020																							x												
Sirisawat, P., Kiatcharoenpol, T.																										x	x	x							
Khor, K.-S., Ramayah, T., Fouladgaran, H.R.P.																	x				x														
Abbas, H., Farooquie, J.A.																			x	x															
Kerdpitak, C., Chakphet, T., Maneechay, S., Jaepho, S.	x																																		
Sittisom, W., Mekhum, W.																																		x	
van Giezen, A., Wiegmans, B.														x																					
Campos, E.A.R.D., Paula, I.C.D., Caten, C.S.T., Maçada, A.C.G., Marôco, J., Ziegelmann, P.K.									x	x					x				x		x						x		x						x

Beiler, B.C., Ignácio, P.S.D.A., Pacagnella Júnior, A.C., Anholon, R., Rampasso, I.S.							x																									x	x		
Pushpamali, N.N.C., Agdas, D., Rose, T.M.					x			x								x															x				
Gardas, BB (Gardas, Bhaskar B.); Raut, RD (Raut, Rakesh D.); Narkhede, B (Narkhede, Balkrishna)																							x												
Javed H., Firdousi S.F., Murad M., Jiatong W., Abrar M.																	x				x													x	
Hong S.-Q., Huang Y.-J.																			x																x
Richnák P., Gubová K.																			x	x							x								
Baah C., Amponsah K.T., Issau K., Ofori D., Acquah I.S.K., Agyeman D.O.																			x		x														
Govindan K., Gholizadeh H.																					x														
de Lorena Diniz Chaves G., Siman R.R., Ribeiro G.M., Chang N.-B.																					x											x		x	
Feng D., Shen C., Pei Z.																					x													x	
Trujillo-Gallego M., Sarache W., Sellitto M.A.																																			
Barcelos S.M.B.D., Salvador R., Barros M.V., de Francisco A.C., Guedes G.																	x	x													x				
Xu, ZT., Elomri, A., Liu, WJ., Liu, H., Li, M.													x								x														
Total	4	3	4	2	3	3	2	4	4	2	1	1	3	2	1	1	3	1	7	3	14	1	5	3	2	2	3	1	1	1	3	4	3	4	2

CHAPTER III: ARTICLE #2 CONNECTING REVERSE LOGISTICS IMPACTS AND THE SUSTAINABLE DEVELOPMENT GOALS

ABSTRACT: Sustainability is a growing theme that has gained traction with the Sustainable Development Goals (SDGs) from the United Nations, thus it is increasingly important to discuss practices that help in achieving these goals. Reverse logistics is an important part of the circular economy and is commonly associated with sustainability by scholars and practitioners. However, little research has been done to connect these topics, being especially scarce when it comes to the intersection of RL and SDGs. Therefore, this study aims to investigate the relationship between reverse logistics and the SDGs. In this context, we employ literature review, expert elicitation and VIKOR method to identify, rank and define the most impacted SDGs by reverse logistics. It was found that SDG 12 (Sustainable Consumption and Production) is the objective most benefited from the adoption of reverse logistics. In addition, results suggest that, from the expert's perspective, the impact of RL in increasing profits and savings – despite being extensively stressed by literature –is not pointed out as an important impact to help to achieve the SDGs. In the end, some directions for future research are provided.

KEYWORDS: Reverse logistics, Sustainable Development Goals, expert elicitation, VIKOR, sustainability.

1 INTRODUCTION

The concept of sustainability is increasingly receiving attention in operations management, due to the fact that can help in the transition to a circular economy (Bag and Pretorius, 2020). Investments in sustainable practices help manufacturers to build up a responsible image and improve their overall sustainable performance in economic and environmental dimensions (Allaoui, Guo and Sarkis, 2019).

Reverse logistics is one of the main foundations of circular economy practices (Hopkinson, De Angelis and Zils, 2020), since it plays a strategic role in the recovery of used products enabling circular systems, inputs and flows (Bag and Pretorius, 2020; Julianelli *et al.*, 2020). Consequently, reverse logistics is usually associated with sustainability (Sellitto, Camfield and Buzuku, 2020; Trujillo-Gallego, Sarache and Sellitto, 2021) and it can be considered important to the achievement of the Sustainable Development Goals (SDGs).

Sustainability is usually described as environmental, social and economic concerns combined – known as the Triple Bottom Line (TBL) –, but there is a lack of theoretically rigorous description of these three pillars (Purvis, Mao and Robinson, 2019). The SDGs by the United Nations have turned it more specific and split sustainability into 17 goals and time-bound targets for Prosperity, People, Planet, Peace and Partnership – known as the five Ps (Sachs *et al.*, 2019). The SDGs has one specific goal for manufacturers: *Goal 12 - Ensure sustainable consumption and production patterns*, however, manufacturing systems can potentially contribute to a far wider range of SDGs (Leurent and Abbosh, 2018; Schroeder, Anggraeni and Weber, 2019).

Transformations in reverse logistics can dramatically change operations and have opportunities for improving sustainability and circular economy (Sun, Yu and Solvang, 2022), being a valid option to promote and help to achieve the SDGs. The adoption of RL can make a significant contribution to improving the sustainability performance of firms (Banihashemi, Fei and Chen, 2019a) and consequently contribute to their participation in the Agenda 2030 of the SDGs.

Although the significant contributions of reverse logistics to sustainability, little research has been undertaken on exploring the relationship between them (Banihashemi, Fei and Chen, 2019a), thus more empirical evidence is necessary to link circular practices in manufacturing to the SDGs (Schroeder, Anggraeni and Weber, 2019). Besides research in this field being limited, there are some studies connecting reverse logistics and the TBL. However, to the best of our knowledge, there is no study linking reverse logistics impacts with the SDGs.

Therefore, this study seeks to answer the following research questions (RQ):

- RQ1: Which SDGs are the most impacted by reverse logistics adoption?
- RQ2: How reverse logistics can contribute to sustainable development?

In this context – of the limited number of papers exploring the relationship between reverse logistics and sustainability (Banihashemi, Fei and Chen, 2019a) and no articles linking reverse logistics and the SDGs – this study aims to empirically investigate the relationship between reverse logistics and the SDGs using expert elicitation, which is a method for situations under uncertainty to extract subjective judgements from experts (Refsgaard *et al.*, 2007). Expert elicitation can be remarkably useful when data are absent, and expert knowledge can increase the precision of models and facilitate informed decision-making in a cost-effective manner (Kuhnert, Martin and Griffiths, 2010).

Furthermore, expert elicitation has been encouraged to link practices and concepts to the SDGs (Fuso Nerini *et al.*, 2018; Fuso Nerini *et al.*, 2019; Vinuesa *et al.*, 2020). To minimize and overcome problems and biases inherent to the method, the structured protocol IDEA was adopted (Hemming *et al.*, 2018). After collecting the data through the expert elicitation using the IDEA protocol, the analyses of the data were done in order to rank the SDGs and define which are the most impacted by reverse logistics. To create this rank, the multiple criteria decision-making VIKOR (*VlseKriterijuska Optimizacija I Komoromisno Resenje*) method was adopted – which is commonly used to evaluate and compare the sustainability of solutions or technologies. VIKOR was chosen cause is a method to consistently rank options and multi-criteria decision-making methods usually provide simple and intuitive tools for making decisions on problems that involve uncertain and subjective information (Mardani *et al.*, 2016).

This paper is organized as follows: after this introduction, Section 2 briefly presents the literature background; Section 3 explains the methodology employed to perform the expert elicitation and the corresponding analysis; Section 4 depicts the results; Section 5 brings the discussion; and, finally, Section 6 outlines some conclusions and propose directions for future research.

2 LITERATURE BACKGROUND

2.1 Empirical evidence of reverse logistics impacts

Although reverse logistics has gained prominence recently and has been boosted with the SDGs, it is not new. According to Rogers and Tibben-Lembke (1998), reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value or proper disposal and its adoption can generate benefits – these results of reverse logistics adoptions will be called *impacts* along this study.

Empirical evidence of reverse logistics impacts found in the literature was split into the TBL to enable the following analysis of reverse logistics contributions to sustainability and, consequently, to the SDGs' achievement. Table 1 shows the authors, the reported impacts and the dimension of sustainability explored.

Table 1. Reverse logistics sustainable impacts summary.

Item	Authors	TBL dimension	Reported impacts
1	Jayaram and Avittathur, 2015	Environmental	Improve strategies environmentally driven
2	Peretti *et al.*, 2015	Environmental	Reduce the environmental footprint

3	Agrawal, Singh and Murtaza, 2016	Environmental, Social and Economic	Reduce energy consumption, Optimize the use of raw material and natural resources, Optimize transport, Increase profit and cost saving, Reduce community complaints and Improve human health and safety
4	Fernando and Tew, 2016	Environmental and economic	Reduce the amount of waste, Optimize transport, Improve operational performance, Improve product quality and Improve capacity utilisation
5	Dias and Braga, 2016	Environmental and economic	Reduce the amount of waste, Reduce landfill disposal, Improve the company's image and reputation, Increase profit and cost saving, Improve management and organization solutions
6	Hsu *et al.*, 2016	Environmental and economic	Improve strategies environmentally driven, Improve the company's image and reputation
7	Jalil *et al.*, 2016	Environmental	Reduce the environmental footprint, Optimize the use of raw material and natural resources, Improve recycling performance, Reduce landfill disposal, Decrease pollution levels
8	Brix-Asala, Hahn and Seuring, 2016	Environmental and social	Reduce the environmental footprint, Provide income for value pickers, Increase job generation
9	Fernando *et al.*, 2017	Economic	Increase profit and cost saving
10	Morgan *et al.*, 2018	Environmental and economic	Optimize transport, Improve operational performance, Improve product quality, Improve capacity utilisation
11	Tseng *et al.*, 2018	Environmental and economic	Meet environmental pressures, Improve customer service and satisfaction
12	Slomski *et al.*, 2018	Environmental, social and economic	Reduce landfill disposal, Increase profit and cost saving, Provide income for value pickers, Increase job generation
13	Liang and Lee, 2018	Environmental	Decrease pollution levels, Reduce carbon footprint, Reduce air pollution
14	Uriarte-Miranda *et al.*, 2018	Environmental and economic	Reduce the amount of waste, Reduce energy consumption, Increase profit and cost saving, Improve product quality
15	Phoosawad *et al.*, 2019	Economic	Improve operational performance
16	Narayana, Pati and Padhi, 2019	Environmental	Reduce soil pollution, Reduce air pollution, Reduce water pollution
17	Wang *et al.*, 2019	Economic	Increase profit and cost saving, Increase the return rate of used products
18	Piyathanavong *et al.*, 2019	Environmental	Reduce the amount of waste, Decrease pollution levels
19	Agrawal and Singh, 2019	Environmental	Improve strategies environmentally driven
20	Bag and Gupta, 2020	Economic	Improve operational performance
21	Sirisawat and Kiatcharoenpol, 2019	Economic	Improve management and organization solutions, Meet legal and governmental requirements, and Increase technology solutions adoption

22	Khor, Ramayah and Fouladgaran, 2020	Environmental and economic	Increase general environmental performance, Increase profit and cost saving
23	Abbas and Farooquie, 2020	Economic	Improve the company's image and reputation, Improve customer service and satisfaction
24	Kerdpitak *et al.*, 2020	Environmental and economic	Improve strategies environmentally driven
25	Sittisom and Mekhum, 2020	Social	Improve general social performance
26	van Giezen and Wiegmans, 2020	Environmental	Reduce water pollution
27	Campos *et al.*, 2020	Environmental, social and economic	Decrease pollution levels, Meet environmental pressures, Increase environmental protection, Improve the company's image and reputation, Increase profit and cost saving, Meet legal and governmental requirements, Increase market competitiveness, Improve social responsibility
28	Beiler *et al.*, 2020	Environmental and social	Improve recycling performance, Provide income for value pickers, Increase job generation
29	Pushpamali, Agdas and Rose, 2020	Environmental and social	Optimize the use of raw material and natural resources, Reduce landfill disposal, Protect and preserve ecosystems, Improve human health and safety
30	Gardas, Raut and Narkhede, 2019	Economic	Improve operational performance
31	Javed *et al.*, 2021	Environmental, social and economic	Increase general environmental performance, Increase profit and cost saving, Improve general social performance
32	Hong and Huang, 2021	Social and economic	Improve the company's image and reputation, Improve social responsibility
33	Richnák and Gubová, 2021	Economic	Improve the company's image and reputation, Improve customer service and satisfaction, and Meet legal and governmental requirements
34	Baah *et al.*, 2021	Economic	Improve the company's image and reputation, Increase profit and cost saving
35	Govindan and Gholizadeh, 2021	Economic	Increase profit and cost saving
36	de Lorena Diniz Chaves *et al.*, 2021	Social and economic	Increase profit and cost saving, Provide income for value pickers, Improve general social performance
37	Feng, Shen and Pei, 2021	Social and economic	Increase profit and cost saving, Improve general social performance
38	Barcelos *et al.*, 2021	Environmental, social and economic	Increase general environmental performance, Decrease local circularity, and Improve human health and safety
39	Xu *et al.*, 2021	Environmental and economic	Reduce air pollution, Increase profit and cost saving

Most of the papers found in the literature just present the economic impacts of RL, and only five papers bring impacts in all three dimensions of sustainability and one discusses just the social impacts. This interception of the literature that handles which dimension of TBL is shown in Figure 1.

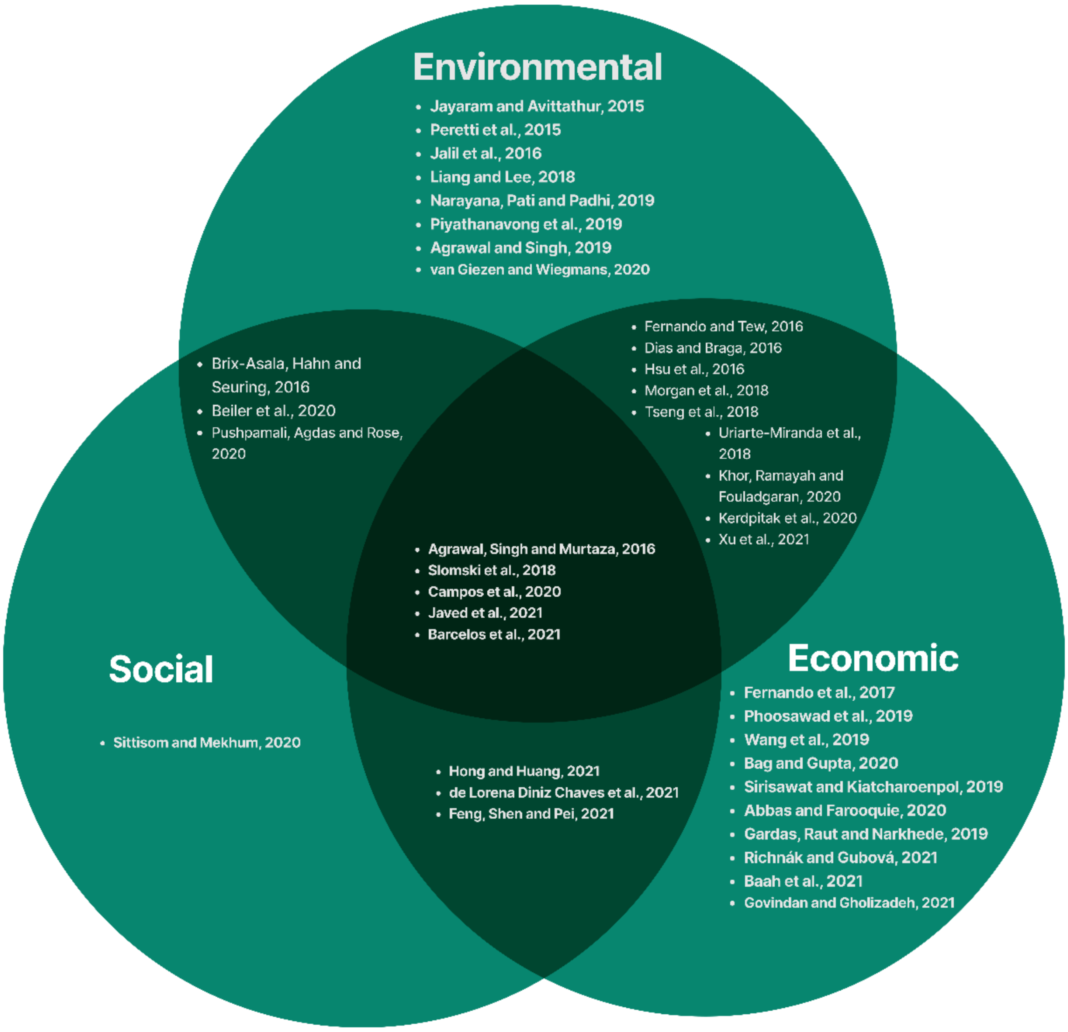


Fig. 1. Papers distribution into TBL.

2.2 Sustainable Development Goals impacted by reverse logistics

To the best of our knowledge – there is no study directly relating reverse logistics impacts with the SDGs. Although, reverse logistics is one of the main foundations of circular economy practices (Hopkinson, De Angelis and Zils, 2020) and, according to Schroeder, Anggraeni and Weber (2019) circular economy practices can help achieve several of the SDGs: *SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG12 (Responsible Consumption and Production), and SDG*

15 (Life on Land) and it also offer potential to create synergies between others, such as those promoting economic growth and jobs *(SDG 8)*, eliminating poverty *(SDG 1)*, ending hunger and sustainable food production *(SDG 2)* and those SDGs aiming for biodiversity protection in the oceans *(SDG 14)* and on land *(SDG 15)*. These SDGs and their descriptions can be seen in Figure 2.

Fig. 2. SDGs impacted by the circular economy.

It was found 39 papers that report sustainable impacts of reverse logistics adoption. Although, these SDGs and their relationship with reverse logistics are not established in the literature, even with the importance of measuring progress towards the SDGs (Maurice, 2016) and the clear relevance of reverse logistics adoption to sustainability and to the achievement of SDGs (Schroeder, Anggraeni and Weber, 2019).

3 RESEARCH DESIGN

This study used mixed methods, combining qualitative and quantitative research. The qualitative approach was used to explore the literature and develop the set of impacts of RL and the structured questionnaire for expert elicitation. After, a quantitative approach was used to turn it measurable and create linkages between the previous findings in the literature with the SDGs, applying descriptive statistics and VIKOR. The complete summarized flow of methodology can be seen in Figure 3.

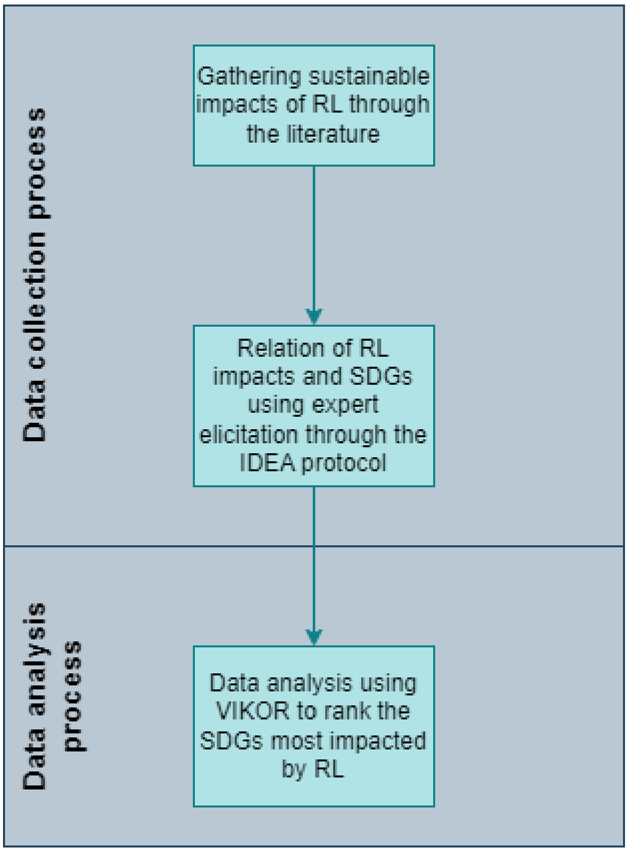


Fig. 3. Methodology flow.

The next sections will present the three steps of methodology in detail.

3.1 Gathering sustainable impacts of reverse logistics through the literature

Some of the impacts found in the literature and presented in Table 1, despite being described with different names, several of them are redundant. For this reason, groupings were made for similar impacts avoiding duplicates. To group it, a coding procedure was adopted, using the "*Coding for test, then analysing data*" approach that enhances qualitative analysis (Glaser and Strauss, 2006). This approach was chosen because the aim of this analysis is the provisional testing of theory (Glaser and Strauss, 2006).

The grouping of impacts was conducted and justified as follows: the impacts *Reduce the environmental footprint, Reduce the amount of waste, Optimize the use of raw material and natural resources, Improve recycling performance and Reduce landfill disposal* were grouped because it regards waste reduction and the use of natural resources. The impacts *Meet environmental pressures, Increase environmental protection, Protect and preserve ecosystems and Meet legal and governmental requirements* were grouped, as they dealt with governmental and legal issues. The impacts *Reduce carbon footprint* and *Reduce air pollution* are grouped since both regard air pollution. *Improve the company's image and reputatio*n *and Improve customer service and satisfaction* were grouped because both deal with the relationship between company and customer. *Improve operational performance, Improve capacity utilisation* and *Improve management and organization solutions* were grouped since it all regards improving operations. Finally, *Provide income for value pickers* and *Increase job generation* were grouped as well; both are related with generate formal and informal jobs. *Increase general environmental performance* and *Improve general social performance* were excluded since it has a general bias and does not provide exactness. In the end, 19 impacts were listed to compose the questionnaire on the next step of methodology (the expert elicitation – it is described in detail in the next section).

The final list of RL impacts is summarized in Table 2, together with it is respective original impacts that were grouped and the respective authors.

Table 2. Final reverse logistics sustainable impacts summary.

Final impacts	Reported impacts	Authors
Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	Reduce the environmental footprint	Peretti et al., 2015; Jalil et al., 2016; Brix-Asala, Hahn and Seuring, 2016
	Reduce the amount of waste	Fernando and Tew, 2016; Dias and Braga, 2016; Uriarte-Miranda et al., 2018; Piyathanavong et al., 2019
	Optimize the use of raw materials and natural resources	Agrawal, Singh and Murtaza, 2016; Jalil et al., 2016; Pushpamali, Agdas and Rose, 2020
	Improve recycling performance	Jalil et al., 2016; Beiler et al., 2020

	Decrease local circularity	Barcelos et al., 2020
	Reduce landfill disposal	Dias and Braga, 2016; Jalil et al., 2016; Slomski et al., 2018; Pushpamali, Agdas and Rose, 2020
Meet environmental pressures and legal and government requirements and increase environmental protection	Meet environmental pressures	Tseng et al., 2018; Campos et al., 2020
	Increase environmental protection	Campos et al., 2020
	Protect and preserve ecosystems	Pushpamali, Agdas and Rose, 2020
	Meet legal and governmental requirements	Sirisawat and Kiatcharoenpol, 2019; Campos et al., 2020; Richnák and Gubová, 2021
Reduce carbon footprint and air pollution	Reduce carbon footprint	Liang and Lee, 2018
	Decrease pollution levels	Jalil et al., 2016; Liang and Lee, 2018; Piyathanavong et al., 2019; Campos et al., 2020
	Reduce air pollution	Liang and Lee, 2018; Narayana, Pati and Padhi, 2019; Xu et al., 2021
Improve customer service and satisfaction and the company's image	Improve the company's image and reputation	Dias and Braga, 2016; Hsu et al., 2016; Abbas and Farooquie, 2020; Campos et al., 2020; Hong and Huang, 2021; Richnák and Gubová, 2021; Baah et al., 2021
	Improve customer service and satisfaction	Tseng et al., 2018; Abbas and Farooquie, 2020; Richnák and Gubová, 2021
Improve operational performance, capacity utilisation and management solutions	Improve operational performance	Fernando and Tew, 2016; Morgan et al., 2018; Phoosawad et al., 2019; Bag and Gupta, 2020; Gardas, Raut and Narkhede, 2019
	Improve capacity utilisation	Fernando and Tew, 2016; Morgan et al., 2018
	Improve management and organization solutions	Dias and Braga, 2016; Sirisawat and Kiatcharoenpol, 2019
Increase job generation and provide income for value pickers	Provide income for value pickers	Brix-Asala, Hahn and Seuring, 2016; Slomski et al., 2018; Beiler et al., 2020; de Lorena Diniz Chaves et al., 2021
	Increase job Generation	Brix-Asala, Hahn and Seuring, 2016; Slomski et al., 2018; Beiler et al., 2020
Improve social responsibility	Improve general social performance	Sittisom and Mekhum, 2020; Javed et al., 2021; de Lorena Diniz Chaves et al., 2021; Feng, Shen and Pei, 2021
	Improve social responsibility	Campos et al., 2020; Hong and Huang, 2021

Improve environmentally-driven strategies	Improve environmentally-driven strategies	Jayaram and Avittathur, 2015; Hsu et al., 2016; Agrawal and Singh, 2019; Kerdpitak et al., 2020
Reduce energy consumption	Reduce energy consumption	Agrawal, Singh and Murtaza, 2016; Uriarte-Miranda et al., 2018
Optimize transport	Optimize transport	Agrawal, Singh and Murtaza, 2016; Fernando and Tew, 2016; Morgan et al., 2018
Reduce soil pollution	Reduce soil pollution	Narayana, Pati and Padhi, 2019
Reduce water pollution	Reduce water pollution	Narayana, Pati and Padhi, 2019; van Giezen and Wiegmans, 2020
Increase profit and cost saving	Increase profit and cost saving	Agrawal, Singh and Murtaza, 2016; Dias and Braga, 2016; Fernando et al., 2017; Slomski et al., 2018; Uriarte-Miranda et al., 2018; Wang et al., 2019; Khor, Ramayah and Fouladgaran, 2020; Campos et al., 2020; Javed et al., 2021; Baah et al., 2021; Govindan and Gholizadeh, 2021; de Lorena Diniz Chaves et al., 2021; Feng, Shen and Pei, 2021; Xu et al., 2021
Increase the return rate of used products	Increase the return rate of used products	Wang et al., 2019
Improve product quality	Improve product quality	Fernando and Tew, 2016; Morgan et al., 2018; Uriarte-Miranda et al., 2018
Increase technology solutions adoption	Increase technology solutions adoption	Sirisawat and Kiatcharoenpol, 2019
Increase market competitiveness	Increase market competitiveness	Campos et al., 2020
Reduce community complaints	Reduce community complaints	Agrawal, Singh and Murtaza, 2016
Improve human health and safety	Improve human health and safety	Agrawal, Singh and Murtaza, 2016; Pushpamali, Agdas and Rose, 2020; Barcelos et al., 2021

3.2 Relationship between RL impacts and SDGs using structured expert elicitation through the IDEA protocol

After gathering the impacts of reverse logistics adoption on sustainability and grouping them, expert elicitation was used to relate those impacts with the SDGs listed in Figure 2 to answer the RQ1 and RQ2 in a structured and rigorous way. To this aim, a structured expert elicitation was conducted through the IDEA protocol.

Expert elicitation was chosen as a method since it has important applications in conservation and natural resource management, including environmental impact assessment and structured decision-making (Hemming *et al.*, 2018). The usage of this method is also informed by previous studies aimed at mapping SDGs interlinkages (Fuso Nerini *et al.*, 2018;

Fuso Nerini *et al.*, 2019; Vinuesa *et al.*, 2020). However, the reliability of expert judgement will always be sensitive to contextual biases; to fill this gap, structured protocols can mitigate these biases, improve the accuracy and transparency of the resulting judgements (Hemming *et al.*, 2018) and ensure uncertainty is captured accurately (Martin *et al.*, 2012).

The IDEA is a structured protocol for expert elicitation, which was chosen for improving the accuracy of expert judgements, including several key steps familiar to conservation researchers – such as the four-step elicitation and a modified Delphi procedure – and incorporating remote elicitation – making structured expert judgement accessible on a modest budget (Hemming *et al.*, 2018). The acronym IDEA stands for key steps of the protocol: “Investigate,” “Discuss,” “Estimate” and “Aggregate”,

At this point, the structured expert elicitation was split into two main stages: Preparation and IDEA Structured Elicitation. These two stages and their respective steps can be seen in Figure 4 and are described in Table 3 and Table 4 as follows.

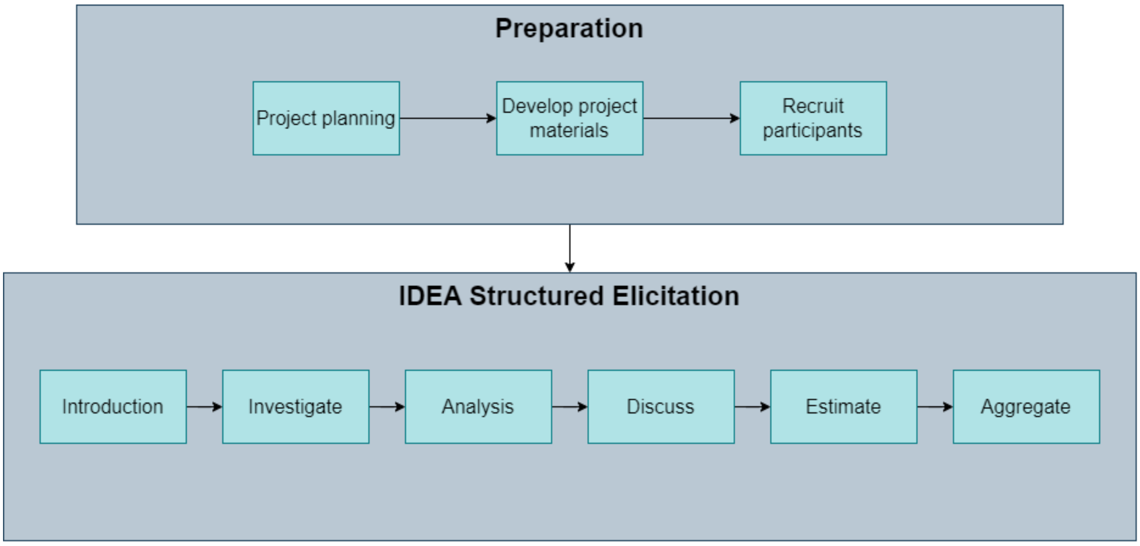


Fig. 4. Main stages for expert elicitation and IDEA protocol.

Table 3. Preparation of expert elicitation.

Preparation steps	What was done
Project planning	Questionnaire (first version) Ethics requirements Recruitment strategy Format for the elicitations (remote) External review of the questionnaire and its application approach
Develop project materials	Questionnaire (final version) Project description

	Consent form Auxiliary material (dynamic website to guide experts during the elicitation/questionnaire response)
Recruit participants	An introductory e-mail was sent Project description provided Auxiliary material provided

The preparation steps (shown in Table 3) are described as follows:

Project planning

In this step – Project planning – the first version of the structured questionnaire was created and sent to outsider sustainability researchers to test and find improvements for the process. The format was defined as remote; ethics requirements were accomplished and the recruitment strategy was established.

The recruitment strategy was defined to aim for 8 participants since only minor improvements in the group's performance are gained by having more than 5 participants (Armstrong, 2001) and groups containing between 8 and 12 members have predictive ability close to the "optimum" under a wide range of circumstances (Hogarth, 1978). The IDEA promotes the use of multiple experts based on empirical evidence and since it is usually not possible to predict who has the requisite knowledge to answer a set of questions accurately, the main criterion when selecting experts is whether the person can understand the questions being asked (Hemming *et al.*, 2018). Therefore, the approach to select the experts was to combine 4 participants who are practitioners working with sustainability and 4 participants who are scholars researching sustainability – as suggested by IDEA, the diversity was prioritised and reflected by variation in age, gender, cultural background, life experience, education and specialisation (Hemming *et al.*, 2018).

Develop project materials

After the review of outsider researchers to test and find improve the application process, improvements to the questionnaire were done: the inclusion of a page for instructions about the scales and how to answer and the development of a website with information about the research, ethics, the questionnaire and the contact; the website also served as a way to make the interviewee's journey more dynamic and clear, showing the complete step-by-step to the interviewed expert. The review and the improvements were important since the results will be used for multi-criteria decision analysis (MCDA) and it requires the formulation of questions that are relatively free from linguistic ambiguity and framing that may generate unwanted bias (Hemming *et al.*, 2018).

The instructions page can be seen in Appendix A, the final questionnaire can be seen in Appendix B and the website can be accessed at https://maquele.web.app/, and the source code was also made available in an online repository on GitHub: https://github.com/Maquele/msc-production-engineering-interview-journey.

The questionnaire for the structured elicitation was developed using the impacts gathered in the literature (see Table 2) and the SDGs shown in Figure 2 previously. To create linkages between these impacts (see Table 2) and the SDGs (see Figure 2), a Likert scale (Likert, 1932) was adopted to define how much one impact generated by reverse logistics contributes to the achievement of one respective SGD, as follows:

1 = This impact generated by reverse logistics does not contribute to the achievement of the respective SDG.

2 = This impact generated by reverse logistics sometimes contributes to the achievement of the respective SDG.

3 = This impact generated by reverse logistics contributes moderately to the achievement of the respective SDG.

4 = This impact generated by reverse logistics contributes to the achievement of the respective SDG.

5 = This impact generated by reverse logistics contributes strongly to the achievement of the respective SDG.

As suggested by the IDEA protocol, the format of the four-step question was also adopted. This format involves asking for upper and lower plausible bounds, the best guess and a degree of belief to measure how sure the expert is about the answer. Accordingly to Hemming *et al.* (2018) *"[...]an expert's responses to the four-step format are designed to be interpreted as a credible interval (i.e. the degree of belief that an event will occur, given all knowledge currently available). If an expert provides a certainty level of, say, 70% for 10 similar events, then the truth should lie within their credible intervals 7 out of 10 times*.".

The application of the Likert scale together with the four-step question to create the questionnaire for the structured elicitation can be seen in Appendix A and Appendix B.

Recruit participants

Finally, at the end of the expert elicitation preparation, an introductory e-mail was sent to the previously selected participants, and a project description was provided to them along with the auxiliary material developed (website with the steps of the interviewee's journey). Of the 8 recruited participants, 4 were scholars and 4 practitioners.

Table 4. IDEA Structured Elicitation.

IDEA Structured Elicitation steps	What was done
Introduction	Context provided Method overview Method rationale Clarifications provided
Investigate	Send reminders (7 days before the deadline and on the last day) Asked if anyone had questions Clarifications provided
Analysis	Clean data Standardized data to prescribed uncertainty level (80%) Aggregate estimate Created summary table
Discuss	Summarised results provided Discussion and comments encouraged
Estimate	Encouraged participants to revise and change their initial estimates if desired Asked participants to provide additional comments
Aggregate	Clean final data Standardized final data to prescribed uncertainty level (80%) Aggregate estimate

Introduction

In the Introduction step of the IDEA Structured Elicitation (see Table 4), the context of the research was provided along with other explanations about the method. The given time for a reply was 15 days, and, as suggested by Hemming *et al.* (2018), reminders ahead of due dates were specified. All communications were remote and it was done by individualised and personalised emails to help ensure that experts would see and respond (Hemming *et al.*, 2018). In this step, the participants received the questionnaire with instructions and the auxiliary material (https://maquele.web.app/) and could clarify their questions about the questionnaire and the research.

Investigation

Seven days after the first official email with the questionnaire, a reminder was sent to the participants and 1 day before the deadline a new reminder was sent to those who had not yet responded to the email. In both moments, it was open to clarify doubts, remembering that the authors were available to help them.

Analysis

For the initial analysis, the raw data was cleaned and standardised, since the questions were in the four-step format. In this format, the experts specify credible intervals and the data should be standardised, typically to 90% or 80% credible intervals (Hemming *et al.*, 2018).

Standardising linear extrapolation was used, as proposed by the IDEA protocol (Hemming *et al.*, 2018), in which:

$$\textbf{Lower standardised interval} = B-((B-L)\times(S/C))$$

$$\textbf{Upper standardised interval} = B+((U-B)\times(S/C))$$

Where B = best guess, L = lowest estimate, U = upper estimate, S = level of credible intervals to be standardised and C = level of confidence given by the participant.

At the end of the Analysis step, the mean of each question was calculated and the table with summarized results was created.

Discuss

For discussion, the summarised results were provided to the participants and they were encouraged to discuss and comment on the results if desired.

Estimate

After instigating the discussion, the participants were encouraged to revise and change their initial estimates. Once again, it was asked participants to provide additional comments if desired – this time just if they want to change their estimates.

Aggregate

At the end of IDEA Structured Elicitation (see Table 4), in the Aggregate step, the final data was cleaned and standardized to the prescribed uncertainty level (80%). Finally, aggregated point estimates and uncertainty intervals were communicated along with the individual estimates.

3.3 Data analysis using VIKOR to rank the SDGs most impacted by reverse logistics

After collecting data using structured expert elicitation through the IDEA protocol to establish the relationship between RL impacts and SDGs, VIKOR was used to rank up the most impacted SDGs by reverse logistics adoption.

Multiple criteria decision-making methods can assist in ranking a known set of alternatives for a problem while considering the conflicting criteria and the preferences of the decision-making are elicited either before or during the evaluation of the alternatives and the criteria (Mardani *et al.*, 2016). Then, the alternatives are compared against each other based on how they perform relative to each criterion and this information is utilised to assign ranks to the alternatives (Mardani *et al.*, 2016).

VIKOR method is one of the popular multi-criteria decision-making techniques which has been increasingly applied by researchers (Mardani *et al.*, 2016). It includes a multi-criteria optimization of complex systems that focuses on ranking and selecting from a set of alternatives among conflicting criteria (Yazdani and Graeml, 2014). It has some advantages over other multiple criteria methods: it can integrate conflicting criteria and provide a simple calculation process, is easily scalable and generates compromise solutions based on proximity to an ideal solution (Awasthi and Kannan, 2016).

VIKOR has four steps, where n is the number of criteria and m is the number of alternatives. The mathematical procedure is presented in Figure 5, adapted from Yazdani and Graeml (2014), where step 1 determines the best value fj and the worst $fi^{-}$and $fi*$ value from each criterion; step 2 finds utility measure and regret measure for alternatives regarding each criterion. Then, step 3 computes the minimum and maximum amounts of the step 2 results. The calculation of Qj as the majority agreement in step 4 prioritizes the alternatives (Yazdani and Graeml, 2014).

$$fi^{*} = \max_{j} fij$$

$$fi^{-} = \min_{j} fij \qquad (1)$$

$$S_j = \frac{\sum_{i=1}^{n} w_i(f_{i^*}-f_{ij})}{(f_{i^*}-f_{i^-})} \qquad R_j = \max_{j} \left[\frac{w_i(f_{i^*}-f_{ij})}{(f_{i^*}-f_{i^-})}\right] \qquad (2)$$

$$Q_j = \frac{v(S_j - S^*)}{(S^- - S^*)} + \frac{(1-v)(R_j - R^*)}{(R^- - R^*)} \qquad (3)$$

Classification by Qj

Fig. 5. Main mathematical stages for the VIKOR method.

In the first mathematical stage for VIKOR (equation 1):

- $\boldsymbol{fi^{*}}$: the highest value of the set
- $\boldsymbol{fi^{-}}$: lowest value in the set
- $\boldsymbol{fij}$: the value of *i*

In the second mathematical stage for VIKOR (equation number 2. See Figure 5):

- $\boldsymbol{S_j}$: utility measure
- $\boldsymbol{R_j}$: regret measure
- $\boldsymbol{w_i}$: weight of each criterion

In the third mathematical stage for VIKOR (equation number 3. See Figure 5):

- $\boldsymbol{Q_j}$: final score to rank the alternatives
- $\boldsymbol{v}$: 0.50 (Keunecke, Hein and Kroenke, 2016; Yazdani and Graeml, 2014)
- $\boldsymbol{S^{*}}$: the highest value of $\boldsymbol{S_j}$
- $\boldsymbol{S^{-}}$: the lowest value of $\boldsymbol{S_j}$
- $\boldsymbol{R^{*}}$: the highest value of $\boldsymbol{R_j}$
- $\boldsymbol{R^{-}}$: the lowest value of $\boldsymbol{R_j}$

This multiple criteria decision-making method was chosen for this case to answer the RQ1 and RQ2, especially the RQ1 which precisely asks "which SDGs are the most impacted by reverse logistics adoption?”. More specifically, VIKOR was chosen to evaluate and rank the SDGs according to the expert elicitation results.

4 RESULTS

The results in this section are divided as follows: firstly, we present the descriptive analysis for each SDG; next, VIKOR is used to create a rank of the SDGs most impacted by RL adoption.

4.1 SDG 1 – No Poverty

All the raw data and cleaned and standardised data remaining SDG 1 – No Poverty – can be seen in Appendix C. Codes for the RL impacts were established (See Table 5, column “*Cod*”). The mean of the lower guess, upper guess and best guess of each impact related to SDG 1 are also described in Table 5.

Table 5. RL impacts and SDG 1.

Cod.	RL impacts	Lower Guess mean	Upper Guess mean	Best Guess mean
RLI1	Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	1.16	3.48	2.50
RLI2	Improve strategies environmentally driven	1.58	3.77	3.00
RLI3	Reduce energy consumption	1.24	3.33	2.63
RLI4	Optimize transport	1.80	3.76	3.00
RLI5	Reduce soil pollution	1.41	3.79	2.88
RLI6	Reduce water pollution	1,54	4.02	3.13
RLI7	Reduce carbon footprint and air pollution	1.37	3.31	2.50
RLI8	Meet environmental pressures and legal and government requirements and increase environmental protection	1.70	3.50	2.63
RLI9	Improve customer service and satisfaction and the company’s image	1.31	3.24	2.38
RLI10	Increase profit and cost saving	1.02	2.76	2.00
RLI11	Increase the return rate of used products	1.44	2.99	2.38
RLI12	Improve product quality	1.27	2.99	2.38
RLI13	Increase technology solutions adoption	1.71	3.89	3.00
RLI14	Increase market competitiveness	1.24	3.02	2.38

RLI15	Improve operational performance, capacity utilisation and management solutions	1.11	3.41	2.63
RLI16	Reduce community complaints	1.49	3.29	2.25
RLI17	Improve human health and safety	2.25	4.12	3.50
RLI18	Increase job generation and provide income for value pickers	3.28	4.62	4.00
RLI19	Improve social responsibility	2.44	4.06	3.50

The highest best guess mean for SDG 1 is related to the *RLI18 Increase job generation and providing income for value pickers* (4.00) and the lowest is related to the *RLI10 Increase in profit and cost saving* (2.00). Indicating that the contribution of RL in increasing job generation and providing income for value pickers has the greatest contribution to the achievement of SDG 1 if compared with the other impacts on the list.

4.2 SDG 2 – Zero Hunger

All the raw data and cleaned and standardised data remaining SDG 2 – Zero Hunger – can be seen in Appendix D The mean of lower guess, upper guess and best guess of each impact related to SDG 2 are also described in Table 6.

Table 6. RL impacts and SDG 2.

Cod.	RL impacts	Lower Guess mean	Upper Guess mean	Best Guess mean
RLI1	Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	2.23	4.14	3.38
RLI2	Improve strategies environmentally driven	3.30	4.50	3.88
RLI3	Reduce energy consumption	1.62	3.58	2.88
RLI4	Optimize transport	1.44	3.96	2.88
RLI5	Reduce soil pollution	2.77	4.42	3.88
RLI6	Reduce water pollution	2.63	4.37	3.75
RLI7	Reduce carbon footprint and air pollution	2.81	4.18	3.63
RLI8	Meet environmental pressures and legal and government requirements and increase environmental protection	2.71	4.31	3.63
RLI9	Improve customer service and satisfaction and the company's image	1.87	3.47	2.75
RLI10	Increase profit and cost saving	1.68	3.39	2.50
RLI11	Increase the return rate of used products	1.43	3.10	2.00
RLI12	Improve product quality	1.30	3.16	2.38

RLI13	Increase technology solutions adoption	2.26	4.60	3.38
RLI14	Increase market competitiveness	1.20	3.78	2.63
RLI15	Improve operational performance, capacity utilisation and management solutions	1.76	4.16	3.13
RLI16	Reduce community complaints	1.14	3.03	2.13
RLI17	Improve human health and safety	2.84	4.67	3.75
RLI18	Increase job generation and provide income for value pickers	2.59	4.43	3.50
RLI19	Improve social responsibility	2.44	4.20	3.38

The highest best guess mean for the SDG 2 is related to the *RLI2 Improve strategies environmentally driven* and *RLI5 Reduce soil pollution* (3.88), and the lowest is related to *RLI11 Increase the return rate of used products* (2.00). Indicating that the contribution of RL in improving environmentally driven strategies and reducing soil pollution has the greatest contribution to the achievement of SDG 2 if compared with the other impacts on the list.

4.3 SDG 6 – Clean Water and Sanitation

All the raw data and cleaned and standardised data remaining SDG 6 – Clean Water and Sanitation – can be seen in Appendix E The mean of lower guess, upper guess and best guess of each impact related to SDG 6 are also described in Table 7.

Table 7. RL impacts and SDG 6.

Cod.	RL impacts	Lower Guess mean	Upper Guess mean	Best Guess mean
RLI1	Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	2.32	4.27	3.00
RLI2	Improve strategies environmentally driven	2.47	4.32	3.50
RLI3	Reduce energy consumption	1.03	3.08	2.25
RLI4	Optimize transport	0.64	3.40	2.50
RLI5	Reduce soil pollution	2.72	4.57	3.50
RLI6	Reduce water pollution	3.20	4.85	4.00
RLI7	Reduce carbon footprint and air pollution	2.12	3.73	3.13
RLI8	Meet environmental pressures and legal and government requirements and increase environmental protection	2.73	4.29	3.38
RLI9	Improve customer service and satisfaction and the company’s image	1.48	3.48	2.75
RLI10	Increase profit and cost saving	1.05	2.74	1.88

RLI11	Increase the return rate of used products	1.47	3.00	2.25
RLI12	Improve product quality	1.38	3.11	2.38
RLI13	Increase technology solutions adoption	2.64	4.72	3.75
RLI14	Increase market competitiveness	1.66	3.63	2.63
RLI15	Improve operational performance, capacity utilisation and management solutions	2.10	4.23	3.00
RLI16	Reduce community complaints	1.23	2.78	2.25
RLI17	Improve human health and safety	2.97	4.40	3.63
RLI18	Increase job generation and provide income for value pickers	1.96	3.87	3.00
RLI19	Improve social responsibility	2.76	4.26	3.50

The highest best guess mean for SDG 6 is related to the *RLI6 Reduce water pollution* (4.00); and the lowest is related to *RLI10 Increase profit and cost saving* (1.88). Indicating that the contribution of RL in reducing water pollution has the greatest contribution to the achievement of SDG 6 if compared with the other impacts on the list.

4.4 SDG 7 – Affordable and Clean Energy

All the raw data and cleaned and standardised data remaining SDG 7 – Affordable and Clean Energy – can be seen in Appendix F The mean of lower guess, upper guess and best guess of each impact related to SDG 7 are also described in Table 8.

Table 8. RL impacts and SDG 7.

Cod.	RL impacts	Lower Guess mean	Upper Guess mean	Best Guess mean
RLI1	Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	1.93	4.05	3.00
RLI2	Improve strategies environmentally driven	2.85	4.71	3.75
RLI3	Reduce energy consumption	3.43	4.79	4.00
RLI4	Optimize transport	1.45	3.96	2.88
RLI5	Reduce soil pollution	1.61	3.40	2.75
RLI6	Reduce water pollution	1.69	3.66	2.75
RLI7	Reduce carbon footprint and air pollution	2.32	4.27	3.38
RLI8	Meet environmental pressures and legal and government requirements and increase environmental protection	2.33	3.87	3.38
RLI9	Improve customer service and satisfaction and the company’s image	2.23	3.93	3.00
RLI10	Increase profit and cost saving	1.58	3.09	2.50

RLI11	Increase the return rate of used products	1.40	2.75	2.25
RLI12	Improve product quality	1.56	3.07	2.38
RLI13	Increase technology solutions adoption	2.71	4.79	3.75
RLI14	Increase market competitiveness	1.60	3.75	2.88
RLI15	Improve operational performance, capacity utilisation and management solutions	2.19	4.34	3.38
RLI16	Reduce community complaints	1.75	3.20	2.63
RLI17	Improve human health and safety	2.27	3.99	3.38
RLI18	Increase job generation and provide income for value pickers	1.34	2.99	2.38
RLI19	Improve social responsibility	2.14	3.70	3.25

The highest best guess mean for SDG 7 is related to the *RLI3 Reduce energy consumption* (4.00); and the lowest is related to *RLI11 Increase the return rate of used products* (2.25). Indicating that the contribution of RL in reducing energy consumption has the greatest contribution to the achievement of SDG 7 if compared with the other impacts on the list.

4.5 SDG 8 – Decent Work and Economic Growth

All the raw data and cleaned and standardised data remaining SDG 8 – Decent work and economic growth – can be seen in Appendix G. The mean of lower guess, upper guess and best guess of each impact related to SDG 8 are also described in Table 9.

Table 9. RL impacts and SDG 8.

Cod.	RL impacts	Lower Guess mean	Upper Guess mean	Best Guess mean
RLI1	Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	1.72	3.83	3.00
RLI2	Improve strategies environmentally driven	1.82	4.17	3.13
RLI3	Reduce energy consumption	1.58	4.22	3.00
RLI4	Optimize transport	2.19	4.42	3.38
RLI5	Reduce soil pollution	1.16	3.65	2.63
RLI6	Reduce water pollution	1.17	3.49	2.63
RLI7	Reduce carbon footprint and air pollution	1.07	3.34	2.38
RLI8	Meet environmental pressures and legal and government requirements and increase environmental protection	2.20	3.78	3.13
RLI9	Improve customer service and satisfaction and the company's image	2.55	4.05	3.38

RLI10	Increase profit and cost saving	1.52	3.46	2.75
RLI11	Increase the return rate of used products	1.86	3.10	2.63
RLI12	Improve product quality	1.95	3.80	2.88
RLI13	Increase technology solutions adoption	1.92	3.72	2.75
RLI14	Increase market competitiveness	1.77	4.36	2.88
RLI15	Improve operational performance, capacity utilisation and management solutions	2.05	3.33	2.75
RLI16	Reduce community complaints	1.57	3.10	2.63
RLI17	Improve human health and safety	2.05	4.52	3.38
RLI18	Increase job generation and provide income for value pickers	3.55	4.75	4.13
RLI19	Improve social responsibility	2.45	4.44	3.75

The highest best guess mean for SDG 8 is related to the *RLI18 Increase job generation and provide income for value pickers* (4.13); and the lowest is related to *RLI7 Reduce carbon footprint and air pollution* (2.38). Indicating that the contribution of RL in increasing job generation and providing income for value pickers has the greatest contribution to the achievement of SDG 8 if compared with the other impacts on the list.

4.6 SDG12 – Responsible Consumption and Production

All the raw data and cleaned and standardised data remaining SDG 12 – Responsible consumption and production – can be seen in Appendix H. The mean of the lower guess, upper guess and best guess of each impact related to SDG 12 are also described in Table 10.

Table 10. RL impacts and SDG 12.

Cod.	RL impacts	Lower Guess mean	Upper Guess mean	Best Guess mean
RLI1	Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	3.39	4.70	4.13
RLI2	Improve strategies environmentally driven	3.67	4.63	4.13
RLI3	Reduce energy consumption	3.73	4.86	4.38
RLI4	Optimize transport	2.75	4.77	3.88
RLI5	Reduce soil pollution	2.50	4.50	3.63
RLI6	Reduce water pollution	2.98	4.59	3.88
RLI7	Reduce carbon footprint and air pollution	3.26	4.64	3.88
RLI8	Meet environmental pressures and legal and government requirements and increase environmental protection	2.88	4.26	3.50

RLI9	Improve customer service and satisfaction and the company's image	2.69	4.32	3.63
RLI10	Increase profit and cost saving	1.93	4.42	2.75
RLI11	Increase the return rate of used products	2.73	3.99	3.63
RLI12	Improve product quality	2.60	4.28	3.25
RLI13	Increase technology solutions adoption	2.75	4.39	3.50
RLI14	Increase market competitiveness	1.58	4.51	2.75
RLI15	Improve operational performance, capacity utilisation and management solutions	2.79	4.18	3.38
RLI16	Reduce community complaints	2.32	3.62	3.13
RLI17	Improve human health and safety	2.06	4.44	3.38
RLI18	Increase job generation and provide income for value pickers	2.51	3.88	3.38
RLI19	Improve social responsibility	2.94	4.31	4.13

The highest best guess mean for SDG 12 is related to the *RLI3 Reduce energy consumption* (4.38); and the lowest is related to *RLI10 Increase profit and cost saving* (2.75) and *RLI14 Increase market competitiveness* (2.75). Indicating that the contribution of RL in reducing energy consumption has the greatest contribution to the achievement of SDG 12 if compared with the other impacts on the list.

4.7 SDG 14 – Life Below Water

All the raw data and cleaned and standardised data remaining SDG 14 – Life Below Water – can be seen in Appendix I. The mean of the lower guess, upper guess and best guess of each impact related to SDG 14 are also described in Table 11.

Table 11. RL impacts and SDG 14.

Cod.	RL impacts	Lower Guess mean	Upper Guess mean	Best Guess mean
RLI1	Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	2.90	4.64	3.75
RLI2	Improve strategies environmentally driven	3.07	4.62	3.63
RLI3	Reduce energy consumption	1.82	4.24	3.13
RLI4	Optimize transport	1.37	3.81	2.63
RLI5	Reduce soil pollution	2.25	4.30	3.63
RLI6	Reduce water pollution	3.28	4.50	3.88
RLI7	Reduce carbon footprint and air pollution	2.70	4.37	3.50

RLI8	Meet environmental pressures and legal and government requirements and increase environmental protection	3.08	4.73	3.88
RLI9	Improve customer service and satisfaction and the company's image	1.65	3.52	2.50
RLI10	Increase profit and cost saving	1.16	2.65	1.88
RLI11	Increase the return rate of used products	2.10	3.49	2.88
RLI12	Improve product quality	1.44	3.69	2.63
RLI13	Increase technology solutions adoption	2.00	4.33	3.13
RLI14	Increase market competitiveness	1.40	3.19	2.25
RLI15	Improve operational performance, capacity utilisation and management solutions	1.72	3.40	2.63
RLI16	Reduce community complaints	1.39	3.12	2.25
RLI17	Improve human health and safety	1.45	3.98	2.63
RLI18	Increase job generation and provide income for value pickers	1.23	3.40	2.50
RLI19	Improve social responsibility	2.61	3.81	3.38

The highest best guess mean for SDG 14 is related to the *RLI6 Reduce water pollution* (3.88) and *RLI8 Meet environmental pressures and legal and government requirements* (3.88); and the lowest is related to *RLI10 Increase profit and cost saving* (1.88). Indicating that the contribution of RL in reducing water pollution consumption and meeting environmental pressures and legal and governmental requirements has the greatest contribution to the achievement of SDG 14 if compared with the other impacts on the list.

4.8 SDG 15 – Life on Land

All the raw data and cleaned and standardised data remaining SDG 15 – Life on Land – can be seen in Appendix J. The mean of the lower guess, upper guess and best guess of each impact related to SDG 15 are also described in Table 12.

Table 12. RL impacts and SDG 15.

Cod.	RL impacts	Lower Guess mean	Upper Guess mean	Best Guess mean
RLI1	Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	3.42	4.79	4.00
RLI2	Improve strategies environmentally driven	3.19	4.74	3.75
RLI3	Reduce energy consumption	1.28	3.94	3.00
RLI4	Optimize transport	1.66	3.89	2.75

RLI5	Reduce soil pollution	2.72	4.63	3.63
RLI6	Reduce water pollution	2.90	4.22	3.63
RLI7	Reduce carbon footprint and air pollution	2.87	4.21	3.75
RLI8	Meet environmental pressures and legal and government requirements and increase environmental protection	2.96	4.70	3.75
RLI9	Improve customer service and satisfaction and the company's image	1.86	3.45	2.63
RLI10	Increase profit and cost saving	1.15	2.51	1.75
RLI11	Increase the return rate of used products	2.31	3.64	3.00
RLI12	Improve product quality	1.64	3.63	2.75
RLI13	Increase technology solutions adoption	1.88	4.20	3.00
RLI14	Increase market competitiveness	1.42	3.17	2.25
RLI15	Improve operational performance, capacity utilisation and management solutions	1.74	3.39	2.63
RLI16	Reduce community complaints	1.53	3.23	2.38
RLI17	Improve human health and safety	1.55	3.94	2.63
RLI18	Increase job generation and provide income for value pickers	1.47	3.54	2.75
RLI19	Improve social responsibility	2.59	3.83	3.38

The highest best guess mean for SDG 15 is related to the *RLI1 Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw material and natural resources and the recycling performance* (4.00) and the lowest is related to *RLI10 Increase profit and cost saving* (1.75). Indicating that the contribution of RL in reducing the environmental footprint, amounts of waste and landfill disposal; optimising the use of raw material and natural resources and the recycling performance has the greatest contribution to the achievement of SDG 14 if compared with the other impacts on the list.

4.9 VIKOR

For the VIKOR application, the *n* (number of criteria) is de number of RL impacts found in the literature and used in the expert elicitation (19 impacts in total) and *m* (number of alternatives) is the number of SDGs also used in the expert elicitation (8 SDGs in total). The best mean (with an 80% of confidence level) of each combination of SDG and impact was used as values for the VIKOR matrix (see Table 13). All impacts were given the same weight (*w*) of 1/19 = 0.05.

Table 13. VIKOR matrix.

	RLI1	**RLI2**	**RLI3**	**RLI4**	**RLI5**	**RLI6**	**RLI7**	**RLI8**	**RLI9**	**RLI10**	**RLI11**	**RLI12**	**RLI13**	**RLI14**	**RLI15**	**RLI16**	**RLI17**	**RLI18**	**RLI19**

ODS 1	2.50	3.00	2.63	3.00	2.88	3.13	2.50	2.63	2.38	2.00	2.38	2.38	3.00	2.38	2.63	2.25	3.50	4.00	3.50
ODS 2	3.38	3.88	2.88	2.88	3.88	3.75	3.63	3.63	2.75	2.50	2.00	2.38	3.38	2.63	3.13	2.13	3.75	3.50	3.38
ODS 6	3.00	3.50	2.25	2.50	3.50	4.00	3.13	3.38	2.75	1.88	2.25	2.38	3.75	2.63	3.00	2.25	3.63	3.00	3.50
ODS 7	3.00	3.75	4.00	2.88	2.75	2.75	3.38	3.38	3.00	2.50	2.25	2.38	3.75	2.88	3.38	2.63	3.38	2.38	3.25
ODS 8	3.00	3.13	3.00	3.38	2.63	2.63	2.38	3.13	3.38	2.75	2.63	2.88	2.75	2.88	2.75	2.63	3.38	4.13	3.75
ODS 12	4.13	4.13	4.38	3.88	3.63	3.88	3.88	3.50	3.63	2.75	3.63	3.25	3.50	2.75	3.38	3.13	3.38	3.38	4.13
ODS 14	3.75	3.63	3.13	2.63	3.63	3.88	3.50	3.88	2.50	1.88	2.88	2.63	3.13	2.25	2.63	2.25	2.63	2.50	3.38
ODS 15	4.00	3.75	3.00	2.75	3.63	3.63	3.75	3.75	2.63	1.75	3.00	2.75	3.00	2.25	2.63	2.38	2.63	2.75	3.38
Max (fi+)	4.13	4.13	4.38	3.88	3.88	4.00	3.88	3.88	3.63	2.75	3.63	3.25	3.75	2.88	3.38	3.13	3.75	4.13	4.13
Min (fi-)	2.50	3.00	2.25	2.50	2.63	2.63	2.38	2.63	2.38	1.75	2.00	2.38	2.75	2.25	2.63	2.13	2.63	2.38	3.25

The results of the stages presented in Figure 5 and described in the Methodology section are shown in Table 14. The alternatives were sorted in ascending order, by values obtained by *S*, *R* and *Qj*. The results are three ranking lists. However, only the values obtained by Qj will be considered at this point – the calculation of Qj as the majority agreement in stage 4 (see Figure 5) prioritises the alternatives to define the rank (Yazdani and Graeml, 2014), but it has to satisfy two conditions before being adopted as the final rank.

Table 14. VIKOR rank by Qj.

	Sj	**Rj**	**Qj**	**Rank**
SDG 1	0.78	0.05	0	1
SDG 14	0.63	0.05	0.109116287	2
SDG 15	0.60	0.05	0.128176196	3
SDG 6	0.59	0.05	0.140439844	4
SDG 8	0.55	0.05	0.163519364	5
SDG 7	0.52	0.05	0.187285047	6
SDG 2	0.47	0.05	0.225378865	7
SDG 12	0.10	0.02	1	8

After ranking the alternatives, sorting by Qj in decreasing order, the result of the rank can be taken as a compromise solution if the following two conditions are satisfied (Opricovic, 2011):

C1. ‘‘Acceptable Advantage’’: $Q(A^2) - Q(A^1) \geq DQ$

Where: $DQ = 1/(j-1)$ and j is the number of alternatives.

C2. ‘‘Acceptable Stability in decision making’’: The first alternative must also be the best ranked by S or/and R.

If one of the conditions is not satisfied, then a set of compromise solutions is proposed, which consists of:

- Alternatives A^1 and A^2 if only condition C2 is not satisfied, or
- Alternatives A^1, A^2, ..., A^M if condition C1 is not satisfied. Where A^M is determined by the relation $Q(A^M) - Q(A^1) < DQ$ for maximum M.

The A^1 and A^2 in the rank in Table 14 are SDG 1 and SDG 2, respectively. Then, C1 is not satisfied, since:

$$0.109116287 - 0 = 0.109116287 < DQ = 1/(8-1) = 0.142857143$$

For C2, it is possible to see that in the rank using *Sj* or *Rj* the first alternative would be SDG 12. So, C2 is not satisfied as well.

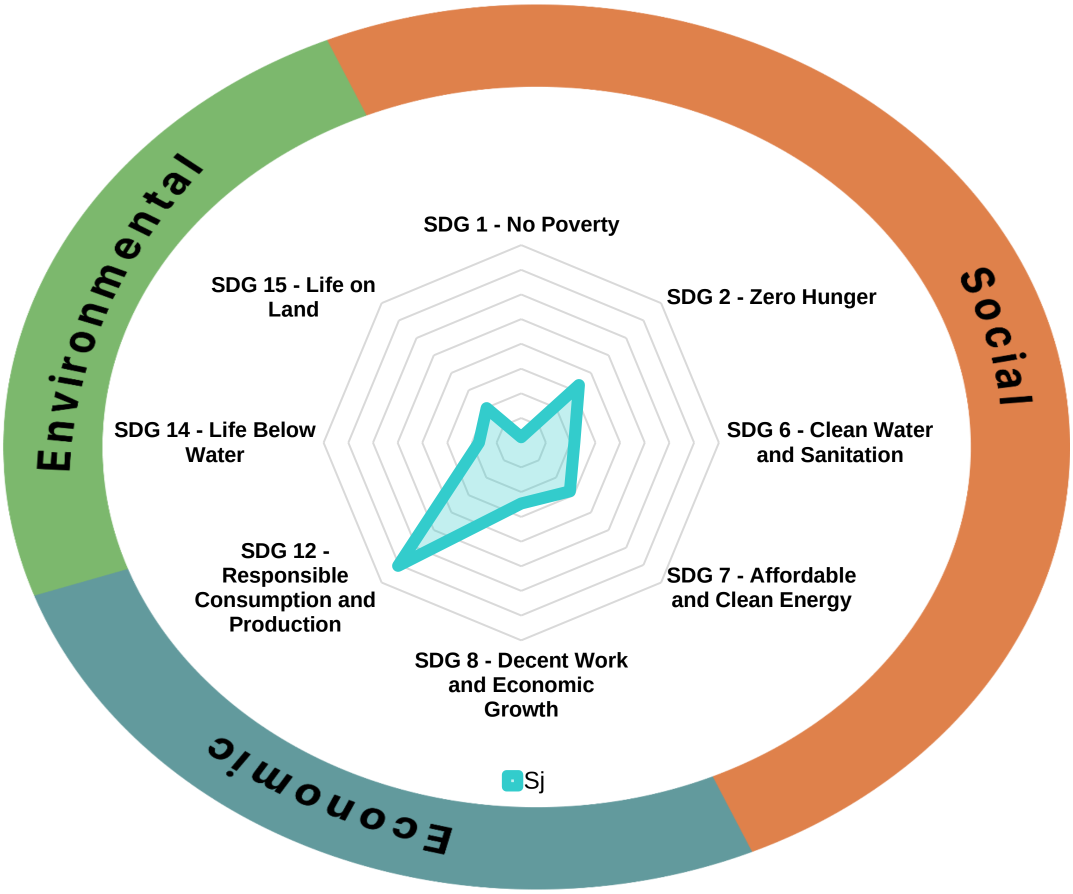
Since the rank by *Qj* does not satisfy the conditions, the rank by the utility measure (*Sj*) is adopted, as shown in Table 15, since it has the same best alternative as the rank by *Rj*.

Table 15. VIKOR rank by *Sj*.

	Sj	Rj	Qj	Rank
SDG 12	0.10	0.02	1	1
SDG 2	0.47	0.05	0.225378865	2
SDG 7	0.52	0.05	0.187285047	3
SDG 8	0.55	0.05	0.163519364	4
SDG 6	0.59	0.05	0.140439844	5
SDG 15	0.60	0.05	0.128176196	6
SDG 14	0.63	0.05	0.109116287	7
SDG 1	0.78	0.05	0	8

At the end of the VIKOR analysis, the best alternative is SDG 12, which means SDG 12 is the one that is more impacted by RL. The SDGs were split into the three pillars of sustainability (Vinuesa *et al.*, 2020) and in Figure 6 is possible to see the impact of RL along SDGs and its distributions according to the TBL.

Fig. 6. RL impacts on SDGs.



5 DISCUSSIONS

The method proposed (see Section 3) allows us to understand how RL adoption and its impacts can contribute to the achievement of various SDGs. The results (see Section 4) are based on the results from the expert elicitation which reflect their opinions about how much one impact generated by RL contributes to the achievement of one respective SGD.

Considering the initial research questions (RQ1: Which SDGs are the most impacted by reverse logistics adoption?; RQ2: How reverse logistics can contribute to sustainable development?), we present and discuss the results taking into account the RQs in order to show: (a) the capacity of the proposed methodology to comprehensively evaluate the contribution of RL logistics adoption according to the SDGs; and (b) the results of the comparisons of RL impacts in terms of their contribution to sustainability and the achievement of various SDGs.

The SDGs were used here since they are the recommended direction when the subject is sustainable development, at the same time RL is also pointed as a key process to the circular economy and sustainable development as well. Even though RL is not the only answer for all SDGs and sustainability problems, it can help to achieve some goals in all three dimensions of TBL – since generating jobs and providing income for value pickers (Brix-Asala, Hahn and

Seuring, 2016; Slomski et al., 2018; Beiler et al., 2020; de Lorena Diniz Chaves et al., 2021) to increase profit for the companies (Agrawal, Singh and Murtaza, 2016; Dias and Braga, 2016; Fernando et al., 2017; Slomski et al., 2018; Uriarte-Miranda et al., 2018; Wang et al., 2019; Khor, Ramayah and Fouladgaran, 2020; Campos et al., 2020; Javed et al., 2021; Baah et al., 2021; Govindan and Gholizadeh, 2021; de Lorena Diniz Chaves et al., 2021; Feng, Shen and Pei, 2021; Xu et al., 2021).

The literature about the sustainable impacts of RL is not equally distributed through the TBL. There is a clear tendency to stress the benefits of RL adoption to the economic aspect, followed by the intuitive connection between RL and the environment. The SDGs try to balance the relevance of the three pillars of sustainability to the world, however, the social aspect keeps fading in the literature, as shown in Figure 1, where just one article talks precisely about this aspect of sustainability. Other studies have previously elucidated this gap (Banihashemi, Fei and Chen, 2019; Sarkis, Helms and Hervani, 2010; Agrawal, Singh and Murtaza, 2016), which can be explained by the fact that, although RL presents social impacts, the full incorporation of the social pillar can be an obstacle due to the high financial incentive required to adopt social initiatives (Sittisom and Mekhum, 2020; Hong and Huang, 2021).

However, according to Schroeder, Anggraeni and Weber (2019), circular economy practices – as RL – can help to achieve and offer the potential to create synergies between the following SDGs: *SDG 1, SDG 2, SDG 6, SDG 7, SDG 8, SDG12, SDG 14* and *SDG 15* (these SDGs and its descriptions can be seen on Figure 2). In this case, 4 goals are categorized as social, 2 as economic and 2 as environmental (see Figure 6), which indicates the amplitude of RL's contribution to sustainable development.

Furthermore, our results were firstly descriptive (from Section 4.1 to 4.8) using the *best guess means* to analyse each SDG. An overview of these results can be seen in Table 16. In this table, it is easy to identify RLI3, RLI6 and RLI18 are the ones appearing twice as RLI^{+}; and RLI10 is remarkably appearing four times as RLI^{-}. These results can suggest from the expert's perspective the impact of RL in increasing profits and savings – besides being extensively stressed by literature – is not an important impact to help to achieve the SDGs by adopting RL. Even further, from the 19 RL impacts on sustainability found in the literature, it is possible to infer that the 7 RLI^{+} presented in Table 16 are the most important contribution of RL adoption to help achieve the SDGs and, consequently, to sustainable development.

Table 16. Summary of the SDGs and the impacts with more and less contribution to its achievement.

Section	SDG	RLI^{+}	RLI^{+} Best Guess mean	RLI^{-}	RLI^{-} Best Guess mean
4.1	**SDG 1** – No Poverty	**RLI18 -** Increase job generation and provide income for value pickers	4.00	**RLI10** - Increase profit and cost saving	2.00
4.2	**SDG 2** – Zero Hunger	**RLI2** - Improve environmentally-driven strategies	3.88	**RLI11** - Increase the return rate of used products	2.00
		RLI5 - Reduce soil pollution			
4.3	**SDG 6** – Clean Water and Sanitation	**RLI6** - Reduce water pollution	4.00	**RLI10** - Increase profit and cost saving	1.88
4.4	**SDG 7** – Affordable and Clean Energy	**RLI3** - Reduce energy consumption	4.00	**RLI11** - Increase the return rate of used products	2.25
4.5	**SDG 8** – Decent Work and Economic Growth	**RLI18** - Increase job generation and provide income for value pickers	4.13	**RLI7** - Reduce carbon footprint and air pollution	2.38
4.6	**SDG 12** – Responsible Consumption and Production	**RLI3** - Reduce energy consumption	4.38	**RLI10** - Increase profit and cost saving	2.75
				RLI14 - Increase market competitiveness	
4.7	**SDG 14** – Life Below Water	**RLI6** - Reduce water pollution	3.88	**RLI10** - Increase profit and cost saving	1.88
		RLI8 - Meet environmental pressures and legal and government requirements			
4.8	**SDG 15** – Life on Land	**RLI1** - Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw materials and natural resources and the recycling performance	4.00	**RLI10** - Increase profit and cost saving	1.75

Aiming to answer the main question from this paper: (RQ1) Which SDGs are the most impacted by reverse logistics adoption?, VIKOR was adopted to create a rank of the SDGs most impacted by the impacts of RL adoption, as input to the analysis of the data from the expert elicitation was used. The final rank (see Table 15) was: ***(1)** SDG 12 - Responsible Consumption and Production*, ***(2)** SDG 2 - Zero Hunger*, ***(3)** SDG 7 - Affordable and Clean Energy*, ***(4)** SDG 8 - Decent Work and Economic Growth*, ***(5)** SDG 6 - Clean Water and Sanitation*, ***(6)** SDG 15 - Life on Land*, ***(7)** SDG 14 - Life Below Water*, ***(8)** SDG 1 - No Poverty*.

The SDG that has the biggest contribution from RL adoption is SDG 12 – Sustainable Consumption and Production, as we may intuitively infer since it is one specific goal for manufacturers: *SDG 12 - Ensure sustainable consumption and production patterns*, however, manufacturing systems can potentially contribute to a far wider range of SDGs (Leurent and Abbosh, 2018; Schroeder, Anggraeni and Weber, 2019) and so do RL.

Surprisingly, the second and third place in our rank (see Table 15) are for two SDGs classified as social (Vinuesa *et al.*, 2020): *SDG 2 – Zero Hunger*, which promotes ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture and *SDG 7 – Affordable and Clean Energy*, which promotes ensuring access to affordable, reliable, sustainable and modern energy for all. RL adoption can provide helpful impacts for these SDGs since RL has high indexes in social performance (Agrawal, Rajesh K. Singh and Murtaza, 2016). For Zero Hunger, RL is an important tool that can help in dealing with food waste (Dutra *et al.*, 2021) and improve human health and safety. Particularly, reducing pollution to soil, water and air can help to achieve food security (see Table 1). For Affordable and Clean Energy RL can help to reduce energy waste and consumption (see Table 1) and can also act as a motor to create energy savings technologies and clean energy (Wu and Zhao, 2022).

The last SDG in the rank is *SDG 1 – No Poverty*, which promotes poverty ending in all its forms everywhere. Despite RL has social impacts and can increase job generation and provide income for value pickers (Brix-Asala, Hahn and Seuring, 2016; Slomski et al., 2018; Beiler et al., 2020; de Lorena Diniz Chaves et al., 2021), these are specific contributions that have a greater contribution in helping the accomplishment of *SDG 8 - Decent Work and Economic Growth*. SDG 8 promotes sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; being more related to the RL capacity of generate jobs adoption than SDG 1.

6 CONCLUSIONS

RL has been gaining attention due to its relevance to sustainable development and the SDGs are the newest way to describe and measure sustainable development. In this context, this paper aimed to investigate the relationship between reverse logistics and the SDGs using literature review, expert elicitation and VIKOR method to identify, rank and define the most impacted SDGs by reverse logistics.

Regarding the research questions *(RQ1: Which SDGs are the most impacted by reverse logistics adoption?* And *RQ2: How reverse logistics can contribute to sustainable development?*), it was found that the SDG most impacted by RL adoption is SDG *12- Sustainable Consumption and Production*. However, as argued by other authors (Leurent and Abbosh, 2018; Schroeder, Anggraeni and Weber, 2019), manufacturing systems can potentially contribute to a far wider range of SDGs. For this reason, a rank was created to show the SDG most impacted by RL, and the final rank (see Table 15) was: (1) SDG 12, (2) SDG 2, (3) SDG 7, (4) SDG 8, (5) SDG 6, (6) SDG 15, (7) SDG 14, (8) SDG 1. It was also found that from the expert's perspective the impact of RL in increasing profits and savings – besides being extensively stressed by literature – is not an important impact to help to achieve the SDGs adopting RL.

Furthermore, from the 19 RL impacts on sustainability found in literature, it is possible to infer that the 7 RLI^+ presented in Table 16 (*RLI1 - Reduce the environmental footprint, amounts of waste and landfill, RLI2 - Improve environmentally-driven strategies, RLI3 - Reduce energy consumption, RLI5 - Reduce soil pollution, RLI6 - Reduce water pollution, RLI8 - Meet environmental pressures and legal and government requirements, RLI18 - Increase job generation and provide income for value pickers*) are the most important contribution of RL adoption to help achieve the SDGs and, consequently, to sustainable development – with special emphases to RLI3, RLI6 and RLI18 which are the ones appearing twice as RLI^+.

The main contributions of this paper (both the identification and classification of the impact of RL adoption to achieve the SDGs) can help practitioners target their investments in RL and have a clear vision of how the adoption of RL by their companies can help in the achievement of SDGs. For policy-makers, it can help to evaluate reverse logistics initiatives and facilitate subsidy distributions more effectively; the results provided here can be also used by policy-makers to promote reverse logistics adoption by local companies since there is a common interest in contributing to the accomplishment of the SDGs. For scholars, the paper fills the gap in literature connecting reverse logistics with the SDGs, and also provides a future research agenda as described in the next paragraphs.

Given these initial findings, the present study has some limitations, which provide opportunities for further research:

(1) The RL impacts here had the same weights. But the same methodology can be applied with other ways of weighing them and doing sensitivity analysis to compare different scenarios.

(2) Since the expert elicitation was extensive, just 8 participants responded. It can be expanded in future applications.

(3) This paper does not consider all SDGs, only those that already had suggestions from the literature of having a relationship with circular economy practices. However, all SDGs should be considered in the next applications to verify if this approach was accurate.

Therefore, this paper proposes a valuable model that provides important initial and exploratory insights and an understanding of the role of RL and its impacts on sustainable development through the SDG perspective.

REFERENCES

Abbas, H. and Farooquie, J. A. (2020) 'Reverse logistics practices in Indian pharmaceutical supply chains: A study of manufacturers', *International Journal of Logistics Systems and Management*, 35(1), pp. 72–89. doi: 10.1504/IJLSM.2020.103863.

Agrawal, S. and Singh, R. K. (2019) 'Analyzing disposition decisions for sustainable reverse logistics: Triple Bottom Line approach', *Resources, Conservation and Recycling*, 150(August), p. 104448. doi: 10.1016/j.resconrec.2019.104448.

Agrawal, S., Singh, Rajesh Kr and Murtaza, Q. (2016) 'Triple bottom line performance evaluation of reverse logistics', *Competitiveness Review*, 26(3), pp. 289–310. doi: 10.1108/CR-04-2015-0029.

Agrawal, S., Singh, Rajesh K. and Murtaza, Q. (2016) 'Triple Bottom Line Performance Evaluation of Reverse Logistics', *Competitiveness Review*, 26(3), pp. 289–310. doi: https://doi.org/10.1108/CR-04-2015-0029.

Allaoui, H., Guo, Y. and Sarkis, J. (2019) 'Decision support for collaboration planning in sustainable supply chains', *Journal of Cleaner Production*, 229, pp. 761–774. doi: 10.1016/j.jclepro.2019.04.367.

Armstrong, J. S. (2001) 'Combining Forecasts', pp. 417–439. doi: 10.1007/978-0-306-47630-3_19.

Awasthi, A. and Kannan, G. (2016) 'Green supplier development program selection using NGT and VIKOR under fuzzy environment', *Computers and Industrial Engineering*, 91, pp. 100–108. doi: 10.1016/j.cie.2015.11.011.

Baah, C. *et al.* (2021) 'Examining the Interconnections Between Sustainable Logistics Practices, Environmental Reputation and Financial Performance: A Mediation Approach', *Vision*, 25(1), pp. 47–64. doi: 10.1177/0972262920988805.

Bag, S. and Gupta, S. (2020) 'Examining the effect of green human capital availability in adoption of reverse logistics and remanufacturing operations performance', *International Journal of Manpower*, 41(7), pp. 1097–1117. doi: 10.1108/IJM-07-2019-0349.

Bag, S. and Pretorius, J. H. C. (2020) 'Relationships between industry 4.0, sustainable manufacturing and circular economy: proposal of a research framework', *International Journal of Organizational Analysis*. doi: 10.1108/IJOA-04-2020-2120.

Banihashemi, T. A., Fei, J. and Chen, P. S.-L. (2019a) 'Exploring the relationship between reverse logistics and sustainability performance', *Modern Supply Chain Research and Applications*, 1(1), pp. 2–27. doi: 10.1108/mscra-03-2019-0009.

Banihashemi, T. A., Fei, J. and Chen, P. S.-L. (2019b) 'Exploring the relationship between reverse logistics and sustainability performance', *Modern Supply Chain Research and Applications*, 1(1), pp. 2–27. doi: 10.1108/mscra-03-2019-0009.

Barcelos, S. M. B. D. *et al.* (2021) 'Circularity of Brazilian silk: Promoting a circular bioeconomy in the production of silk cocoons', *Journal of Environmental Management*, 296(April), p. 113373. doi: 10.1016/j.jenvman.2021.113373.

Beiler, B. C. *et al.* (2020) 'Reverse logistics system analysis of a Brazilian beverage company: An exploratory study', *Journal of Cleaner Production*, 274. doi: 10.1016/j.jclepro.2020.122624.

Brix-Asala, C., Hahn, R. and Seuring, S. (2016) 'Reverse logistics and informal valorisation at the Base of the Pyramid: A case study on sustainability synergies and trade-offs', *European Management Journal*, 34(4), pp. 414–423. doi: 10.1016/j.emj.2016.01.004.

Campos, E. A. R. de *et al.* (2020) 'The effect of collaboration and IT competency on reverse logistics competency - Evidence from Brazilian supply chain executives', *Environmental Impact Assessment Review*, 84(March), p. 106433. doi: 10.1016/j.eiar.2020.106433.

Dias, K. T. S. and Braga, S. S. (2016) 'The use of reverse logistics for waste management in a Brazilian grocery retailer', *Waste Management and Research*, 34(1), pp. 22–29. doi: 10.1177/0734242X15615696.

Dutra, A. R. de A. *et al.* (2021) 'POTENTIAL CONTRIBUTION OF REVERSE LOGISTICS TO RESTAURANTS', *Revista Brasileira de Meio Ambiente e Sustentabilidade*, 1(5), pp. 133–152.

Feng, D., Shen, C. and Pei, Z. (2021) 'Production decisions of a closed-loop supply chain considering remanufacturing and refurbishing under government subsidy', *Sustainable Production and Consumption*, 27, pp. 2058–2074. doi: 10.1016/j.spc.2021.04.034.

Fernando, Y. *et al.* (2017) 'The effects of reverse logistics on cost control abilities: An insight into manufacturing companies in Malaysia', *International Journal of Value Chain Management*, 8(4), pp. 285–306. doi: 10.1504/IJVCM.2017.089377.

Fernando, Y. and Tew, M. M. (2016) 'Reverse logistics in manufacturing waste management: The missing link between environmental commitment and operational performance', *International Journal of Integrated Supply Management*, 10(3–4), pp. 264–282. doi: 10.1504/IJISM.2016.081273.

Fuso Nerini, F. *et al.* (2018) 'Mapping synergies and trade-offs between energy and the Sustainable Development Goals', *Nature Energy*, 3(1), pp. 10–15. doi: 10.1038/s41560-017-0036-5.

Fuso Nerini, F. *et al.* (2019) 'Connecting climate action with other Sustainable Development Goals', *Nature Sustainability*, 2(8), pp. 674–680. doi: 10.1038/s41893-019-0334-y.

Gardas, B. B., Raut, R. D. and Narkhede, B. (2019) 'Determinants of sustainable supply chain management: A case study from the oil and gas supply chain', *Sustainable Production and Consumption*, 17, pp. 241–253. doi: 10.1016/j.spc.2018.11.005.

van Giezen, A. and Wiegmans, B. (2020) 'Spoilt - Ocean Cleanup: Alternative logistics chains to accommodate plastic waste recycling: An economic evaluation', *Transportation Research Interdisciplinary Perspectives*, 5, p. 100115. doi: 10.1016/j.trip.2020.100115.

Glaser, B. and Strauss, A. (2006) *The Discovery of Grounded Theory - Strategies for Qualitative Research*.

Govindan, K. and Gholizadeh, H. (2021) 'Robust network design for sustainable-resilient reverse logistics network using big data: A case study of end-of-life vehicles', *Transportation Research Part E: Logistics and Transportation Review*, 149(February), p. 102279. doi: 10.1016/j.tre.2021.102279.

Hemming, V. *et al.* (2018) 'A practical guide to structured expert elicitation using the IDEA protocol', *Methods in Ecology and Evolution*, 9(1), pp. 169–180. doi: 10.1111/2041-210X.12857.

Hogarth, R. M. (1978) 'A note on aggregating opinions', *Organizational Behavior and Human Performance*, 21(1), pp. 40–46. doi: 10.1016/0030-5073(78)90037-5.

Hong, S. Q. and Huang, Y. J. (2021) 'Relationship among reverse logistics, corporate image and social impact in medical device industry', *Revista de Cercetare si Interventie Sociala*, 72, pp. 109–121. doi: 10.33788/rcis.72.7.

Hopkinson, P., De Angelis, R. and Zils, M. (2020) 'Systemic building blocks for creating and capturing value from circular economy', *Resources, Conservation and Recycling*, 155(November 2018), p. 104672. doi: 10.1016/j.resconrec.2019.104672.

Hsu, C.-C. *et al.* (2016) 'Strategic orientations, sustainable supply chain initiatives, and reverse logistics: Empirical evidence from an emerging market', *International Journal of Operations & Production Management*, 36(1), p. 360. Available at: https://www.emeraldinsight.com/doi/pdfplus/10.1108/IJOPM-06-2014-0252.

Jalil, E. E. A. *et al.* (2016) 'Reverse logistics in household recycling and waste systems: a symbiosis perspective', *Supply Chain Management: An International Journal*, 21(2). Available at: https://doi.org/10.1108/13598540910954539.

Javed, H. *et al.* (2021) 'Exploring disposition decision for sustainable reverse logistics in the era of a circular economy: Applying the triple bottom line approach in the manufacturing industry', *International Journal of Supply and Operations Management*, 8(1), pp. 53–68. doi: 10.22034/IJSOM.2021.1.5.

Jayaram, J. and Avittathur, B. (2015) 'Green supply chains: A perspective from an emerging economy', *International Journal of Production Economics*, 164, pp. 234–244. doi: 10.1016/j.ijpe.2014.12.003.

Julianelli, V. *et al.* (2020) 'Interplay between reverse logistics and circular economy: Critical success factors-based taxonomy and framework', *Resources, conservation and recycling*, 158, p. 104784.

Kerdpitak, C. *et al.* (2020) 'The mediating role of sustainable supply chain in the relationship between ECO-strategic orientation and the reverse logistic in Thai electronic industry', *International Journal of Supply Chain Management*, 9(1), pp. 10–18.

Keunecke, L., Hein, N. and Kroenke, A. (2016) 'Avaliação De Insumos Têxteis – Uma Análise Multicritério Por Meio Do Método Vikor', pp. 589–599. doi: 10.5151/marine-spolm2015-140621.

Khor, K.-S., Ramayah, T. and Fouladgaran, H. R. P. (2020) 'Managing eco-design for reverse logistics Thurasamy Ramayah Hamid Reza Panjeh Fouladgaran', *International Journal of Environment and Waste Management*, 26(2), pp. 125–146.

Kuhnert, P. M., Martin, T. G. and Griffiths, S. P. (2010) 'A guide to eliciting and using expert knowledge in Bayesian ecological models', *Ecology Letters*, 13(7), pp. 900–914. doi:

10.1111/j.1461-0248.2010.01477.x.

Leurent, H. and Abbosh, O. (2018) ‘Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation’, *World Economic Forum (WEF)*, (January), p. 58. Available at: http://www3.weforum.org/docs/WEF_39558_White_Paper_Driving_the_Sustainability_of_Production_Systems_4IR.pdf.

Liang, C. C. and Lee, J. P. (2018) ‘Carbon footprint model for reverse logistics of waste disposal in interior design industry’, *Asia Pacific Journal of Marketing and Logistics*, 30(4), pp. 889–906. doi: 10.1108/APJML-01-2018-0035.

Likert, R. (1932) ‘A Technique for the Measurement of Attitudes’, *Archives of Psychology*, 22(140), p. 55.

de Lorena Diniz Chaves, G. *et al.* (2021) ‘Synergizing environmental, social, and economic sustainability factors for refuse derived fuel use in cement industry: A case study in Espirito Santo, Brazil’, *Journal of Environmental Management*, 288(February), p. 112401. doi: 10.1016/j.jenvman.2021.112401.

Mardani, A. *et al.* (2016) ‘VIKOR Technique : A Systematic Review of the State of the Art Literature on Methodologies and Applications’, *Sustainability*, 8. doi: 10.3390/su8010037.

Martin, T. G. *et al.* (2012) ‘Eliciting Expert Knowledge in Conservation Science’, *Conservation Biology*, 26(1), pp. 29–38. doi: 10.1111/j.1523-1739.2011.01806.x.

Maurice, J. (2016) ‘Measuring progress towards the SDGs — a new vital science A new statistical methodology has emerged to gauge progress towards reaching the 2030’, *The Lancet*, 388(10053), pp. 1455–1458. doi: 10.1016/S0140-6736(16)31791-3.

Morgan, T. R. *et al.* (2018) ‘Resource commitment and sustainability: a reverse logistics performance process model’, *International Journal of Physical Distribution and Logistics Management*, 48(2), pp. 164–182. doi: 10.1108/IJPDLM-02-2017-0068.

Narayana, S. A., Pati, R. K. and Padhi, S. S. (2019) ‘Market dynamics and reverse logistics for sustainability in the Indian Pharmaceuticals industry’, *Journal of Cleaner Production*, 208, pp. 968–987. doi: 10.1016/j.jclepro.2018.10.171.

Opricovic, S. (2011) ‘Expert Systems with Applications Fuzzy VIKOR with an application to water resources planning’, *Expert Systems With Applications*, 38(10), pp. 12983–12990. doi: 10.1016/j.eswa.2011.04.097.

Peretti, U. *et al.* (2015) ‘Reverse logistics in humanitarian operations: challenges and opportunities’, *Journal of Humanitarian Logistics and Supply Chain Management*, 5(2), pp. 253–274.

Phoosawad, P. *et al.* (2019) ‘Impacts of collaboration networks, operational performance and reverse logistics determinants on the performance outcomes of the auto parts industry’, *Management and Production Engineering Review*, 10(3), pp. 61–72. doi: 10.24425/mper.2019.129599.

Piyathanavong, V. *et al.* (2019) ‘The adoption of operational environmental sustainability approaches in the Thai manufacturing sector’, *Journal of Cleaner Production*, 220, pp. 507–528. doi: 10.1016/j.jclepro.2019.02.093.

Purvis, B., Mao, Y. and Robinson, D. (2019) ‘Three pillars of sustainability: in search of conceptual origins', *Sustainability Science*, 14(3), pp. 681–695. doi: 10.1007/s11625-018-0627-5.

Pushpamali, N. N. C., Agdas, D. and Rose, T. M. (2020) 'Strategic Decision Making in Construction Supply Chains: A Comparison of Reverse Logistics Strategies', *Frontiers in Built Environment*, 6(December). doi: 10.3389/fbuil.2020.593372.

Refsgaard, J. C. *et al.* (2007) 'Uncertainty in the environmental modelling process - A framework and guidance', *Environmental Modelling and Software*, 22(11), pp. 1543–1556. doi: 10.1016/j.envsoft.2007.02.004.

Richnák, P. and Gubová, K. (2021) 'Green and reverse logistics in conditions of sustainable development in enterprises in Slovakia', *Sustainability (Switzerland)*, 13(2), pp. 1–23. doi: 10.3390/su13020581.

Rogers, D. S. and Tibben-Lembke, R. S. (1998) 'Going Backwards: Reverse Logistics Trends and Practices', *Reverse Logistics Executive Council*, p. 283.

Sachs, J. D. *et al.* (2019) 'Six Transformations to achieve the Sustainable Development Goals', *Nature Sustainability*, 2(9), pp. 805–814. doi: 10.1038/s41893-019-0352-9.

Sarkis, J., Helms, M. M. and Hervani, A. A. (2010) 'Reverse Logistics and Social Sustainability', *Corporate Social Responsibility and Environmental Management*, 354(January), pp. 337–354.

Schroeder, P., Anggraeni, K. and Weber, U. (2019) 'The Relevance of Circular Economy Practices to the Sustainable Development Goals', *Journal of Industrial Ecology*, 23(1), pp. 77–95. doi: 10.1111/jiec.12732.

Sellitto, M. A., Camfield, C. G. and Buzuku, S. (2020) 'Green innovation and competitive advantages in a furniture industrial cluster: A survey and structural model', *Sustainable Production and Consumption*, 23, pp. 94–104. doi: 10.1016/j.spc.2020.04.007.

Sirisawat, P. and Kiatcharoenpol, T. (2019) 'Correlation of Reverse Logistics Performance to Solutions Using Structural Equation Modeling', *Journal of Advanced Manufacturing Systems*, 18(4), pp. 511–525. doi: 10.1142/S0219686719500276.

Sittisom, W. and Mekhum, W. (2020) 'External supply chain management factors and social performance in Thai manufacturing industry: Moderating role of green human resource practices', *International Journal of Supply Chain Management*, 9(1), pp. 190–198.

Slomski, V. *et al.* (2018) 'A disclosure of social and environmental results/economy resulting from the implementation of reverse logistics and final disposal of the post-consumption product: The case of computer peripherals industry', *Environmental Quality Management*, 27(3), pp. 73–87. doi: 10.1002/tqem.21530.

Sun, X., Yu, H. and Solvang, W. D. (2022) 'Towards the smart and sustainable transformation of Reverse Logistics 4.0: a conceptualization and research agenda', *Environmental Science and Pollution Research*, 29(46), pp. 69275–69293. doi: 10.1007/s11356-022-22473-3.

Trujillo-Gallego, M., Sarache, W. and Sellitto, M. A. (2021) 'Identification of practices that facilitate manufacturing companies' environmental collaboration and their influence on sustainable production', *Sustainable Production and Consumption*, 27, pp. 1372–1391. doi: 10.1016/j.spc.2021.03.009.

Tseng, M. L. *et al.* (2018) 'A framework for evaluating the performance of sustainable service supply chain management under uncertainty', *International Journal of Production Economics*, 195, pp. 359–372. doi: 10.1016/j.ijpe.2016.09.002.

Uriarte-Miranda, M. L. *et al.* (2018) 'Reverse logistic strategy for the management of tire waste in Mexico and Russia: Review and conceptual model', *Sustainability (Switzerland)*, 10(10). doi: 10.3390/su10103398.

Vinuesa, R. *et al.* (2020) 'The role of artificial intelligence in achieving the Sustainable Development Goals', *Nature Communications*, 11(1), pp. 1–10. doi: 10.1038/s41467-019-14108-y.

Wang, W. *et al.* (2019) 'Assessing the cost structure of component reuse in a product family for remanufacturing', *Journal of Intelligent Manufacturing*, 30(2), pp. 575–587. doi: 10.1007/s10845-016-1267-1.

Wu, J. and Zhao, Z. (2022) 'Sustainable development of green reverse logistics based on blockchain', *Energy Reports*, 8, pp. 11547–11553. doi: 10.1016/j.egyr.2022.08.219.

Xu, Z. *et al.* (2021) 'Robust global reverse logistics network redesign for high-grade plastic wastes recycling', *Waste Management*, 134(October 2020), pp. 251–262. doi: 10.1016/j.wasman.2021.08.024.

Yazdani, M. and Graeml, F. R. (2014) 'VIKOR and its Applications: A State-of-the-Art Survey', *International Journal of Strategic Decision Sciences*, 5(2), pp. 56–83. doi: 10.4018/ijsds.2014040105.

APPENDIX

Appendix A

Avaliação da Contribuição da Logística Reversa e seus Impactos para o Desenvolvimento Sustentável

O TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE) foi enviado no seu e-mail junto a este questionário. Também consta no link a seguir e detalha as questões legais para a participação nesta pesquisa: (https://drive.google.com/file/d/1NfuEBoZH6LXn1tw1pLZwkhyuXAo_GaUZ/view?usp=sharing).

☐ Ao assinalar este item declaro que recebi uma via do TCLE, li e concordo com o Termo.

Como preencher este questionário?

Para assegurar a qualidade dos dados, o questionário foi elaborado em quatro passos:

-	[Menor palpite] Em uma escala de 1 a 5, qual o seu menor palpite para o nível de correlação entre esse impacto da logística reversa e o cumprimento do respectivo ODS?
★	[Melhor palpite] Em uma escala de 1 a 5, qual o seu melhor palpite para o nível de correlação entre esse impacto da logística reversa e o cumprimento do respectivo ODS?
+	[Maior palpite] Em uma escala de 1 a 5, qual o seu maior palpite para o nível de correlação entre esse impacto da logística reversa e o cumprimento do respectivo ODS?
%	[Nível de certeza] Em uma escala 0% a 100%, quão certo você está da sua resposta?

Para dar os palpites, o questionário utiliza uma escala Likert de 1 a 5, sendo:
1 = Este impacto gerado pela logística reversa não é importante para o cumprimento do respectivo ODS;
2 = Este impacto gerado pela logística reversa às vezes é importante para o cumprimento do respectivo ODS;
3 = Este impacto gerado pela logística reversa contribui moderadamente para com o cumprimento do respectivo ODS;
4 = Este impacto gerado pela logística reversa é importante para o cumprimento do respectivo ODS;
5 = Este impacto gerado pela logística reversa é muito importante para o cumprimento do respectivo ODS.

A seguir, você encontra um exemplo do preenchimento do questionário:

	A	B	C	D
1			ODS	ODS
2	Impacto da logística reversa	-	2	1
3		★	3	3
4		+	4	5
5		%	85	50

Appendix B

		ODS 1 - Erradicação da pobreza	ODS 2 - Fome Zero e Agricultura Sustentável	ODS 6 - Água Potável e Saneamento	ODS 7 - Energia Limpa e Acessível	ODS 8 - Emprego Decente e Crescimento Econômico	ODS 12 - Consumo e Produção Responsáveis	ODS 14 - Vida na Água	ODS 15 - Vida Terrestre
Reduzir a pegada ambiental, a quantidade de resíduos e a disposição em aterros. Otimizando o uso de matéria-prima e recursos naturais e o desempenho da reciclagem	-								
	★								
	+								
	%								
Melhorar as estratégias orientadas ao meio ambiente	-								
	★								
	+								
	%								
Reduzir o consumo de energia	-								
	★								
	+								
	%								
Otimizar o transporte	-								
	★								
	+								
	%								
Reduzir a poluição do solo	-								
	★								
	+								
	%								
Reduzir a poluição da água	-								
	★								
	+								
	%								
Reduzir a pegada de carbono e a poluição do ar	-								
	★								
	+								
	%								
Atender às pressões ambientais, exigências legais e governamentais e aumentar a proteção ambiental.	-								
	★								
	+								
	%								
Melhorar o atendimento e a satisfação do cliente e a imagem da empresa	-								
	★								
	+								
	%								
Aumentar o lucro e a redução de custos	-								
	★								
	+								
	%								
Aumentar a taxa de devolução de produtos usados	-								
	★								
	+								
	%								
Melhorar a qualidade do produto	-								
	★								
	+								
	%								
Aumentar a adoção de soluções de tecnologia	-								
	★								
	+								
	%								
Aumentar a competitividade do mercado	-								
	★								
	+								
	%								
Melhorar o desempenho operacional, a capacidade de utilização e as soluções de gerenciamento	-								
	★								
	+								
	%								
Reduzir as críticas da comunidade	-								
	★								
	+								
	%								
Melhorar a saúde e a segurança humana	-								
	★								
	+								
	%								
Aumentar a geração de empregos e geração renda para catadores	-								
	★								
	+								
	%								
Aumentar a responsabilidade social	-								
	★								
	+								
	%								

Appendix C

Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw material and natural resources and the recycling performance									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	40	acdv	0.00	2.00	2.00	80
acaf	2.00	5.00	4.00	80	acaf	2.00	5.00	4.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	4.00	3.00	50	prlm	1.40	4.60	3.00	80
prmm	2.00	4.00	3.00	50	prmm	1.40	4.60	3.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	2.00	3.00	2.00	70	proh	2.00	3.14	2.00	80
					Mean	1.16	3.48	2.50	80.00

Improve strategies environmental driven									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	40	acdv	0.00	2.00	2.00	80
acaf	2.00	5.00	4.00	75	acaf	1.87	5.07	4.00	80
acgg	2.00	4.00	3.00	40	acgg	1.00	5.00	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	2.00	4.00	3.00	70	prlm	1.86	4.14	3.00	80
prmm	3.00	5.00	4.00	75	prmm	2.93	5.07	4.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.58	3.77	3.00	80.00

Reduce energy consumption	
Raw data	**Standardised data**

Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	40	acdv	0.00	2.00	2.00	80
acaf	3.00	5.00	4.00	50	acaf	2.40	5.60	4.00	80
acgg	1.00	3.00	2.00	60	acgg	0.67	3.33	2.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	2.00	4.00	3.00	50	prmm	1.40	4.60	3.00	80
prmc	0.00	1.00	1.00	90	prmc	0.11	1.00	1.00	80
proh	2.00	3.00	3.00	60	proh	1.67	3.00	3.00	80
					Mean	1.24	3.33	2.63	80.00

Optimize transport									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	40	acdv	0.00	2.00	2.00	80
acaf	1.00	3.00	2.00	40	acaf	0.00	4.00	2.00	80
acgg	4.00	5.00	5.00	80	acgg	4.00	5.00	5.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	4.00	5.00	4.00	50	prlm	4.00	5.60	4.00	80
prmm	2.00	4.00	3.00	50	prmm	1.40	4.60	3.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.80	3.76	3.00	80.00

Reduce soil pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	85	acaf	2.12	4.94	4.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80

acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	30	prlm	1.33	6.67	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	3.00	2.00	85	prmc	1.06	2.94	2.00	80
proh	2.00	3.00	3.00	80	proh	2.00	3.00	3.00	80
					Mean	1.41	3.79	2.88	80.00

Reduce water pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	80	acaf	2.00	5.00	4.00	80
acgg	3.00	5.00	4.00	80	acgg	3.00	5.00	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	30	prlm	1.33	6.67	4.00	80
prmm	2.00	4.00	3.00	50	prmm	1.40	4.60	3.00	80
prmc	1.00	4.00	3.00	90	prmc	1.22	3.89	3.00	80
proh	2.00	3.00	3.00	70	proh	1.86	3.00	3.00	80
					Mean	1.54	4.02	3.13	80.00

Reduce carbon footprint and air pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	3.00	2.00	40	acaf	0.00	4.00	2.00	80
acgg	4.00	5.00	4.00	90	acgg	4.00	4.89	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	0.00	2.00	1.00	95	prmc	0.16	1.84	1.00	80

proh	2.00	3.00	3.00	80	proh	2.00	3.00	3.00	80
					Mean	1.37	3.31	2.50	80.00

Meet environmental pressures and legal and government requirements and increase environmental protection									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	70	acaf	1.71	5.14	4.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	2.00	4.00	3.00	60	prmm	1.67	4.33	3.00	80
prmc	1.00	2.00	1.00	75	prmc	1.00	2.07	1.00	80
proh	2.00	3.00	2.00	85	proh	2.00	2.94	2.00	80
					Mean	1.70	3.50	2.63	80.00

Improve customer service and satisfaction and the company's image									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	80	acaf	2.00	5.00	4.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	95	acmf	1.16	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	3.00	2.00	80	prmm	1.00	3.00	2.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	2.00	3.00	3.00	70	proh	1.86	3.00	3.00	80
					Mean	1.31	3.24	2.38	80.00

Increase profit and cost saving

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	3.00	2.00	40	acaf	0.00	4.00	2.00	80
acgg	2.00	4.00	3.00	70	acgg	1.86	4.14	3.00	80
acmf	1.00	2.00	2.00	95	acmf	1.16	2.00	2.00	80
prlm	2.00	3.00	3.00	50	prlm	1.40	3.00	3.00	80
prmm	1.00	2.00	1.00	80	prmm	1.00	2.00	1.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	1.00	2.00	1.00	75	proh	1.00	2.07	1.00	80
					Mean	1.02	2.76	2.00	80.00

Increase the return rate of used products									
Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	80	acaf	2.00	5.00	4.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	4.00	4.00	70	prlm	2.86	4.00	4.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	1.00	2.00	1.00	90	prmc	1.00	1.89	1.00	80
proh	3.00	4.00	3.00	80	proh	3.00	4.00	3.00	80
					Mean	1.44	2.99	2.38	80.00

Improve product quality									
Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	70	acdv	0.86	2.00	2.00	80
acaf	2.00	5.00	4.00	80	acaf	2.00	5.00	4.00	80

acgg	1.00	3.00	2.00	50	acgg	0.40	3.60	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	0.00	1.00	1.00	95	prmc	0.16	1.00	1.00	80
proh	2.00	4.00	3.00	70	proh	1.86	4.14	3.00	80
					Mean	1.27	2.99	2.38	80.00

Increase technology solutions adoption									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	75	acaf	1.87	5.07	4.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.71	3.89	3.00	80.00

Increase market competitiveness									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	3.00	2.00	40	acaf	0.00	4.00	2.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	3.00	50	prlm	1.40	3.00	3.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80

prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	1.24	3.02	2.38	80.00

Improve operational performance, capacity utilisation and management solutions									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	3.00	2.00	40	acaf	0.00	4.00	2.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	3.00	50	prlm	1.40	3.00	3.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	1.00	2.00	2.00	90	prmc	1.11	2.00	2.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.11	3.41	2.63	80.00

Reduce community complaints									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	5.00	3.00	85	proh	3.00	4.88	3.00	80
					Mean	1.49	3.29	2.25	80.00

Improve human health and safety									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	85	acaf	2.12	4.94	4.00	80
acgg	1.00	4.00	3.00	40	acgg	-1.00	5.00	3.00	80
acmf	2.00	3.00	3.00	85	acmf	2.06	3.00	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.25	4.12	3.50	80.00

Increase job generation and provide income for value pickers									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	5.00	80	acdv	4.00	5.00	5.00	80
acaf	2.00	5.00	4.00	75	acaf	1.87	5.07	4.00	80
acgg	4.00	5.00	4.00	70	acgg	4.00	5.14	4.00	80
acmf	2.00	3.00	3.00	95	acmf	2.16	3.00	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	4.00	2.00	100	prmc	1.20	3.60	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	3.28	4.62	4.00	80.00

Improve social responsability									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	5.00	80	acdv	4.00	5.00	5.00	80

acaf	1.00	3.00	2.00	60	acaf	0.67	3.33	2.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	2.00	3.00	3.00	70	acmf	1.86	3.00	3.00	80
prlm	2.00	4.00	3.00	70	prlm	1.86	4.14	3.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	0.00	2.00	1.00	95	prmc	0.16	1.84	1.00	80
proh	4.00	5.00	5.00	90	proh	4.11	5.00	5.00	80
					Mean	2.44	4.06	3.50	80.00

Appendix D

Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw material and natural resources and the recycling performance									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	5.00	80	acdv	5.00	5.00	5.00	80
acaf	1.00	5.00	3.00	100	acaf	1.40	4.60	3.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	4.00	3.00	50	prlm	1.40	4.60	3.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	0.00	4.00	2.00	100	prmc	0.40	3.60	2.00	80
proh	2.00	3.00	3.00	70	proh	1.86	3.00	3.00	80
					Mean	2.23	4.14	3.38	80.00

Improve strategies environmental driven									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	4.00	70	acdv	4.00	5.14	4.00	80
acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	4.00	5.00	4.00	80	acgg	4.00	5.00	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	2.00	4.00	3.00	100	prmc	2.20	3.80	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	3.30	4.50	3.88	80.00

Reduce energy consumption									
Raw data					**Standardised data**				

Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	3.00	4.00	4.00	60	acdv	2.67	4.00	4.00	80
acaf	2.00	4.00	3.00	60	acaf	1.67	4.33	3.00	80
acgg	2.00	4.00	3.00	70	acgg	1.86	4.14	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	2.00	4.00	3.00	50	prlm	1.40	4.60	3.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	2.00	2.00	90	prmc	1.11	2.00	2.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.62	3.58	2.88	80.00

Optimize transport									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	50	acdv	0.40	2.00	2.00	80
acaf	2.00	4.00	3.00	50	acaf	1.40	4.60	3.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	2.00	4.00	3.00	30	prlm	0.33	5.67	3.00	80
prmm	2.00	4.00	3.00	50	prmm	1.40	4.60	3.00	80
prmc	1.00	3.00	2.00	100	prmc	1.20	2.80	2.00	80
proh	3.00	5.00	4.00	90	proh	3.11	4.89	4.00	80
					Mean	1.44	3.96	2.88	80.00

Reduce soil pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	4.00	4.00	50	acdv	2.40	4.00	4.00	80
acaf	3.00	5.00	4.00	95	acaf	3.16	4.84	4.00	80
acgg	3.00	5.00	4.00	80	acgg	3.00	5.00	4.00	80

acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.77	4.42	3.88	80.00

Reduce water pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	4.00	4.00	70	acdv	2.86	4.00	4.00	80
acaf	1.00	5.00	3.00	100	acaf	1.40	4.60	3.00	80
acgg	3.00	5.00	4.00	90	acgg	3.11	4.89	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.63	4.37	3.75	80.00

Reduce carbon footprint and air pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	90	acdv	4.89	4.89	4.00	80
acaf	2.00	4.00	3.00	50	acaf	1.40	4.60	3.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	3.00	4.00	4.00	85	prmm	3.06	4.00	4.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80

proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.81	4.18	3.63	80.00

Meet environmental pressures and legal and government requirements and increase environmental protection									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	5.00	4.00	60	acdv	2.67	5.33	4.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	2.00	3.00	3.00	90	proh	2.11	3.00	3.00	80
					Mean	2.71	4.31	3.63	80.00

Improve customer service and satisfaction and the company's image									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	70	acdv	5.14	5.14	4.00	80
acaf	1.00	5.00	3.00	100	acaf	1.40	4.60	3.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	1.00	2.00	2.00	95	acmf	1.16	2.00	2.00	80
prlm	2.00	3.00	3.00	50	prlm	1.40	3.00	3.00	80
prmm	1.00	3.00	2.00	80	prmm	1.00	3.00	2.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	2.00	3.00	3.00	70	proh	1.86	3.00	3.00	80
					Mean	1.87	3.47	2.75	80.00

Increase profit and cost saving

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	2.00	4.00	3.00	50	acaf	1.40	4.60	3.00	80
acgg	3.00	5.00	4.00	50	acgg	2.40	5.60	4.00	80
acmf	1.00	2.00	2.00	95	acmf	1.16	2.00	2.00	80
prlm	2.00	3.00	3.00	30	prlm	0.33	3.00	3.00	80
prmm	1.00	2.00	1.00	80	prmm	1.00	2.00	1.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	1.00	2.00	1.00	75	proh	1.00	2.07	1.00	80
					Mean	1.68	3.39	2.50	80.00

Increase the return rate of used products

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	1.00	50	acdv	1.00	2.60	1.00	80
acaf	1.00	5.00	3.00	100	acaf	1.40	4.60	3.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	4.00	3.00	50	prlm	3.00	4.60	3.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	1.00	2.00	1.00	90	prmc	1.00	1.89	1.00	80
proh	3.00	4.00	3.00	70	proh	3.00	4.14	3.00	80
					Mean	1.43	3.10	2.00	80.00

Improve product quality

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	5.00	3.00	100	acaf	1.40	4.60	3.00	80

acgg	1.00	3.00	2.00	50	acgg	0.40	3.60	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	1.00	3.00	2.00	100	prmc	1.20	2.80	2.00	80
proh	2.00	4.00	3.00	70	proh	1.86	4.14	3.00	80
					Mean	1.30	3.16	2.38	80.00

Increase technology solutions adoption									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	5.00	4.00	70	acdv	2.86	5.14	4.00	80
acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	1.00	4.00	2.00	90	prmc	1.11	3.78	2.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	2.26	4.60	3.38	80.00

Increase market competitiveness									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	3.00	3.00	60	acdv	0.33	3.00	3.00	80
acaf	2.00	4.00	3.00	50	acaf	1.40	4.60	3.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	3.00	2.00	80	acmf	1.00	3.00	2.00	80
prlm	2.00	3.00	3.00	30	prlm	0.33	3.00	3.00	80
prmm	1.00	3.00	1.00	50	prmm	1.00	4.20	1.00	80

prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	1.20	3.78	2.63	80.00

Improve operational performance, capacity utilisation and management solutions									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	4.00	80	acdv	4.00	5.00	4.00	80
acaf	2.00	4.00	3.00	50	acaf	1.40	4.60	3.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	3.00	30	prlm	0.33	3.00	3.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	1.76	4.16	3.13	80.00

Reduce community complaints									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	4.00	3.00	75	acaf	1.93	4.07	3.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	3.00	2.00	80	acmf	1.00	3.00	2.00	80
prlm	2.00	3.00	3.00	50	prlm	1.40	3.00	3.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	3.00	5.00	3.00	70	proh	3.00	5.29	3.00	80
					Mean	1.14	3.03	2.13	80.00

Improve human health and safety									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	5.00	80	acdv	4.00	5.00	5.00	80
acaf	3.00	5.00	4.00	75	acaf	2.93	5.07	4.00	80
acgg	2.00	4.00	3.00	40	acgg	1.00	5.00	3.00	80
acmf	1.00	3.00	2.00	60	acmf	0.67	3.33	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	2.00	4.00	3.00	95	prmc	2.16	3.84	3.00	80
proh	4.00	5.00	4.00	85	proh	4.00	4.94	4.00	80
					Mean	2.84	4.67	3.75	80.00

Increase job generation and provide income for value pickers									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	5.00	80	acdv	4.00	5.00	5.00	80
acaf	1.00	5.00	3.00	95	acaf	1.32	4.68	3.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	3.00	2.00	70	acmf	0.86	3.14	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	4.00	5.00	4.00	80	proh	4.00	5.00	4.00	80
					Mean	2.59	4.43	3.50	80.00

Improve social responsability									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	5.00	80	acdv	4.00	5.00	5.00	80

acaf	2.00	4.00	3.00	75	acaf	1.93	4.07	3.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	3.00	2.00	60	acmf	0.67	3.33	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	0.00	2.00	1.00	95	prmc	0.16	1.84	1.00	80
proh	3.00	5.00	4.00	90	proh	3.11	4.89	4.00	80
					Mean	2.44	4.20	3.38	80.00

Appendix E

Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw material and natural resources and the recycling performance									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	4.00	4.00	60	acdv	2.67	4.00	4.00	80
acaf	2.00	5.00	3.00	70	acaf	1.86	5.29	3.00	80
acgg	4.00	5.00	4.00	70	acgg	4.00	5.14	4.00	80
acmf	2.00	4.00	3.00	80	acmf	2.00	4.00	3.00	80
prlm	3.00	4.00	3.00	30	prlm	3.00	5.67	3.00	80
prmm	2.00	4.00	3.00	70	prmm	1.86	4.14	3.00	80
prmc	1.00	3.00	2.00	100	prmc	1.20	2.80	2.00	80
proh	2.00	3.00	2.00	70	proh	2.00	3.14	2.00	80
					Mean	2.32	4.27	3.00	80.00

Improve strategies environmental driven									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	4.00	4.00	60	acdv	2.67	4.00	4.00	80
acaf	2.00	5.00	3.00	90	acaf	2.11	4.78	3.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	4.00	5.00	5.00	85	prmm	4.06	5.00	5.00	80
prmc	1.00	4.00	2.00	95	prmc	1.16	3.68	2.00	80
proh	3.00	5.00	4.00	95	proh	3.16	4.84	4.00	80
					Mean	2.47	4.32	3.50	80.00

Reduce energy consumption	
Raw data	**Standardised data**

Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	50	acdv	0.40	2.00	2.00	80
acaf	2.00	4.00	3.00	70	acaf	1.86	4.14	3.00	80
acgg	1.00	3.00	2.00	60	acgg	0.67	3.33	2.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	2.00	4.00	3.00	50	prlm	1.40	4.60	3.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	2.00	1.00	85	prmc	1.00	1.94	1.00	80
proh	2.00	3.00	3.00	60	proh	1.67	3.00	3.00	80
					Mean	1.03	3.08	2.25	80.00

Optimize transport									
Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	50	acdv	0.40	2.00	2.00	80
acaf	1.00	3.00	2.00	60	acaf	0.67	3.33	2.00	80
acgg	1.00	4.00	3.00	50	acgg	-0.20	4.60	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	2.00	4.00	3.00	30	prlm	0.33	5.67	3.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	3.00	3.00	80	prmc	1.00	3.00	3.00	80
proh	2.00	3.00	3.00	60	proh	1.67	3.00	3.00	80
					Mean	0.64	3.40	2.50	80.00

Reduce soil pollution									
Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	3.00	4.00	3.00	40	acdv	3.00	5.00	3.00	80
acaf	2.00	5.00	3.00	85	acaf	2.06	4.88	3.00	80
acgg	3.00	4.00	3.00	70	acgg	3.00	4.14	3.00	80

acmf	1.00	3.00	2.00	75	acmf	0.93	3.07	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.72	4.57	3.50	80.00

Reduce water pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	2.00	5.00	3.00	70	acaf	1.86	5.29	3.00	80
acgg	4.00	5.00	5.00	80	acgg	4.00	5.00	5.00	80
acmf	2.00	4.00	3.00	80	acmf	2.00	4.00	3.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	3.20	4.85	4.00	80.00

Reduce carbon footprint and air pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	3.00	2.00	60	acaf	0.67	3.33	2.00	80
acgg	3.00	5.00	4.00	90	acgg	3.11	4.89	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	2.00	1.00	80	prmc	1.00	2.00	1.00	80

proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.12	3.73	3.13	80.00

Meet environmental pressures and legal and government requirements and increase environmental protection									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	4.00	3.00	60	acdv	1.67	4.33	3.00	80
acaf	2.00	5.00	3.00	85	acaf	2.06	4.88	3.00	80
acgg	4.00	5.00	4.00	80	acgg	4.00	5.00	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	4.00	5.00	4.00	75	proh	4.00	5.07	4.00	80
					Mean	2.73	4.29	3.38	80.00

Improve customer service and satisfaction and the company’s image									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	3.00	70	acaf	1.86	5.29	3.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	2.00	2.00	95	acmf	1.16	2.00	2.00	80
prlm	2.00	3.00	3.00	50	prlm	1.40	3.00	3.00	80
prmm	1.00	3.00	2.00	80	prmm	1.00	3.00	2.00	80
prmc	1.00	3.00	2.00	85	prmc	1.06	2.94	2.00	80
proh	3.00	5.00	5.00	95	proh	3.32	5.00	5.00	80
					Mean	1.48	3.48	2.75	80.00

Increase profit and cost saving

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	3.00	2.00	60	acaf	0.67	3.33	2.00	80
acgg	2.00	4.00	3.00	40	acgg	1.00	5.00	3.00	80
acmf	1.00	2.00	2.00	95	acmf	1.16	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	1.00	2.00	1.00	90	prmc	1.00	1.89	1.00	80
proh	1.00	2.00	2.00	75	proh	0.93	2.00	2.00	80
					Mean	1.05	2.74	1.88	80.00

Increase the return rate of used products

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	1.00	70	acdv	1.00	2.14	1.00	80
acaf	2.00	5.00	3.00	70	acaf	1.86	5.29	3.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	4.00	4.00	50	prlm	2.40	4.00	4.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	0.00	1.00	1.00	90	prmc	0.11	1.00	1.00	80
proh	3.00	4.00	3.00	80	proh	3.00	4.00	3.00	80
					Mean	1.47	3.00	2.25	80.00

Improve product quality

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	3.00	70	acaf	1.86	5.29	3.00	80

acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	0.00	1.00	1.00	95	prmc	0.16	1.00	1.00	80
proh	2.00	4.00	3.00	70	proh	1.86	4.14	3.00	80
					Mean	1.38	3.11	2.38	80.00

Increase technology solutions adoption									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	5.00	4.00	60	acdv	2.67	5.33	4.00	80
acaf	2.00	5.00	3.00	90	acaf	2.11	4.78	3.00	80
acgg	4.00	5.00	5.00	70	acgg	3.86	5.00	5.00	80
acmf	1.00	3.00	3.00	80	acmf	1.00	3.00	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	2.00	4.00	3.00	95	prmc	2.16	3.84	3.00	80
proh	5.00	5.00	5.00	90	proh	5.00	5.00	5.00	80
					Mean	2.64	4.72	3.75	80.00

Increase market competitiveness									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	3.00	2.00	60	acaf	0.67	3.33	2.00	80
acgg	2.00	4.00	4.00	70	acgg	1.71	4.00	4.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	3.00	1.00	50	prmm	1.00	4.20	1.00	80

prmc	2.00	4.00	3.00	95	prmc	2.16	3.84	3.00	80
proh	4.00	5.00	5.00	90	proh	4.11	5.00	5.00	80
					Mean	1.66	3.63	2.63	80.00

Improve operational performance, capacity utilisation and management solutions									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	4.00	80	acdv	4.00	5.00	4.00	80
acaf	1.00	3.00	2.00	60	acaf	0.67	3.33	2.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	5.00	5.00	5.00	90	proh	5.00	5.00	5.00	80
					Mean	2.10	4.23	3.00	80.00

Reduce community complaints									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	3.00	2.00	75	acaf	0.93	3.07	2.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	3.00	50	prlm	1.40	3.00	3.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	0.00	2.00	1.00	95	prmc	0.16	1.84	1.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	1.23	2.78	2.25	80.00

Improve human health and safety									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	4.00	80	acdv	4.00	5.00	4.00	80
acaf	2.00	5.00	3.00	95	acaf	2.16	4.68	3.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	2.00	3.00	3.00	80	acmf	2.00	3.00	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	3.00	2.00	100	prmc	1.20	2.80	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.97	4.40	3.63	80.00

Increase job generation and provide income for value pickers									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	3.00	80	acaf	2.00	5.00	3.00	80
acgg	4.00	5.00	5.00	80	acgg	4.00	5.00	5.00	80
acmf	1.00	3.00	2.00	70	acmf	0.86	3.14	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	3.00	2.00	60	prmm	0.67	3.33	2.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	1.96	3.87	3.00	80.00

Improve social responsability									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	4.00	70	acdv	4.00	5.14	4.00	80

acaf	1.00	3.00	2.00	75	acaf	0.93	3.07	2.00	80
acgg	3.00	5.00	4.00	80	acgg	3.00	5.00	4.00	80
acmf	1.00	3.00	2.00	90	acmf	1.11	2.89	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	5.00	5.00	5.00	90	proh	5.00	5.00	5.00	80
					Mean	2.76	4.26	3.50	80.00

Appendix F

Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw material and natural resources and the recycling performance									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	3.00	5.00	4.00	100	acaf	3.20	4.80	4.00	80
acgg	2.00	4.00	3.00	40	acgg	1.00	5.00	3.00	80
acmf	1.00	3.00	2.00	80	acmf	1.00	3.00	2.00	80
prlm	2.00	4.00	3.00	30	prlm	0.33	5.67	3.00	80
prmm	1.00	2.00	2.00	70	prmm	0.86	2.00	2.00	80
prmc	1.00	3.00	2.00	85	prmc	1.06	2.94	2.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.93	4.05	3.00	80.00

Improve strategies environmental driven									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	2.00	5.00	4.00	90	acaf	2.22	4.89	4.00	80
acgg	2.00	4.00	3.00	40	acgg	1.00	5.00	3.00	80
acmf	1.00	3.00	2.00	90	acmf	1.11	2.89	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	85	prmm	4.06	5.00	5.00	80
prmc	2.00	5.00	4.00	90	prmc	2.22	4.89	4.00	80
proh	3.00	5.00	4.00	95	proh	3.16	4.84	4.00	80
					Mean	2.85	4.71	3.75	80.00

Reduce energy consumption									
Raw data					**Standardised data**				

Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	4.00	5.00	4.00	80	acdv	4.00	5.00	4.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	4.00	5.00	4.00	60	acgg	4.00	5.33	4.00	80
acmf	2.00	4.00	3.00	80	acmf	2.00	4.00	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	3.43	4.79	4.00	80.00

Optimize transport									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	50	acdv	0.40	2.00	2.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	2.00	4.00	3.00	30	prlm	0.33	5.67	3.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	2.00	4.00	3.00	95	prmc	2.16	3.84	3.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	1.45	3.96	2.88	80.00

Reduce soil pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	90	acaf	2.22	4.89	4.00	80
acgg	3.00	4.00	3.00	70	acgg	3.00	4.14	3.00	80

acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	0.00	1.00	1.00	100	prmc	0.20	1.00	1.00	80
proh	3.00	4.00	4.00	90	proh	3.11	4.00	4.00	80
					Mean	1.61	3.40	2.75	80.00

Reduce water pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	3.00	2.00	60	acdv	0.67	3.33	2.00	80
acaf	3.00	5.00	4.00	100	acaf	3.20	4.80	4.00	80
acgg	3.00	4.00	3.00	70	acgg	3.00	4.14	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	2.00	3.00	3.00	70	proh	1.86	3.00	3.00	80
					Mean	1.69	3.66	2.75	80.00

Reduce carbon footprint and air pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	5.00	4.00	80	acdv	3.00	5.00	4.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	2.00	4.00	3.00	70	acgg	1.86	4.14	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	4.00	5.00	4.00	50	prlm	4.00	5.60	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	2.00	4.00	3.00	95	prmc	2.16	3.84	3.00	80

proh	3.00	5.00	5.00	90	proh	3.22	5.00	5.00	80
					Mean	2.32	4.27	3.38	80.00

Meet environmental pressures and legal and government requirements and increase environmental protection									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	75	acaf	1.87	5.07	4.00	80
acgg	2.00	3.00	3.00	40	acgg	1.00	3.00	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	4.00	5.00	4.00	90	proh	4.00	4.89	4.00	80
					Mean	2.33	3.87	3.38	80.00

Improve customer service and satisfaction and the company's image									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	70	acdv	5.14	5.14	4.00	80
acaf	3.00	5.00	4.00	100	acaf	3.20	4.80	4.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	2.00	2.00	95	acmf	1.16	2.00	2.00	80
prlm	3.00	4.00	3.00	50	prlm	3.00	4.60	3.00	80
prmm	1.00	3.00	2.00	80	prmm	1.00	3.00	2.00	80
prmc	2.00	3.00	3.00	90	prmc	2.11	3.00	3.00	80
proh	2.00	5.00	4.00	90	proh	2.22	4.89	4.00	80
					Mean	2.23	3.93	3.00	80.00

Increase profit and cost saving

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	90	acdv	4.89	4.89	4.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	2.00	2.00	95	acmf	1.16	2.00	2.00	80
prlm	2.00	3.00	3.00	30	prlm	0.33	3.00	3.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	1.00	2.00	2.00	90	proh	1.11	2.00	2.00	80
					Mean	1.58	3.09	2.50	80.00

Increase the return rate of used products

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	1.00	50	acdv	1.00	2.60	1.00	80
acaf	3.00	5.00	4.00	100	acaf	3.20	4.80	4.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	4.00	4.00	50	prlm	2.40	4.00	4.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	0.00	1.00	1.00	90	prmc	0.11	1.00	1.00	80
proh	1.00	2.00	2.00	90	proh	1.11	2.00	2.00	80
					Mean	1.40	2.75	2.25	80.00

Improve product quality

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	1.00	70	acdv	1.00	2.14	1.00	80
acaf	3.00	5.00	4.00	100	acaf	3.20	4.80	4.00	80

acgg	1.00	3.00	2.00	50	acgg	0.40	3.60	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	1.00	2.00	1.00	90	prmc	1.00	1.89	1.00	80
proh	2.00	4.00	4.00	80	proh	2.00	4.00	4.00	80
					Mean	1.56	3.07	2.38	80.00

Increase technology solutions adoption									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	5.00	4.00	80	acdv	3.00	5.00	4.00	80
acaf	2.00	5.00	4.00	90	acaf	2.22	4.89	4.00	80
acgg	4.00	5.00	5.00	80	acgg	4.00	5.00	5.00	80
acmf	1.00	3.00	2.00	80	acmf	1.00	3.00	2.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	2.00	5.00	3.00	90	prmc	2.11	4.78	3.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.71	4.79	3.75	80.00

Increase market competitiveness									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	3.00	3.00	60	acdv	0.33	3.00	3.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	3.00	30	prlm	0.33	3.00	3.00	80
prmm	1.00	3.00	1.00	50	prmm	1.00	4.20	1.00	80

prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	1.60	3.75	2.88	80.00

Improve operational performance, capacity utilisation and management solutions									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	4.00	80	acdv	4.00	5.00	4.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	3.00	30	prlm	0.33	3.00	3.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	1.00	4.00	2.00	90	prmc	1.11	3.78	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.19	4.34	3.38	80.00

Reduce community complaints									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	40	acdv	0.00	2.00	2.00	80
acaf	3.00	5.00	4.00	95	acaf	3.16	4.84	4.00	80
acgg	1.00	3.00	2.00	60	acgg	0.67	3.33	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	4.00	3.00	50	prlm	3.00	4.60	3.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	2.00	4.00	3.00	95	prmc	2.16	3.84	3.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.75	3.20	2.63	80.00

Improve human health and safety									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	3.00	3.00	60	acdv	1.67	3.00	3.00	80
acaf	2.00	5.00	4.00	100	acaf	2.40	4.80	4.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	3.00	2.00	85	prmc	1.06	2.94	2.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.27	3.99	3.38	80.00

Increase job generation and provide income for value pickers									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	1.00	3.00	2.00	50	acgg	0.40	3.60	2.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	1.00	1.00	60	prmm	1.00	1.00	1.00	80
prmc	0.00	2.00	1.00	95	prmc	0.16	1.84	1.00	80
proh	2.00	3.00	3.00	90	proh	2.11	3.00	3.00	80
					Mean	1.34	2.99	2.38	80.00

Improve social responsability									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	2.00	3.00	60	acdv	1.67	1.67	3.00	80

acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	2.00	2.00	90	acmf	1.11	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	40	prmm	3.00	5.00	5.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	4.00	4.00	95	proh	3.16	4.00	4.00	80
					Mean	2.14	3.70	3.25	80.00

Appendix G

Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw material and natural resources and the recycling performance									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	50	acdv	0.40	2.00	2.00	80
acaf	2.00	5.00	3.00	90	acaf	2.11	4.78	3.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	2.00	4.00	3.00	90	acmf	2.11	3.89	3.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	0.00	3.00	2.00	95	prmc	0.32	2.84	2.00	80
proh	2.00	3.00	3.00	70	proh	1.86	3.00	3.00	80
					Mean	1.72	3.83	3.00	80.00

Improve strategies environmental driven									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	50	acdv	0.40	2.00	2.00	80
acaf	2.00	5.00	3.00	60	acaf	1.67	5.67	3.00	80
acgg	2.00	4.00	3.00	70	acgg	1.86	4.14	3.00	80
acmf	1.00	3.00	2.00	95	acmf	1.16	2.84	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	3.00	5.00	4.00	70	prmm	2.86	5.14	4.00	80
prmc	1.00	4.00	3.00	85	prmc	1.12	3.94	3.00	80
proh	3.00	4.00	4.00	90	proh	3.11	4.00	4.00	80
					Mean	1.82	4.17	3.13	80.00

Reduce energy consumption	
Raw data	**Standardised data**

Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	50	acdv	0.40	2.00	2.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	3.00	5.00	4.00	50	acgg	2.40	5.60	4.00	80
acmf	1.00	3.00	2.00	70	acmf	0.86	3.14	2.00	80
prlm	3.00	5.00	4.00	30	prlm	1.33	6.67	4.00	80
prmm	2.00	4.00	3.00	50	prmm	1.40	4.60	3.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	2.00	4.00	3.00	80	proh	2.00	4.00	3.00	80
					Mean	1.58	4.22	3.00	80.00

Optimize transport									
Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	4.00	5.00	4.00	70	acdv	4.00	5.14	4.00	80
acaf	1.00	4.00	3.00	75	acaf	0.87	4.07	3.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	2.00	3.00	3.00	70	acmf	1.86	3.00	3.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	2.00	4.00	3.00	100	prmc	2.20	3.80	3.00	80
proh	3.00	5.00	4.00	95	proh	3.16	4.84	4.00	80
					Mean	2.19	4.42	3.38	80.00

Reduce soil pollution									
Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	3.00	75	acaf	1.93	5.13	3.00	80
acgg	2.00	3.00	3.00	40	acgg	1.00	3.00	3.00	80

acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	30	prlm	1.33	6.67	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	4.00	2.00	90	prmc	1.11	3.78	2.00	80
proh	2.00	3.00	3.00	80	proh	2.00	3.00	3.00	80
					Mean	1.16	3.65	2.63	80.00

Reduce water pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	3.00	90	acaf	2.11	4.78	3.00	80
acgg	2.00	3.00	3.00	40	acgg	1.00	3.00	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	30	prlm	1.33	6.67	4.00	80
prmm	2.00	4.00	3.00	50	prmm	1.40	4.60	3.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	2.00	3.00	3.00	70	proh	1.86	3.00	3.00	80
					Mean	1.17	3.49	2.63	80.00

Reduce carbon footprint and air pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	4.00	3.00	75	acaf	0.87	4.07	3.00	80
acgg	1.00	3.00	2.00	50	acgg	0.40	3.60	2.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	2.00	1.00	90	prmc	1.00	1.89	1.00	80

proh	2.00	4.00	3.00	80	proh	2.00	4.00	3.00	80
					Mean	1.07	3.34	2.38	80.00

Meet environmental pressures and legal and government requirements and increase environmental protection									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	3.00	75	acaf	1.93	5.13	3.00	80
acgg	3.00	5.00	4.00	80	acgg	3.00	5.00	4.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	3.00	2.00	80	prmc	1.00	3.00	2.00	80
proh	2.00	3.00	3.00	80	proh	2.00	3.00	3.00	80
					Mean	2.20	3.78	3.13	80.00

Improve customer service and satisfaction and the company’s image									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	70	acdv	5.14	5.14	4.00	80
acaf	2.00	5.00	3.00	90	acaf	2.11	4.78	3.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	2.00	3.00	3.00	80	acmf	2.00	3.00	3.00	80
prlm	3.00	4.00	4.00	50	prlm	2.40	4.00	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	3.00	4.00	4.00	90	proh	3.11	4.00	4.00	80
					Mean	2.55	4.05	3.38	80.00

Increase profit and cost saving

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	4.00	3.00	75	acaf	0.87	4.07	3.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	2.00	3.00	3.00	80	acmf	2.00	3.00	3.00	80
prlm	2.00	4.00	3.00	30	prlm	0.33	5.67	3.00	80
prmm	1.00	2.00	1.00	80	prmm	1.00	2.00	1.00	80
prmc	2.00	4.00	3.00	85	prmc	2.06	3.94	3.00	80
proh	1.00	2.00	2.00	90	proh	1.11	2.00	2.00	80
					Mean	1.52	3.46	2.75	80.00

Increase the return rate of used products									
Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	1.00	70	acdv	1.00	2.14	1.00	80
acaf	2.00	5.00	3.00	90	acaf	2.11	4.78	3.00	80
acgg	3.00	4.00	4.00	60	acgg	2.67	4.00	4.00	80
acmf	2.00	4.00	3.00	90	acmf	2.11	3.89	3.00	80
prlm	3.00	4.00	4.00	70	prlm	2.86	4.00	4.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	0.00	1.00	1.00	95	prmc	0.16	1.00	1.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.86	3.10	2.63	80.00

Improve product quality									
Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	1.00	70	acdv	1.00	2.14	1.00	80
acaf	2.00	5.00	3.00	90	acaf	2.11	4.78	3.00	80

acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	1.00	3.00	3.00	80	acmf	1.00	3.00	3.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	4.00	3.00	90	proh	3.00	3.89	3.00	80
					Mean	1.95	3.80	2.88	80.00

Increase technology solutions adoption									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	3.00	60	acaf	1.67	5.67	3.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	1.00	2.00	1.00	40	prmm	1.00	3.00	1.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.92	3.72	2.75	80.00

Increase market competitiveness									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	4.00	3.00	75	acaf	0.87	4.07	3.00	80
acgg	4.00	5.00	5.00	80	acgg	4.00	5.00	5.00	80
acmf	1.00	3.00	2.00	90	acmf	1.11	2.89	2.00	80
prlm	2.00	4.00	3.00	30	prlm	0.33	5.67	3.00	80
prmm	1.00	5.00	1.00	50	prmm	1.00	7.40	1.00	80

prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	5.00	5.00	5.00	90	proh	5.00	5.00	5.00	80
					Mean	1.77	4.36	2.88	80.00

Improve operational performance, capacity utilisation and management solutions									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	4.00	3.00	75	acaf	0.87	4.07	3.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	4.00	4.00	3.00	50	prlm	4.60	4.60	3.00	80
prmm	1.00	2.00	1.00	40	prmm	1.00	3.00	1.00	80
prmc	1.00	2.00	2.00	95	prmc	1.16	2.00	2.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	2.05	3.33	2.75	80.00

Reduce community complaints									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	2.00	3.00	50	acdv	1.40	1.40	3.00	80
acaf	1.00	4.00	3.00	85	acaf	1.12	3.94	3.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	3.00	2.00	90	acmf	1.11	2.89	2.00	80
prlm	3.00	4.00	4.00	50	prlm	2.40	4.00	4.00	80
prmm	1.00	1.00	1.00	60	prmm	1.00	1.00	1.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	4.00	3.00	70	proh	3.00	4.14	3.00	80
					Mean	1.57	3.10	2.63	80.00

Improve human health and safety									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	3.00	3.00	70	acdv	1.86	3.00	3.00	80
acaf	2.00	5.00	3.00	55	acaf	1.55	5.91	3.00	80
acgg	2.00	4.00	3.00	40	acgg	1.00	5.00	3.00	80
acmf	3.00	4.00	4.00	95	acmf	3.16	4.00	4.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	1.00	2.00	2.00	90	prmc	1.11	2.00	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.05	4.52	3.38	80.00

Increase job generation and provide income for value pickers									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	5.00	90	acdv	5.00	5.00	5.00	80
acaf	2.00	5.00	3.00	75	acaf	1.93	5.13	3.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	3.00	5.00	4.00	95	acmf	3.16	4.84	4.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	3.55	4.75	4.13	80.00

Improve social responsability									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	5.00	80	acdv	4.00	5.00	5.00	80

acaf	1.00	4.00	3.00	65	acaf	0.54	4.23	3.00	80
acgg	3.00	5.00	4.00	80	acgg	3.00	5.00	4.00	80
acmf	2.00	4.00	4.00	95	acmf	2.32	4.00	4.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	0.00	2.00	1.00	95	prmc	0.16	1.84	1.00	80
proh	3.00	5.00	4.00	95	proh	3.16	4.84	4.00	80
					Mean	2.45	4.44	3.75	80.00

Appendix H

Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw material and natural resources and the recycling performance									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	2.00	5.00	4.00	100	acaf	2.40	4.80	4.00	80
acgg	4.00	5.00	5.00	80	acgg	4.00	5.00	5.00	80
acmf	3.00	4.00	4.00	95	acmf	3.16	4.00	4.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	0.00	4.00	2.00	95	prmc	0.32	3.68	2.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	3.39	4.70	4.13	80.00

Improve strategies environmental driven									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	3.00	5.00	4.00	70	acaf	2.86	5.14	4.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	3.00	4.00	4.00	95	acmf	3.16	4.00	4.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	3.67	4.63	4.13	80.00

Reduce energy consumption									
Raw data					**Standardised data**				

Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	4.00	5.00	5.00	80	acgg	4.00	5.00	5.00	80
acmf	3.00	5.00	4.00	95	acmf	3.16	4.84	4.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	2.00	4.00	4.00	95	prmc	2.32	4.00	4.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	3.73	4.86	4.38	80.00

Optimize transport									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	4.00	70	acdv	4.00	5.14	4.00	80
acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	3.00	5.00	4.00	95	acmf	3.16	4.84	4.00	80
prlm	3.00	5.00	4.00	30	prlm	1.33	6.67	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	3.00	3.00	75	prmc	0.87	3.00	3.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.75	4.77	3.88	80.00

Reduce soil pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	4.00	4.00	70	acdv	2.86	4.00	4.00	80
acaf	3.00	5.00	4.00	60	acaf	2.67	5.33	4.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80

acmf	2.00	4.00	3.00	80	acmf	2.00	4.00	3.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	0.00	2.00	1.00	95	prmc	0.16	1.84	1.00	80
proh	3.00	5.00	4.00	90	proh	3.11	4.89	4.00	80
					Mean	2.50	4.50	3.63	80.00

Reduce water pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	2.00	5.00	4.00	100	acaf	2.40	4.80	4.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	2.00	4.00	3.00	80	acmf	2.00	4.00	3.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	2.00	2.00	90	prmc	1.11	2.00	2.00	80
proh	4.00	5.00	5.00	90	proh	4.11	5.00	5.00	80
					Mean	2.98	4.59	3.88	80.00

Reduce carbon footprint and air pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	90	acdv	4.89	4.89	4.00	80
acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	1.00	3.00	2.00	80	acmf	1.00	3.00	2.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	4.00	3.00	95	prmc	1.32	3.84	3.00	80

proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	3.26	4.64	3.88	80.00

Meet environmental pressures and legal and government requirements and increase environmental protection									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	5.00	4.00	60	acdv	2.67	5.33	4.00	80
acaf	3.00	5.00	4.00	80	acaf	3.00	5.00	4.00	80
acgg	4.00	5.00	4.00	90	acgg	4.00	4.89	4.00	80
acmf	2.00	4.00	3.00	95	acmf	2.16	3.84	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	3.00	3.00	3.00	70	proh	3.00	3.00	3.00	80
					Mean	2.88	4.26	3.50	80.00

Improve customer service and satisfaction and the company's image									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	70	acdv	5.14	5.14	4.00	80
acaf	2.00	5.00	4.00	100	acaf	2.40	4.80	4.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	2.00	3.00	3.00	80	acmf	2.00	3.00	3.00	80
prlm	3.00	4.00	4.00	50	prlm	2.40	4.00	4.00	80
prmm	2.00	4.00	3.00	50	prmm	1.40	4.60	3.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.69	4.32	3.63	80.00

Increase profit and cost saving

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	5.00	5.00	4.00	90	acdv	4.89	4.89	4.00	80
acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	3.00	4.00	4.00	70	acgg	2.86	4.00	4.00	80
acmf	2.00	3.00	3.00	80	acmf	2.00	3.00	3.00	80
prlm	2.00	4.00	3.00	30	prlm	0.33	5.67	3.00	80
prmm	1.00	5.00	1.00	40	prmm	1.00	9.00	1.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	1.00	2.00	2.00	90	proh	1.11	2.00	2.00	80
					Mean	1.93	4.42	2.75	80.00

Increase the return rate of used products

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	3.00	5.00	4.00	70	acdv	2.86	5.14	4.00	80
acaf	2.00	5.00	4.00	100	acaf	2.40	4.80	4.00	80
acgg	4.00	5.00	5.00	80	acgg	4.00	5.00	5.00	80
acmf	3.00	4.00	4.00	50	acmf	2.40	4.00	4.00	80
prlm	3.00	5.00	4.00	80	prlm	3.00	5.00	4.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	1.00	2.00	2.00	95	prmc	1.16	2.00	2.00	80
proh	5.00	5.00	5.00	90	proh	5.00	5.00	5.00	80
					Mean	2.73	3.99	3.63	80.00

Improve product quality

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	3.00	5.00	4.00	70	acdv	2.86	5.14	4.00	80
acaf	2.00	5.00	4.00	100	acaf	2.40	4.80	4.00	80

acgg	4.00	5.00	4.00	80	acgg	4.00	5.00	4.00	80
acmf	2.00	4.00	3.00	90	acmf	2.11	3.89	3.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	2.00	4.00	3.00	50	prmm	1.40	4.60	3.00	80
prmc	1.00	2.00	1.00	95	prmc	1.00	1.84	1.00	80
proh	3.00	4.00	3.00	80	proh	3.00	4.00	3.00	80
					Mean	2.60	4.28	3.25	80.00

Increase technology solutions adoption									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	5.00	4.00	80	acdv	3.00	5.00	4.00	80
acaf	3.00	5.00	4.00	70	acaf	2.86	5.14	4.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	3.00	4.00	4.00	90	acmf	3.11	4.00	4.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	1.00	2.00	1.00	40	prmm	1.00	3.00	1.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	4.00	5.00	5.00	80	proh	4.00	5.00	5.00	80
					Mean	2.75	4.39	3.50	80.00

Increase market competitiveness									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	3.00	3.00	60	acdv	0.33	3.00	3.00	80
acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	1.00	3.00	2.00	90	acmf	1.11	2.89	2.00	80
prlm	2.00	4.00	3.00	30	prlm	0.33	5.67	3.00	80
prmm	1.00	5.00	1.00	50	prmm	1.00	7.40	1.00	80

prmc	1.00	2.00	1.00	85	prmc	1.00	1.94	1.00	80
proh	3.00	5.00	4.00	70	proh	2.86	5.14	4.00	80
					Mean	1.58	4.51	2.75	80.00

Improve operational performance, capacity utilisation and management solutions									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	4.00	5.00	4.00	80	acdv	4.00	5.00	4.00	80
acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	3.00	4.00	3.00	50	prlm	3.00	4.60	3.00	80
prmm	1.00	2.00	1.00	40	prmm	1.00	3.00	1.00	80
prmc	2.00	4.00	3.00	85	prmc	2.06	3.94	3.00	80
proh	4.00	5.00	5.00	80	proh	4.00	5.00	5.00	80
					Mean	2.79	4.18	3.38	80.00

Reduce community complaints									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	2.00	2.00	60	acdv	2.00	2.00	2.00	80
acaf	3.00	5.00	4.00	70	acaf	2.86	5.14	4.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	3.00	5.00	4.00	95	acmf	3.16	4.84	4.00	80
prlm	3.00	4.00	4.00	50	prlm	2.40	4.00	4.00	80
prmm	1.00	1.00	1.00	70	prmm	1.00	1.00	1.00	80
prmc	0.00	2.00	1.00	95	prmc	0.16	1.84	1.00	80
proh	4.00	5.00	5.00	90	proh	4.11	5.00	5.00	80
					Mean	2.32	3.62	3.13	80.00

Improve human health and safety									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	3.00	3.00	70	acdv	1.86	3.00	3.00	80
acaf	3.00	5.00	4.00	85	acaf	3.06	4.94	4.00	80
acgg	2.00	4.00	3.00	40	acgg	1.00	5.00	3.00	80
acmf	2.00	4.00	3.00	95	acmf	2.16	3.84	3.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	1.00	5.00	3.00	60	prmm	0.33	5.67	3.00	80
prmc	1.00	3.00	2.00	85	prmc	1.06	2.94	2.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.06	4.44	3.38	80.00

Increase job generation and provide income for value pickers									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	5.00	4.00	90	acaf	2.22	4.89	4.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	3.00	5.00	4.00	90	acmf	3.11	4.89	4.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	1.00	1.00	1.00	60	prmm	1.00	1.00	1.00	80
prmc	2.00	3.00	3.00	85	prmc	2.06	3.00	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.51	3.88	3.38	80.00

Improve social responsability									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	3.00	4.00	60	acdv	1.33	2.67	4.00	80

acaf	3.00	5.00	4.00	90	acaf	3.11	4.89	4.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	2.00	4.00	4.00	70	acmf	1.71	4.00	4.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.94	4.31	4.13	80.00

Appendix I

Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw material and natural resources and the recycling performance									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	1.00	5.00	3.00	80	acaf	1.00	5.00	3.00	80
acgg	3.00	5.00	4.00	50	acgg	2.40	5.60	4.00	80
acmf	2.00	4.00	3.00	90	acmf	2.11	3.89	3.00	80
prlm	3.00	4.00	3.00	50	prlm	3.00	4.60	3.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	3.00	3.00	100	prmc	1.40	3.00	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.90	4.64	3.75	80.00

Improve strategies environmental driven									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	2.00	5.00	3.00	60	acaf	1.67	5.67	3.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	1.00	3.00	2.00	80	acmf	1.00	3.00	2.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	3.00	5.00	4.00	70	prmm	2.86	5.14	4.00	80
prmc	2.00	3.00	3.00	95	prmc	2.16	3.00	3.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	3.07	4.62	3.63	80.00

Reduce energy consumption									
Raw data					**Standardised data**				

Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	2.00	3.00	2.00	50	acdv	2.00	3.60	2.00	80
acaf	1.00	4.00	3.00	70	acaf	0.71	4.14	3.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	1.00	3.00	3.00	80	acmf	1.00	3.00	3.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	3.00	5.00	4.00	85	proh	3.06	4.94	4.00	80
					Mean	1.82	4.24	3.13	80.00

Optimize transport									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	3.00	2.00	50	acdv	2.00	3.60	2.00	80
acaf	2.00	4.00	3.00	60	acaf	1.67	4.33	3.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	2.00	4.00	3.00	30	prlm	0.33	5.67	3.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	2.00	2.00	80	prmc	1.00	2.00	2.00	80
proh	3.00	5.00	4.00	85	proh	3.06	4.94	4.00	80
					Mean	1.37	3.81	2.63	80.00

Reduce soil pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	3.00	4.00	80	acdv	2.00	3.00	4.00	80
acaf	2.00	5.00	3.00	70	acaf	1.86	5.29	3.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80

acmf	1.00	3.00	3.00	80	acmf	1.00	3.00	3.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.25	4.30	3.63	80.00

Reduce water pollution

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	90	acdv	4.89	4.89	4.00	80
acaf	1.00	5.00	3.00	80	acaf	1.00	5.00	3.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80
acmf	2.00	4.00	3.00	80	acmf	2.00	4.00	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	2.00	2.00	95	prmc	1.16	2.00	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	3.28	4.50	3.88	80.00

Reduce carbon footprint and air pollution

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	3.00	2.00	60	acdv	0.67	3.33	2.00	80
acaf	2.00	4.00	3.00	60	acaf	1.67	4.33	3.00	80
acgg	3.00	5.00	4.00	80	acgg	3.00	5.00	4.00	80
acmf	2.00	3.00	3.00	80	acmf	2.00	3.00	3.00	80
prlm	4.00	5.00	4.00	50	prlm	4.00	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	4.00	2.00	95	prmc	1.16	3.68	2.00	80

proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.70	4.37	3.50	80.00

Meet environmental pressures and legal and government requirements and increase environmental protection									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	5.00	4.00	60	acdv	2.67	5.33	4.00	80
acaf	2.00	5.00	3.00	65	acaf	1.77	5.46	3.00	80
acgg	3.00	5.00	4.00	80	acgg	3.00	5.00	4.00	80
acmf	2.00	3.00	3.00	80	acmf	2.00	3.00	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	3.08	4.73	3.88	80.00

Improve customer service and satisfaction and the company's image									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	5.00	3.00	80	acaf	1.00	5.00	3.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	1.00	1.00	95	acmf	1.00	1.00	1.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	3.00	2.00	80	prmm	1.00	3.00	2.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	1.65	3.52	2.50	80.00

Increase profit and cost saving

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	4.00	3.00	60	acaf	1.67	4.33	3.00	80
acgg	1.00	3.00	2.00	60	acgg	0.67	3.33	2.00	80
acmf	1.00	1.00	1.00	95	acmf	1.00	1.00	1.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	1.00	2.00	2.00	90	proh	1.11	2.00	2.00	80
					Mean	1.16	2.65	1.88	80.00

Increase the return rate of used products

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	1.00	50	acdv	1.00	2.60	1.00	80
acaf	1.00	5.00	3.00	80	acaf	1.00	5.00	3.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	3.00	4.00	4.00	95	acmf	3.16	4.00	4.00	80
prlm	3.00	4.00	4.00	70	prlm	2.86	4.00	4.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	1.00	2.00	2.00	95	prmc	1.16	2.00	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.10	3.49	2.88	80.00

Improve product quality

Raw data					Standardised data				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	1.00	60	acdv	1.00	2.33	1.00	80
acaf	1.00	5.00	3.00	80	acaf	1.00	5.00	3.00	80

acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	4.00	4.00	70	proh	2.86	4.00	4.00	80
					Mean	1.44	3.69	2.63	80.00

Increase technology solutions adoption									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	3.00	3.00	60	acdv	0.33	3.00	3.00	80
acaf	2.00	5.00	3.00	60	acaf	1.67	5.67	3.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	1.00	3.00	2.00	70	acmf	0.86	3.14	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	2.00	1.00	40	prmm	1.00	3.00	1.00	80
prmc	2.00	4.00	3.00	90	prmc	2.11	3.89	3.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.00	4.33	3.13	80.00

Increase market competitiveness									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	40	acdv	0.00	2.00	2.00	80
acaf	2.00	4.00	3.00	60	acaf	1.67	4.33	3.00	80
acgg	1.00	3.00	2.00	50	acgg	0.40	3.60	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80

prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	4.00	5.00	4.00	80	proh	4.00	5.00	4.00	80
					Mean	1.40	3.19	2.25	80.00

Improve operational performance, capacity utilisation and management solutions									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	3.00	3.00	60	acdv	0.33	3.00	3.00	80
acaf	2.00	4.00	3.00	60	acaf	1.67	4.33	3.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	40	prmm	1.00	1.00	1.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	1.72	3.40	2.63	80.00

Reduce community complaints									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	50	acdv	0.40	2.00	2.00	80
acaf	2.00	4.00	3.00	75	acaf	1.93	4.07	3.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	0.00	2.00	1.00	90	prmc	0.11	1.89	1.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	1.39	3.12	2.25	80.00

Improve human health and safety									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	4.00	3.00	60	acdv	1.67	4.33	3.00	80
acaf	2.00	5.00	3.00	55	acaf	1.55	5.91	3.00	80
acgg	1.00	3.00	2.00	40	acgg	0.00	4.00	2.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	2.00	1.00	40	prmm	1.00	3.00	1.00	80
prmc	1.00	2.00	2.00	90	prmc	1.11	2.00	2.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	1.45	3.98	2.63	80.00

Increase job generation and provide income for value pickers									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	1.00	5.00	3.00	85	acaf	1.12	4.88	3.00	80
acgg	1.00	4.00	3.00	50	acgg	-0.20	4.60	3.00	80
acmf	1.00	3.00	2.00	70	acmf	0.86	3.14	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	1.00	1.00	60	prmm	1.00	1.00	1.00	80
prmc	1.00	2.00	1.00	85	prmc	1.00	1.94	1.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.23	3.40	2.50	80.00

Improve social responsability									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	2.00	3.00	60	acdv	1.67	1.67	3.00	80

acaf	2.00	4.00	3.00	85	acaf	2.06	3.94	3.00	80
acgg	2.00	4.00	3.00	70	acgg	1.86	4.14	3.00	80
acmf	1.00	3.00	2.00	90	acmf	1.11	2.89	2.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.61	3.81	3.38	80.00

Appendix J

Reduce the environmental footprint, amounts of waste and landfill disposal. Optimising the use of raw material and natural resources and the recycling performance									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	3.00	5.00	4.00	60	acaf	2.67	5.33	4.00	80
acgg	3.00	4.00	3.00	50	acgg	3.00	4.60	3.00	80
acmf	3.00	4.00	4.00	90	acmf	3.11	4.00	4.00	80
prlm	4.00	5.00	4.00	50	prlm	4.00	5.60	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	4.00	3.00	100	prmc	1.40	3.80	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	3.42	4.79	4.00	80.00

Improve strategies environmental driven									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	2.00	5.00	3.00	60	acaf	1.67	5.67	3.00	80
acgg	3.00	5.00	4.00	70	acgg	2.86	5.14	4.00	80
acmf	2.00	4.00	3.00	80	acmf	2.00	4.00	3.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	3.00	5.00	4.00	70	prmm	2.86	5.14	4.00	80
prmc	2.00	3.00	3.00	90	prmc	2.11	3.00	3.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	3.19	4.74	3.75	80.00

Reduce energy consumption									
Raw data					**Standardised data**				

Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	40	acdv	0.00	2.00	2.00	80
acaf	1.00	4.00	3.00	60	acaf	0.33	4.33	3.00	80
acgg	2.00	4.00	3.00	70	acgg	1.86	4.14	3.00	80
acmf	1.00	3.00	3.00	80	acmf	1.00	3.00	3.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	4.00	3.00	90	prmc	1.22	3.89	3.00	80
proh	3.00	5.00	4.00	85	proh	3.06	4.94	4.00	80
					Mean	1.28	3.94	3.00	80.00

Optimize transport									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	3.00	2.00	50	acdv	2.00	3.60	2.00	80
acaf	2.00	4.00	3.00	65	acaf	1.77	4.23	3.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	3.00	5.00	4.00	85	proh	3.06	4.94	4.00	80
					Mean	1.66	3.89	2.75	80.00

Reduce soil pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	5.00	5.00	4.00	80	acdv	5.00	5.00	4.00	80
acaf	2.00	5.00	3.00	65	acaf	1.77	5.46	3.00	80
acgg	4.00	5.00	5.00	90	acgg	4.11	5.00	5.00	80

acmf	1.00	4.00	3.00	80	acmf	1.00	4.00	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	4.00	3.00	95	prmc	1.32	3.84	3.00	80
proh	4.00	5.00	5.00	95	proh	4.16	5.00	5.00	80
					Mean	2.72	4.63	3.63	80.00

Reduce water pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	3.00	4.00	80	acdv	2.00	3.00	4.00	80
acaf	3.00	5.00	4.00	60	acaf	2.67	5.33	4.00	80
acgg	4.00	5.00	4.00	80	acgg	4.00	5.00	4.00	80
acmf	2.00	3.00	2.00	80	acmf	2.00	3.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	2.00	1.00	95	prmc	1.00	1.84	1.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.90	4.22	3.63	80.00

Reduce carbon footprint and air pollution									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	3.00	4.00	80	acdv	2.00	3.00	4.00	80
acaf	2.00	4.00	3.00	65	acaf	1.77	4.23	3.00	80
acgg	3.00	5.00	4.00	80	acgg	3.00	5.00	4.00	80
acmf	2.00	3.00	3.00	80	acmf	2.00	3.00	3.00	80
prlm	4.00	5.00	4.00	50	prlm	4.00	5.60	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80

proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.87	4.21	3.75	80.00

Meet environmental pressures and legal and government requirements and increase environmental protection									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	3.00	5.00	4.00	60	acdv	2.67	5.33	4.00	80
acaf	2.00	5.00	3.00	75	acaf	1.93	5.13	3.00	80
acgg	3.00	5.00	4.00	80	acgg	3.00	5.00	4.00	80
acmf	2.00	3.00	3.00	80	acmf	2.00	3.00	3.00	80
prlm	4.00	5.00	4.00	70	prlm	4.00	5.14	4.00	80
prmm	4.00	5.00	5.00	90	prmm	4.11	5.00	5.00	80
prmc	1.00	4.00	2.00	80	prmc	1.00	4.00	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.96	4.70	3.75	80.00

Improve customer service and satisfaction and the company's image									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	3.00	5.00	4.00	60	acaf	2.67	5.33	4.00	80
acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	1.00	1.00	95	acmf	1.00	1.00	1.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	3.00	2.00	80	prmm	1.00	3.00	2.00	80
prmc	1.00	2.00	2.00	90	prmc	1.11	2.00	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	1.86	3.45	2.63	80.00

Increase profit and cost saving

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	2.00	4.00	3.00	65	acaf	1.77	4.23	3.00	80
acgg	1.00	3.00	2.00	60	acgg	0.67	3.33	2.00	80
acmf	1.00	1.00	1.00	95	acmf	1.00	1.00	1.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	1.00	2.00	1.00	90	prmc	1.00	1.89	1.00	80
proh	1.00	2.00	2.00	90	proh	1.11	2.00	2.00	80
					Mean	1.15	2.51	1.75	80.00

Increase the return rate of used products

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	1.00	50	acdv	1.00	2.60	1.00	80
acaf	3.00	5.00	4.00	60	acaf	2.67	5.33	4.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	3.00	5.00	4.00	95	acmf	3.16	4.84	4.00	80
prlm	3.00	4.00	4.00	70	prlm	2.86	4.00	4.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80
prmc	1.00	2.00	2.00	95	prmc	1.16	2.00	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.31	3.64	3.00	80.00

Improve product quality

Raw data					Standardised data				
Name	Lower	Upper	Best	Conf(%)	Name	Lower	Upper	Best	Conf(%)
acdv	1.00	2.00	1.00	60	acdv	1.00	2.33	1.00	80
acaf	3.00	5.00	4.00	60	acaf	2.67	5.33	4.00	80

acgg	2.00	4.00	3.00	50	acgg	1.40	4.60	3.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	70	prlm	2.86	5.14	4.00	80
prmm	1.00	3.00	2.00	50	prmm	0.40	3.60	2.00	80
prmc	1.00	2.00	2.00	90	prmc	1.11	2.00	2.00	80
proh	3.00	4.00	4.00	70	proh	2.86	4.00	4.00	80
					Mean	1.64	3.63	2.75	80.00

Increase technology solutions adoption									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	3.00	3.00	60	acdv	0.33	3.00	3.00	80
acaf	2.00	5.00	3.00	60	acaf	1.67	5.67	3.00	80
acgg	3.00	5.00	4.00	60	acgg	2.67	5.33	4.00	80
acmf	1.00	3.00	2.00	70	acmf	0.86	3.14	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	2.00	1.00	40	prmm	1.00	3.00	1.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	1.88	4.20	3.00	80.00

Increase market competitiveness									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	40	acdv	0.00	2.00	2.00	80
acaf	2.00	4.00	3.00	65	acaf	1.77	4.23	3.00	80
acgg	1.00	3.00	2.00	50	acgg	0.40	3.60	2.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	80	prmm	1.00	1.00	1.00	80

prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	4.00	5.00	4.00	80	proh	4.00	5.00	4.00	80
					Mean	1.42	3.17	2.25	80.00

Improve operational performance, capacity utilisation and management solutions									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	3.00	3.00	60	acdv	0.33	3.00	3.00	80
acaf	2.00	4.00	3.00	65	acaf	1.77	4.23	3.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	40	prmm	1.00	1.00	1.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	1.74	3.39	2.63	80.00

Reduce community complaints									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	50	acdv	0.40	2.00	2.00	80
acaf	2.00	4.00	3.00	90	acaf	2.11	3.89	3.00	80
acgg	2.00	4.00	3.00	60	acgg	1.67	4.33	3.00	80
acmf	1.00	2.00	2.00	80	acmf	1.00	2.00	2.00	80
prlm	2.00	3.00	2.00	30	prlm	2.00	4.67	2.00	80
prmm	1.00	1.00	1.00	50	prmm	1.00	1.00	1.00	80
prmc	1.00	3.00	2.00	85	prmc	1.06	2.94	2.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	1.53	3.23	2.38	80.00

Improve human health and safety									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	4.00	3.00	60	acdv	1.67	4.33	3.00	80
acaf	2.00	5.00	3.00	75	acaf	1.93	5.13	3.00	80
acgg	1.00	3.00	2.00	50	acgg	0.40	3.60	2.00	80
acmf	1.00	2.00	2.00	70	acmf	0.86	2.00	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	2.00	1.00	40	prmm	1.00	3.00	1.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	3.00	5.00	4.00	80	proh	3.00	5.00	4.00	80
					Mean	1.55	3.94	2.63	80.00

Increase job generation and provide income for value pickers									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	1.00	2.00	2.00	60	acdv	0.67	2.00	2.00	80
acaf	3.00	5.00	4.00	75	acaf	2.93	5.07	4.00	80
acgg	1.00	4.00	3.00	50	acgg	-0.20	4.60	3.00	80
acmf	1.00	3.00	2.00	70	acmf	0.86	3.14	2.00	80
prlm	3.00	5.00	4.00	50	prlm	2.40	5.60	4.00	80
prmm	1.00	1.00	1.00	60	prmm	1.00	1.00	1.00	80
prmc	1.00	3.00	2.00	90	prmc	1.11	2.89	2.00	80
proh	3.00	4.00	4.00	80	proh	3.00	4.00	4.00	80
					Mean	1.47	3.54	2.75	80.00

Improve social responsability									
Raw data					**Standardised data**				
Name	**Lower**	**Upper**	**Best**	**Conf(%)**	**Name**	**Lower**	**Upper**	**Best**	**Conf(%)**
acdv	2.00	2.00	3.00	60	acdv	1.67	1.67	3.00	80

acaf	2.00	4.00	3.00	75	acaf	1.93	4.07	3.00	80
acgg	2.00	4.00	3.00	70	acgg	1.86	4.14	3.00	80
acmf	1.00	3.00	2.00	90	acmf	1.11	2.89	2.00	80
prlm	4.00	5.00	4.00	80	prlm	4.00	5.00	4.00	80
prmm	4.00	5.00	5.00	80	prmm	4.00	5.00	5.00	80
prmc	1.00	3.00	2.00	95	prmc	1.16	2.84	2.00	80
proh	5.00	5.00	5.00	95	proh	5.00	5.00	5.00	80
					Mean	2.59	3.83	3.38	80.00

CHAPTER IV: RESEARCH CLOSURE

1 INTRODUCTION

For better comprehension, this conclusion section is separated into discussions – that summarise and discuss the results from both articles presented in this dissertation – and conclusion – presenting the limitations of this dissertation and directions for future research.

Section 2 (General discussions) reiterates the research questions and discusses the results of Article #1 and Article #2 respectively; and, in the two last paragraphs it compares the results found in both of them answering the primary question (*can RL contribute to sustainable development?*).

Section 3 (General conclusions) summarizes Article #1 and Article #2 contributions, limitations and directions for futher researchs, providing insights for practitioners, scholars and policy-makers.

2 GENERAL DISCUSSIONS

It is not new that sustainability is a crucial topic for practitioners, scholars and policy-makers; with the rise of the SDGs by United Nations it only become structured into specific objectives to be achieved in collaboration with all sectors. RL is typically associated with sustainability, but can RL really contribute to sustainable development? This was the initial question that led to the development of this dissertation.

Aiming to answer the initial question, it was separated into four specific research questions: (RQ1) What are the specific sustainable impacts generated by RL? (RQ2) Which dimensions (environmental, social and economic) of sustainability are the most impacted? (RQ3) Which SDGs are the most impacted by RL adoption? (RQ4) How can it contribute to sustainable development? In order to answer those questions in a rigorous way, the research was unfolded into two articles using literature review, expert elicitation and VIKOR method – respectively – to identify, classify, rank and define the most impacted SDGs by reverse logistics.

In this context, the first article (Article #1) answered RQ1 and RQ2. Article #1 provides a list of the RL impacts on sustainability gathered in literature (see Figure 7) and demonstrates that the environmental dimension of sustainability is the one with more impacts reported in literature. It was also found that the economic dimension is the one which appears most in the examined literature, being the "*improve profit and cost savings*" impact the one with more citations. This demonstrates that besides the environment being mildly impacted by RL adoption in different ways, there is a tendency (or a concern) in presenting economic benefits when reporting RL adoption results. It can be a signal of greenwashing increasing and companies adopting "green practices" – as RL – just as a way to increase profits and improve the company image, as a new form of marketing (Astakhova, Reznikova and Astakhova, 2020).

Also in the Article #1, it was found that the social dimension of sustainability has great benefits coming from RL adoption (i.e.: Provide income for the value pickers, improve human health and safety, increase job generation, improve social responsibility and reduce community complaints. As shown in Article #1 Figure 7), although – as elucidated by other authors (Banihashemi, Fei and Chen, 2019; Sarkis, Helms and Hervani, 2010) – the social dimension of sustainability is still not extensively explored in the literature.

As described in the previous paragraphs, Article #1 shed some light on the contributions of RL to sustainability, a subject whose literature is overlooked. Results emerging from this paper were used as data input to conduct the second article (Article #2) presented in this dissertation (the impacts gathered in Article #1 were used to construct the questionnaire for the expert elicitation in Article #2).

Article #2 answered RQ3 and RQ4. In this case, it was found the SDG most impacted by RL adoption is *SDG 12 - Sustainable Consumption and Production*, reinforcing the intuitive link between SDG 12 and RL. However, as argued by other authors (Leurent and Abbosh, 2018; Schroeder, Anggraeni and Weber, 2019), RL may potentially contribute to a far wider range of SDGs; for this reason, a rank was created with all the SDGs considered in this research impacted by RL. The final rank was: ***(1)*** *SDG 12 - Responsible Consumption and Production,* ***(2)*** *SDG 2 - Zero Hunger,* ***(3)*** *SDG 7 - Affordable and Clean Energy,* ***(4)*** *SDG 8 - Decent Work and Economic Growth,* ***(5)*** *SDG 6 - Clean Water and Sanitation,* ***(6)*** *SDG 15 - Life on Land,* ***(7)*** *SDG 14 - Life Below Water,* ***(8)*** *SDG 1 - No Poverty*.

Furthermore, Table 16 in Article #2 shows that the followings impacts of RL are the most important contributions of RL adoption to help achieve the SDGs and, consequently, to sustainable development: ***(1)*** *RLI1 - Reduce the environmental footprint, amounts of waste and landfill,* ***(2)*** *RLI2 - Improve environmentally-driven strategies,* ***(3)*** *RLI3 - Reduce energy consumption,* ***(4)*** *RLI5 - Reduce soil pollution,* ***(5)*** *RLI6 - Reduce water pollution,* ***(6)*** *RLI8 - Meet environmental pressures and legal and government requirements,* ***(7)*** *RLI18 - Increase job generation and provide income for value pickers.*

At this point, the answer to the initial question is established: RL can contribute to sustainable development, and it is reinforced by literature and by experts. Furthermore, together, Article #1 and Article #2 make some interesting counterpoints. In Article #1 it was found that the social dimension of sustainability is not a major source of investigation in literature, but the creation of the SDGs bringing social goals in its core is a clear indication of evolution in this way. Therefore, in Article #2, the second and third place in the rank (see Table 15) are for two SDGs classified as social (Vinuesa *et al.*, 2020): *SDG 2 – Zero Hunger,* which promotes ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture and *SDG 7 – Affordable and Clean Energy,* which promotes ensuring access to affordable, reliable, sustainable and modern energy for all. These results indicate a relation between RL adoption and the social dimension of sustainability but also demonstrate that there is a need for more investigations and reports about the intersection of these two subjects.

On top of that, besides Article #1 declaring "*improve profit and cost savings*" impact as one with more citations, Article #2 brings fresh analysis, where "*improve profit and cost savings*" is indicated as the RL impact with less contribution for most of the SDGs. These results demonstrate once again there is a pointless insistence in literature in focusing on the economic impacts of RL. Of course, it is an important RL outcoming that can help motivate companies to adopt RL and consequently contribute to all three dimensions of sustainability. However, for scholars, it is still necessary to balance the importance of these three dimensions and extend our understanding of how RL can potentialize social sustainability.

3 GENERAL CONCLUSIONS

Motivated by the increasing relevance of RL for sustainability and as elucidated in the previous section (2 General discussions), this dissertation aimed to investigate the intersection of reverse logistics and the SDGs, using literature review (through PRISMA approach), expert elicitation (through IDEA protocol) and VIKOR to identify, rank and define the most impacted SDGs by reverse logistics. In the end, our exploratory results suggest that RL has significant contributions to sustainable development and to the achievement of the SDGs. Thus, its adoption could and should be encouraged by policy-makers and there is still a need for research aiming to establish a linkage between RL and social sustainability.

The main contributions of this dissertation are summarised as follows:

(1) For practitioners, the adoption of RL can increase profits and cost savings. Plus, it can also generate jobs and benefit the community and stakeholders. Even if the social dimension of sustainability is not a primary concern for companies, the results presented in this dissertation give a glimpse about the importance in measuring this aspect and consolidate it as a sustainability dimension of equal importance.
(2) The results can also help practitioners target their investments in RL and have a clear vision of how the adoption of RL by their companies can help in the achievement of SDGs.
(3) For policy-makers, it can help to evaluate reverse logistics initiatives and facilitate subsidy distributions more effectively; the results provided here can be also used by policy-makers to promote reverse logistics adoption by local companies since there is a common interest in contributing to the accomplishment of the SDGs.
(4) For scholars, the paper fills the gap in literature connecting reverse logistics with the SDGs and providing a future research agenda as described in the next paragraphs.

Given these findings, the present study has some limitations, which provide opportunities for further research:
(1) The RL impacts here had the same weights. But the same methodology can be applied with other ways of weighing them and doing sensitivity analysis to compare different scenarios.
(2) Since the expert elicitation was extensive, just 8 participants responded. It can be expanded in future applications.
(3) This paper does not consider all SDGs, only those that already had suggestions from the literature of having a relationship with circular economy practices. However, all SDGs should be considered in the next applications to verify if this approach was accurate.
(4) Considering the results found, future studies may seek to focus on the social dimension of sustainability to identify more RL impacts and report them – it can be achieved by adopting methodologies as social life cycle assessment (SLCA), for example – to generate more empirical evidence and contribute to the knowledge construction in social sustainability.

Lastly, this dissertation has valuable information and insights from literature, empirical studies and experts perspective about RL, sustainability and SDG achievement that can be used as input for future studies.

REFERENCES

Abbas, H. and Farooquie, J. A. (2020) 'Reverse logistics practices in Indian pharmaceutical supply chains: A study of manufacturers', *International Journal of Logistics Systems and Management*, 35(1), pp. 72–89. doi: 10.1504/IJLSM.2020.103863.

Agrawal, S. and Singh, R. K. (2019) 'Analyzing disposition decisions for sustainable reverse logistics: Triple Bottom Line approach', *Resources, Conservation and Recycling*, 150(August), p. 104448. doi: 10.1016/j.resconrec.2019.104448.

Agrawal, S., Singh, R. K. and Murtaza, Q. (2015) 'A literature review and perspectives in reverse logistics', *Resources, Conservation and Recycling jo*, 97, pp. 76–92. doi: 10.1016/j.resconrec.2015.02.009.

Agrawal, S., Singh, R. K. and Murtaza, Q. (2016) 'Triple bottom line performance evaluation of reverse logistics', *Competitiveness Review*, 26(3), pp. 289–310. doi: 10.1108/CR-04-2015-0029.

Aitken, J. and Harrison, A. (2013) 'Supply governance structures for reverse logistics systems', *International Journal of Operations and Production Management*, 33(6), pp. 745–764. doi: 10.1108/IJOPM-10-2011-0362.

Astakhova, I., Reznikova, T. and Astakhova, E. (2020) 'Greenwashing as a form of modern eco-marketing', *Acta Innovations*, 34(5), pp. 5–12.

Baah, C. *et al.* (2021) 'Examining the Interconnections Between Sustainable Logistics Practices, Environmental Reputation and Financial Performance: A Mediation Approach', *Vision*, 25(1), pp. 47–64. doi: 10.1177/0972262920988805.

Bag, S. and Gupta, S. (2020) 'Examining the effect of green human capital availability in adoption of reverse logistics and remanufacturing operations performance', *International Journal of Manpower*, 41(7), pp. 1097–1117. doi: 10.1108/IJM-07-2019-0349.

Banihashemi, T. A., Fei, J. and Chen, P. S.-L. (2019) 'Exploring the relationship between reverse logistics and sustainability performance', *Modern Supply Chain Research and Applications*, 1(1), pp. 2–27. doi: 10.1108/mscra-03-2019-0009.

Barcelos, S. M. B. D. *et al.* (2021) 'Circularity of Brazilian silk: Promoting a circular bioeconomy in the production of silk cocoons', *Journal of Environmental Management*, 296(April), p. 113373. doi: 10.1016/j.jenvman.2021.113373.

Beiler, B. C. *et al.* (2020) 'Reverse logistics system analysis of a Brazilian beverage company: An exploratory study', *Journal of Cleaner Production*, 274. doi: 10.1016/j.jclepro.2020.122624.

Brito, M. P. de and Dekker, R. (2004) 'A Framework for Reverse Logistics', in *Reverse Logistics*, pp. 3–27. doi: 10.1007/978-3-540-24803-3.

Brix-Asala, C., Hahn, R. and Seuring, S. (2016) 'Reverse logistics and informal valorisation at the Base of the Pyramid: A case study on sustainability synergies and trade-offs', *European Management Journal*, 34(4), pp. 414–423. doi: 10.1016/j.emj.2016.01.004.

Campos, E. A. R. de *et al.* (2020) 'The effect of collaboration and IT competency on reverse logistics competency - Evidence from Brazilian supply chain executives', *Environmental Impact Assessment Review*, 84(March), p. 106433. doi: 10.1016/j.eiar.2020.106433.

Dias, K. T. S. and Braga, S. S. (2016) 'The use of reverse logistics for waste management in a Brazilian grocery retailer', *Waste Management and Research*, 34(1), pp. 22–29. doi: 10.1177/0734242X15615696.

Earth Overshoot Day (2020) *About Earth Overshoot Day*. Available at: https://www.overshootday.org/about-earth-overshoot-day/.

Elkington, J. (1998) 'Partnerships from Cannibals with Forks: The Triple Bottom line of 21st - Century Business', *Environmental Quality Management*, 8(1), pp. 37–51.

Feng, D., Shen, C. and Pei, Z. (2021) 'Production decisions of a closed-loop supply chain considering remanufacturing and refurbishing under government subsidy', *Sustainable Production and Consumption*, 27, pp. 2058–2074. doi: 10.1016/j.spc.2021.04.034.

Fernando, Y. *et al.* (2017) 'The effects of reverse logistics on cost control abilities: An insight into manufacturing companies in Malaysia', *International Journal of Value Chain Management*, 8(4), pp. 285–306. doi: 10.1504/IJVCM.2017.089377.

Fernando, Y. and Tew, M. M. (2016) 'Reverse logistics in manufacturing waste management: The missing link between environmental commitment and operational performance', *International Journal of Integrated Supply Management*, 10(3–4), pp. 264–282. doi: 10.1504/IJISM.2016.081273.

Frei, R., Jack, L. and Brown, S. (2020) 'Product returns: a growing problem for business, society and environment', *International Journal of Operations and Production Management*, 40(10), pp. 1613–1621. doi: 10.1108/IJOPM-02-2020-0083.

Gardas, B. B., Raut, R. D. and Narkhede, B. (2019) 'Determinants of sustainable supply chain management: A case study from the oil and gas supply chain', *Sustainable Production and Consumption*, 17, pp. 241–253. doi: 10.1016/j.spc.2018.11.005.

van Giezen, A. and Wiegmans, B. (2020) 'Spoilt - Ocean Cleanup: Alternative logistics chains to accommodate plastic waste recycling: An economic evaluation', *Transportation Research*

Interdisciplinary Perspectives, 5, p. 100115. doi: 10.1016/j.trip.2020.100115.

Gil, A. C. (2008) *Métodos e Técnicas de Pesquisa Social*. 6th edn.

Govindan, K. and Gholizadeh, H. (2021) 'Robust network design for sustainable-resilient reverse logistics network using big data: A case study of end-of-life vehicles', *Transportation Research Part E: Logistics and Transportation Review*, 149(February), p. 102279. doi: 10.1016/j.tre.2021.102279.

Guarnieri, P. (2014) *Logística Reversa*. Clube de Autores (managed).

Hami, N., Muhamad, M. R. and Ebrahim, Z. (2015) 'The impact of sustainable manufacturing practices and innovation performance on economic sustainability', *Procedia CIRP*, 26, pp. 190–195. doi: 10.1016/j.procir.2014.07.167.

Hemming, V. *et al.* (2018) 'A practical guide to structured expert elicitation using the IDEA protocol', *Methods in Ecology and Evolution*, 9(1), pp. 169–180. doi: 10.1111/2041-210X.12857.

Hervani, A. A., Sarkis, J. and Helms, M. M. (2017) 'Environmental goods valuations for social sustainability: A conceptual framework', *Technological Forecasting and Social Change*, 125(July), pp. 137–153. doi: 10.1016/j.techfore.2017.07.015.

Hong, S. Q. and Huang, Y. J. (2021) 'Relationship among reverse logistics, corporate image and social impact in medical device industry', *Revista de Cercetare si Interventie Sociala*, 72, pp. 109–121. doi: 10.33788/rcis.72.7.

Hsu, C.-C. *et al.* (2016) 'Strategic orientations, sustainable supply chain initiatives, and reverse logistics: Empirical evidence from an emerging market', *International Journal of Operations & Production Management*, 36(1), p. 360. Available at: https://www.emeraldinsight.com/doi/pdfplus/10.1108/IJOPM-06-2014-0252.

IBAMA (2016) *Política Nacional de Resíduos Sólidos (PNRS)*. Available at: http://www.ibama.gov.br/residuos/controle-de-residuos/politica-nacional-de-residuos-solidos-pnrs.

Jalil, E. E. A. *et al.* (2016) 'Reverse logistics in household recycling and waste systems: a symbiosis perspective', *Supply Chain Management: An International Journal*, 21(2). Available at: https://doi.org/10.1108/13598540910954539.

Jamali, D. (2006) 'Insights into triple bottom line integration from a learning organization perspective', *Business Process Management Journal*, 12(6), pp. 809–821. doi: 10.1108/14637150610710945.

Javed, H. *et al.* (2021) 'Exploring disposition decision for sustainable reverse logistics in the era of a circular economy: Applying the triple bottom line approach in the manufacturing industry', *International Journal of Supply and Operations Management*, 8(1), pp. 53–68. doi: 10.22034/IJSOM.2021.1.5.

Jayaram, J. and Avittathur, B. (2015) 'Green supply chains: A perspective from an emerging economy', *International Journal of Production Economics*, 164, pp. 234–244. doi: 10.1016/j.ijpe.2014.12.003.

Keeble, B. R. (1988) 'The Brundtland Report: "Our Common Future"', *Medicine and War*, 4(1), pp. 17–25. doi: 10.1080/07488008808408783.

Kerdpitak, C. *et al.* (2020) 'The mediating role of sustainable supply chain in the relationship between ECO-strategic orientation and the reverse logistic in Thai electronic industry', *International Journal of Supply Chain Management*, 9(1), pp. 10–18.

Khor, K.-S., Ramayah, T. and Fouladgaran, H. R. P. (2020) 'Managing eco-design for reverse logistics Thurasamy Ramayah Hamid Reza Panjeh Fouladgaran', *International Journal of Environment and Waste Management*, 26(2), pp. 125–146.

Kiremire, A. R. (2011) 'The application of the pareto principle in software engineering', *Consulted January*, 13, p. 2016.

Kleindorfer, P., Singhal, K. and Wassenhove, L. (2005) 'Sustainable Operations Management', *Production and Operations Management Society*, 14(4), pp. 482–492.

Koberg, E. and Longoni, A. (2019) 'A systematic review of sustainable supply chain management in global supply chains', *Journal of Cleaner Production*, 207, pp. 1084–1098. doi: 10.1016/j.jclepro.2018.10.033.

Köhler, J. *et al.* (2019) 'An agenda for sustainability transitions research: State of the art and future directions', *Environmental Innovation and Societal Transitions*, 31(December 2018), pp. 1–32. doi: 10.1016/j.eist.2019.01.004.

Leurent, H. and Abbosh, O. (2018) 'Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation', *World Economic Forum (WEF)*, (January), p. 58. Available at: http://www3.weforum.org/docs/WEF_39558_White_Paper_Driving_the_Sustainability_of_Production_Systems_4IR.pdf.

Levy, Y. and Ellis, T. J. (2006) 'A systems approach to conduct an effective literature review in support of information systems research', *Informing Science*, 9, pp. 181–212. doi: 10.28945/479.

Liang, C. C. and Lee, J. P. (2018) 'Carbon footprint model for reverse logistics of waste disposal in interior design industry', *Asia Pacific Journal of Marketing and Logistics*, 30(4), pp. 889–906. doi: 10.1108/APJML-01-2018-0035.

de Lorena Diniz Chaves, G. *et al.* (2021) 'Synergizing environmental, social, and economic sustainability factors for refuse derived fuel use in cement industry: A case study in Espirito Santo, Brazil', *Journal of Environmental Management*, 288(February), p. 112401. doi: 10.1016/j.jenvman.2021.112401.

Mafini, C. and Loury-Okoumba, W. V. (2018) 'Extending green supply chain management activities to manufacturing small and medium enterprises in a developing economy', *South African Journal of Economic and Management Sciences*. doi: 10.4102/sajems.v21i1.1996.

Martin, T. G. *et al.* (2012) 'Eliciting Expert Knowledge in Conservation Science', *Conservation Biology*, 26(1), pp. 29–38. doi: 10.1111/j.1523-1739.2011.01806.x.

Maurice, J. (2016) 'Measuring progress towards the SDGs — a new vital science A new statistical methodology has emerged to gauge progress towards reaching the 2030', *The Lancet*, 388(10053), pp. 1455–1458. doi: 10.1016/S0140-6736(16)31791-3.

Mensah, J. (2019) 'Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review', *Cogent Social Sciences*, 5(1), pp. 1–21. doi: 10.1080/23311886.2019.1653531.

Moher, D. *et al.* (2009) 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement', *PLoS Med*.

Mongeon, P. and Paul-Hus, A. (2016) 'The journal coverage of Web of Science and Scopus: a comparative analysis', *Scientometrics*, 106(1), pp. 213–228. doi: 10.1007/s11192-015-1765-5.

Morgan, M. G. (2014) 'Use (and abuse) of expert elicitation in support of decision making for public policy', *Proceedings of the National Academy of Sciences of the United States of America*, 111(20), pp. 7176–7184. doi: 10.1073/pnas.1319946111.

Morgan, T. R. *et al.* (2018) 'Resource commitment and sustainability: a reverse logistics performance process model', *International Journal of Physical Distribution and Logistics Management*, 48(2), pp. 164–182. doi: 10.1108/IJPDLM-02-2017-0068.

Narayana, S. A., Pati, R. K. and Padhi, S. S. (2019) 'Market dynamics and reverse logistics for sustainability in the Indian Pharmaceuticals industry', *Journal of Cleaner Production*, 208, pp. 968–987. doi: 10.1016/j.jclepro.2018.10.171.

Nations, U. (2015) *The 17 Goals*. Available at: https://sdgs.un.org/goals.

Nosratabadi, S. *et al.* (2019) 'Sustainable business models: A review', *Sustainability (Switzerland)*, 11(6), pp. 1–30. doi: 10.3390/su11061663.

O’Hagan, A. *et al.* (2006) *Uncertain Judgements: Eliciting Experts’ Probabilities*. John Wiley & Sons, Ltd. doi: 10.1002/0470033312.

Peña-Montoya, C. C. *et al.* (2020) ‘Assessment of maturity of reverse logistics as a strategy to sustainable solid waste management’, *Waste management & research*, 38(1_suppl), pp. 65–76.

Peretti, U. *et al.* (2015) ‘Reverse logistics in humanitarian operations: challenges and opportunities’, *Journal of Humanitarian Logistics and Supply Chain Management*, 5(2), pp. 253–274.

Phoosawad, P. *et al.* (2019) ‘Impacts of collaboration networks, operational performance and reverse logistics determinants on the performance outcomes of the auto parts industry’, *Management and Production Engineering Review*, 10(3), pp. 61–72. doi: 10.24425/mper.2019.129599.

Piyathanavong, V. *et al.* (2019) ‘The adoption of operational environmental sustainability approaches in the Thai manufacturing sector’, *Journal of Cleaner Production*, 220, pp. 507–528. doi: 10.1016/j.jclepro.2019.02.093.

Pullin, A. S. and Stewart, G. B. (2006) ‘Guidelines for systematic review in conservation and environmental management’, *Conservation Biology*, 20(6), pp. 1647–1656. doi: 10.1111/j.1523-1739.2006.00485.x.

Purvis, B., Mao, Y. and Robinson, D. (2019) ‘Three pillars of sustainability: in search of conceptual origins’, *Sustainability Science*, 14(3), pp. 681–695. doi: 10.1007/s11625-018-0627-5.

Pushpamali, N. N. C., Agdas, D. and Rose, T. M. (2020) ‘Strategic Decision Making in Construction Supply Chains: A Comparison of Reverse Logistics Strategies’, *Frontiers in Built Environment*, 6(December). doi: 10.3389/fbuil.2020.593372.

Rasit, Z. A. *et al.* (2019) ‘Green Supply Chain Management (GSCM) practices for sustainability performance: An empirical evidence of Malaysian SMEs’, *International Journal of Financial Research*, 10(3), pp. 371–379. doi: 10.5430/ijfr.v10n3p371.

Refsgaard, J. C. *et al.* (2007) ‘Uncertainty in the environmental modelling process - A framework and guidance’, *Environmental Modelling and Software*, 22(11), pp. 1543–1556. doi: 10.1016/j.envsoft.2007.02.004.

Richnák, P. and Gubová, K. (2021) ‘Green and reverse logistics in conditions of sustainable development in enterprises in Slovakia’, *Sustainability (Switzerland)*, 13(2), pp. 1–23. doi: 10.3390/su13020581.

Rowley, J. and Slack, F. (2004) ‘Conducting a literature review’, *Management Research News*, 27(6), pp. 31–39. doi: 10.1108/01409170410784185.

Sarkis, J., Helms, M. M. and Hervani, A. A. (2010) ‘Reverse Logistics and Social Sustainability’, *Corporate Social Responsibility and Environmental Management*, 354(January), pp. 337–354.

Schroeder, P., Anggraeni, K. and Weber, U. (2019) ‘The Relevance of Circular Economy Practices to the Sustainable Development Goals’, *Journal of Industrial Ecology*, 23(1), pp. 77–95. doi: 10.1111/jiec.12732.

Sellitto, M. A., Camfield, C. G. and Buzuku, S. (2020) ‘Green innovation and competitive advantages in a furniture industrial cluster: A survey and structural model’, *Sustainable Production and Consumption*, 23, pp. 94–104. doi: 10.1016/j.spc.2020.04.007.

Sirisawat, P. and Kiatcharoenpol, T. (2019) ‘Correlation of Reverse Logistics Performance to Solutions Using Structural Equation Modeling’, *Journal of Advanced Manufacturing Systems*, 18(4), pp. 511–525. doi: 10.1142/S0219686719500276.

Sittisom, W. and Mekhum, W. (2020) ‘External supply chain management factors and social performance in Thai manufacturing industry: Moderating role of green human resource practices’, *International Journal of Supply Chain Management*, 9(1), pp. 190–198.

Slomski, V. *et al.* (2018) ‘A disclosure of social and environmental results/economy resulting from the implementation of reverse logistics and final disposal of the post-consumption product: The case of computer peripherals industry’, *Environmental Quality Management*, 27(3), pp. 73–87. doi: 10.1002/tqem.21530.

Sorkun, M. F. and Onay, M. (2018) ‘The Effects of Companies ’ Reverse Logistics Motivations on Their Reverse Logistics Networks’, *Strategic Design and Innovative Thinking in Business Operations*, pp. 3–21. doi: 10.1007/978-3-319-77622-4.

Toffel, M. W. and Toffel, M. W. (2004) ‘Management of Product Recovery’.

Tranfield, D., Denyer, D. and Smart, P. (2003) ‘Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review’, *British Journal of Management*, 14, pp. 207–222.

Trujillo-Gallego, M., Sarache, W. and Sellitto, M. A. (2021) ‘Identification of practices that facilitate manufacturing companies’ environmental collaboration and their influence on sustainable production’, *Sustainable Production and Consumption*, 27, pp. 1372–1391. doi: 10.1016/j.spc.2021.03.009.

Tseng, M. L. *et al.* (2018) ‘A framework for evaluating the performance of sustainable service supply chain management under uncertainty’, *International Journal of Production Economics*, 195, pp. 359–372. doi: 10.1016/j.ijpe.2016.09.002.

UNIDO (2015) ‘The 2030 Agenda for Sustainable Development: Achieving the industry-related goals and targets’, *Sustainable Development Knowledge Platform*. Available at: https://sustainabledevelopment.un.org/?menu=1300.

Uriarte-Miranda, M. L. *et al.* (2018) ‘Reverse logistic strategy for the management of tire waste in Mexico and Russia: Review and conceptual model’, *Sustainability (Switzerland)*, 10(10). doi: 10.3390/su10103398.

VOSviewer (2021) *VOSviewer*. Available at: https://www.vosviewer.com/.

Wang, W. *et al.* (2019) ‘Assessing the cost structure of component reuse in a product family for remanufacturing’, *Journal of Intelligent Manufacturing*, 30(2), pp. 575–587. doi: 10.1007/s10845-016-1267-1.

Xu, Z. *et al.* (2021) ‘Robust global reverse logistics network redesign for high-grade plastic wastes recycling’, *Waste Management*, 134(October 2020), pp. 251–262. doi: 10.1016/j.wasman.2021.08.024.

Zupic, I. and Čater, T. (2015) ‘Bibliometric Methods in Management and Organization’, *Organizational Research Methods*, 18(3), pp. 429–472. doi: 10.1177/1094428114562629.

ANNEXES

ANNEX A

UNIVERSIDADE FEDERAL DE SÃO CARLOS - UFSCAR

COMPROVANTE DE ENVIO DO PROJETO

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL

Pesquisador: MAQUELE ANTUNES DE OLIVEIRA

Versão: 2

CAAE: 58134622.9.0000.5504

Instituição Proponente: Universidade Federal de São Carlos/UFSCar

DADOS DO COMPROVANTE

Número do Comprovante: 040541/2022

Patrocionador Principal: Financiamento Próprio

Informamos que o projeto AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL que tem como pesquisador responsável MAQUELE ANTUNES DE OLIVEIRA, foi recebido para análise ética no CEP Universidade Federal de São Carlos - UFSCar em 26/04/2022 às 10:43.

Endereço: WASHINGTON LUIZ KM 235
Bairro: JARDIM GUANABARA **CEP:** 13.565-905
UF: SP **Município:** SAO CARLOS
Telefone: (16)3351-9685 **E-mail:** cephumanos@ufscar.br

ANNEX B

UFSCAR - UNIVERSIDADE FEDERAL DE SÃO CARLOS

Informamos que o projeto AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL que tem como pesquisador responsável MAQUELE ANTUNES DE OLIVEIRA, foi recebido para análise ética no CEP UFSCar - Universidade Federal de São Carlos em 26/04/2022 às 10:43.

Endereço: WASHINGTON LUIZ KM 235
Bairro: JARDIM GUANABARA **CEP:** 13.565-905
UF: SP **Município:** SAO CARLOS
Telefone: (16)3351-9685 **E-mail:** cephumanos@ufscar.br

ANNEX C

MINISTÉRIO DA SAÚDE - Conselho Nacional de Saúde - Comissão Nacional de Ética em Pesquisa – CONEP
PROJETO DE PESQUISA ENVOLVENDO SERES HUMANOS

Projeto de Pesquisa:
AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL

Informações Preliminares

Responsável Principal

CPF/Documento: 443.390.258-60	Nome: MAQUELE ANTUNES DE OLIVEIRA
Telefone: 15998004654	E-mail: maquele_antunes@yahoo.com

Instituição Proponente

CNPJ: 45.358.058/0001-40	Nome da Instituição: Universidade Federal de São Carlos/UFSCar

É um estudo internacional? Não

■ **Equipe de Pesquisa**

CPF/Documento	Nome
106.418.598-30	JULIANA VEIGA MENDES
200.473.838-36	Luis Antonio de Santa Eulalia

Área de Estudo

Grandes Áreas do Conhecimento (CNPq)

- Grande Área 3. Engenharias

Título Público da Pesquisa: AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL

Contato Público

CPF/Documento	Nome	Telefone	E-mail
443.390.258-60	MAQUELE ANTUNES DE OLIVEIRA	15998004654	maquele_antunes@yahoo.com

Contato Científico: MAQUELE ANTUNES DE OLIVEIRA

Data de Submissão do Projeto: 08/09/2022 **Nome do Arquivo:** PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1910029.pdf **Versão do Projeto:** 2

Desenho de Estudo / Apoio Financeiro

Desenho:

AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL

Apoio Financeiro

CNPJ	Nome	E-mail	Telefone	Tipo
				Financiamento Próprio

Palavra Chave

Palavra-chave
logística reversa
sustentabilidade
ODS
desenvolvimento sustentável

Detalhamento do Estudo

Resumo:

A preocupação global com o desenvolvimento sustentável aumentou e as práticas de produção que podem contribuir para isso ganharam destaque – sendo a logística reversa (RL) uma delas. No entanto, o tema ainda é emergente e requer novos esforços. A definição de quais contribuições a logística reversa pode trazer para a sustentabilidade ainda é inexata. O objetivo da pesquisa é ampliar a compreensão dos impactos sustentáveis que a RL pode gerar econômica, ambiental e socialmente e definir quais ODS (Objetivos de Desenvolvimento Sustentável) são os mais impactados. Além disso, pretende-se contribuir para a produção de conhecimento relacionado à LR e sustentabilidade em suas três dimensões – onde faltam estudos –; demonstrar às empresas interessadas em aumentar sua adesão ao pacto global ODS como a adoção da RL pode beneficiá-las; identificar os principais impactos do RL para o desenvolvimento sustentável e elucidar como a adoção do RL pode ajudar no alcance dos ODS. Para tanto, a pesquisa fará uso de: (i) uma revisão sistemática da literatura a fim de reunir as evidências empíricas dos impactos da RL na sustentabilidade e (ii) elicitação de especialistas por meio do protocolo IDEA para analisar e definir quais ODS são os mais impactados pela adoção de práticas de RL.

Introdução:

A extração inconsciente de recursos naturais para a produção aumentou a quantidade de resíduos que produzimos e colocou em risco as gerações futuras (Guarnieri, 2014). De acordo com o Earth Overshoot Day organizado pela Global Footprint Network, nossa demanda por recursos naturais atualmente excede a capacidade de regeneração da Terra (Earth Overshoot Day, 2020), o que demonstra o déficit de sustentabilidade do nosso atual modelo de produção. Esse cenário atual elevou consideravelmente o interesse acadêmico e corporativo pela gestão sustentável da cadeia de suprimentos (Seuring e Müller, 2008), sendo impulsionado principalmente pelo crescente uso de tecnologias avançadas (Nosratabadi et al., 2019). A sustentabilidade é a integração dos aspectos ambientais, sociais e econômicos, que permitem às organizações alcançar a viabilidade econômica (Carter e Rogers, 2008). Requer mudanças drásticas em uma ampla gama de setores e ainda há muito trabalho a ser feito em pesquisa de sustentabilidade, mas a história das revoluções industriais nos mostra que os sistemas sociais, econômicos e tecnológicos podem e se transformam (Köhler et al., 2019). O desenvolvimento sustentável também tem ganhado cada vez mais atenção no espaço acadêmico, de governança, planejamento e intervenção no desenvolvimento (Mensah, 2019). O conceito de “desenvolvimento sustentável” gira em torno dos três pilares da sustentabilidade que os interligam; o que aumenta a necessidade de conscientização dos tomadores de decisão sobre as relações, complementaridades e trade-offs entre esses pilares (Mensah, 2019). Apesar da falta de conceituação da sustentabilidade em geral, a Organização das Nações Unidas (ONU) apresentou 17 metas e 169 metas para o desenvolvimento sustentável – são os chamados Objetivos de Desenvolvimento Sustentável (ODS); no entanto – apesar das metas e indicadores serem animadores – sua fundamentação teórica não é clara (Purvis, Mao e Robinson, 2019). Adotada por todos os Estados Membros das Nações Unidas em 2015, a Agenda 2030 para o Desenvolvimento Sustentável é descrita pela ONU como um plano de ação para as pessoas, o planeta e a prosperidade (Nations, 2015). Os 17 ODS são integrados e indivisíveis e equilibram as três dimensões do desenvolvimento sustentável (Nações, 2015) (Figura 1). Fig. 1. Descrição dos 17 ODS. O ODS 12 é bastante específico para manufatura, no entanto, os sistemas de produção podem contribuir potencialmente para uma gama muito maior de ODS (Leurent e Abbosh, 2018). Práticas de economia circular e modelos de negócios relacionados podem ajudar a alcançar vários dos ODS, especialmente vinculados ao ODS 6 (Água Limpa e Saneamento), ODS 7 (Energia Limpa e Acessível), ODS 8 (Trabalho Decente e Crescimento Econômico), ODS 12 (Responsável Consumo e Produção) e ODS 15 (Vida na Terra) (Schroeder, Anggraeni e Weber, 2019). A gestão da cadeia de suprimentos é importante para a sustentabilidade (Koberg e Longoni, 2019). A gestão de operações pode e deve contribuir para a sustentabilidade: É preciso maximizar a recuperação e reutilização de produtos; reduzindo os efeitos nocivos sobre o meio ambiente da eliminação de resíduos, extração de matérias-primas, transporte e distribuição – e também pode aumentar os lucros como consequência (Kleindorfer, Singhal e Wassenhove, 2005). Na literatura, a logística reversa (LR) é considerada uma prática sustentável (Sellitto, Camfield e Buzuku, 2020; Trujillo-Gallego, Sarache e Sellitto, 2021) e é descrita como uma área emergente de pesquisa com oportunidades para alcançar impactos consideráveis na sociedade , meio ambiente e economia (Sarkis, Helms e Hervani, 2010; Frei, Jack e Brown, 2020). A RL é a estratégia que operacionaliza a devolução de resíduos pós-consumo e visa possibilitar o desenvolvimento econômico e sustentável; caracterizando-se pelo fluxo de clientes para empresas que recebem produtos pós-consumo. Em muitas empresas, algumas práticas de logística reversa já acontecem mesmo que de forma informal, devido à necessidade de descarte de resíduos (Guarnieri, 2014). O gerenciamento de reciclagem chamou a atenção da maioria das organizações de manufatura e serviços nos últimos anos (Govindan e Gholizadeh, 2021). As motivações para a adoção da logística reversa são variadas, sendo orientadas tanto para o mercado quanto para o desejo de manter os custos baixos (Sorkun e Onay, 2018). A crescente necessidade de tornar o desenvolvimento mais sustentável obrigou muitas empresas não apenas a adotar a logística reversa, mas a torná-la cada vez mais eficiente e eficaz (Agrawal, Singh e Murtaza, 2015). Investir na sustentabilidade da RL também é uma forma de ganhar participação de mercado promovendo uma forte reputação ambiental, ampliando o alcance entre os clientes que valorizam o desempenho sustentável (Toffel e Toffel, 2004). Com relação aos três pilares da sustentabilidade, a recuperação de produtos ao final de sua vida útil por meio da logística reversa tornou-se significativa para as organizações devido a questões ambientais e econômicas, porém a atenção à sustentabilidade social ainda é rudimentar (Sarkis, Helms e Hervani, 2010; Banihashemi, Fei e Chen, 2019). A sustentabilidade é fundamental para vincular a RL ao desempenho e, portanto, requer exame detalhado e trabalho de confirmação (por exemplo: redes nomológicas) para examinar como a sustentabilidade e a RL se relacionam (Morgan et al., 2018). Ainda há um número limitado de artigos que estudam a LR como prática para a sustentabilidade (Aitken e Harrison, 2013; Piyathanavong et al., 2019) e as abordagens sustentáveis para a LR são tipicamente gerais, tornando necessário que mais esforços sejam feitos nessa direção (Banihashemi, Fei e Chen, 2019a). Além disso, até onde sabemos, não foram encontrados artigos que reúnam sistematicamente os impactos sustentáveis da LR e os relacionem com os ODS – mesmo com as recomendações para usá-los como medidas de sustentabilidade (Maurice, 2016).

Hipótese:

H1) Quais ODS são os mais impactados pela adoção de RL?H2) Como a RL pode contribuir para o desenvolvimento sustentável?

Objetivo Primário:

O objetivo deste estudo é preencher as lacunas apresentadas anteriormente na introdução, reunindo os impactos das práticas de RL para a sustentabilidade e, então, relacionando-os aos ODSs para descobrir onde estão as principais contribuições da RL para o desenvolvimento sustentável. Para tanto, este estudo foi dividido em 2 partes principais e artigos específicos: i) Em primeiro lugar, foi realizada uma revisão sistemática da literatura para reunir sistematicamente todos os impactos sustentáveis empíricos de LR relatados pela literatura, a fim de responder às duas seguintes questões de pesquisa (QR): (RQ1) Quais são os impactos sustentáveis gerados pela RL?; e (RQ2) Quais dimensões da sustentabilidade são as mais impactadas pela RL?; ii) Em segundo lugar, os resultados obtidos na revisão sistemática foram usados como insumo para criação de questionário a fim de se realizar uma elicitação de especialistas que busca entender a relação entre os impactos da RL e como ela pode contribuir para a cumprimento dos ODS. Esta etapa da pesquisa está aguardando aprovação do Comitê de Ética para que os questionários sejam aplicados. Esta segunda parte teve como objetivo responder às seguintes RQ:(RQ1) Quais ODS são os mais impactados pela adoção de RL?; e (RQ2) Como a RL pode contribuir para o desenvolvimento sustentável?

Metodologia Proposta:

O objetivo deste estudo é ser uma pesquisa exploratória – pois busca ir além do conceito de sustentabilidade e gerar contribuições acadêmicas para as lacunas da literatura –, mas sua característica fundamental é o interesse nas práticas de conhecimento de aplicação, uso e consequências (Gil, 2008), com foco em investigar as práticas de RL e como sua adoção contribui para o alcance dos ODS. Segundo Gil (2008) o nível de estudo é descritivo, pois visa estabelecer relações entre RL e desenvolvimento sustentável. Este estudo utiliza métodos mistos, combinando pesquisa qualitativa e quantitativa. A abordagem qualitativa foi utilizada inicialmente para explorar o estado da arte atual e desenvolver o conjunto de impactos da LR. Após, a abordagem quantitativa será utilizada para torná-la mensurável e criar vínculos entre as descobertas anteriores e os ODS. Para isso, a pesquisa se valerá de entrevista/elicitação com especialistas (expert elicitation) através da aplicação de questionário e seguirá o protocolo IDEA a fim de melhorar o processo aumentando sua rigorosidade e reduzindo vieses. Para a análise de dados a pesquisa utilizará estatística descritiva e demais métodos de tomada de decisão multicritério quando necessário.

Critério de Inclusão:

Vão ser incluídos os participantes que adequarem ao critério: ser um especialista na área de sustentabilidade.

Critério de Exclusão:

Vão ser excluídos os participantes que não se adequarem ao critério: ser um especialista na área de sustentabilidade.

Riscos:

Os riscos e desconfortos que poderão existir estão relacionados ao conhecimento e entendimento e crença da pessoa que será entrevistada, sendo que esta pode sentir-se constrangida por não saber responder certas questões, por desconhecimento do assunto. Os procedimentos utilizados para minimizar esse desconforto, envolvem esclarecimentos prévios por parte dos pesquisadores (e sempre que for solicitado) dos conceitos não conhecidos, além de total compreensão da possibilidade da não divulgação de dados que permitam a identificação do respondente e da compreensão por parte do respondente de que a sua participação é voluntária. O tempo para responder também é um risco que pode gerar desconforto nos respondentes, portanto será esclarecido ao início do questionário. O tempo estimado para responder ao questionário é de 1 hora. Você não deve participar deste estudo se sentir qualquer desconforto em fornecer as informações solicitadas. Caso tenha começado a participar e sinta qualquer desconforto, você pode interromper sua participação a qualquer momento. Para salvar uma via do TCLE, basta imprimir a página referente ao TCLE do questionário por meio das opções do seu navegador.

Benefícios:

Os respondentes não terão benefícios diretos ao participar da pesquisa. Com relação aos benefícios sociais, durante a reunião intermediária, ao final da coleta de resultados e após a conclusão da pesquisa completa, os resultados serão comunicados em formas de relatório e texto para que todos os participantes tenham conhecimento sobre o tema estudado e para que se sintam motivados a contribuir com a ciência novamente no futuro.

Metodologia de Análise de Dados:

O objetivo deste estudo é ser uma pesquisa aplicada, pois possui muitos pontos em comum com a pesquisa pura – pois busca ir além do conceito de sustentabilidade e gerar contribuições acadêmicas para as lacunas da literatura –, mas sua característica fundamental é o interesse nas práticas de conhecimento de aplicação, uso e consequências (Gil, 2008), com foco em investigar as práticas de RL e como sua adoção contribui para o alcance dos ODS. Segundo Gil (2008) o nível de estudo é descritivo, pois visa estabelecer relações entre RL e desenvolvimento sustentável. Este estudo utiliza métodos mistos, combinando pesquisa qualitativa e quantitativa. A abordagem qualitativa foi utilizada inicialmente para explorar o estado da arte atual e desenvolver o conjunto de impactos da LR. Após, a abordagem quantitativa será utilizada para torná-la mensurável e criar vínculos entre as descobertas anteriores e os ODS. Para isso, a pesquisa se valerá de entrevista com especialistas (expert elicitation) e seguirá o protocolo IDEA a fim de melhorar o processo aumentando sua rigorosidade e reduzindo vieses, para a análise de dados a pesquisa utilizará estatística descritiva e demais métodos de tomada de decisão multicritério quando necessário.

Desfecho Primário:

Almeja-se o desenvolvimento de artigo e a elaboração da dissertação final. Com a aplicação do questionário busca-se compreender a relação entre a adoção da logística reversa e o cumprimento dos ODSs sob a ótica de especialistas. Ao final, espera-se obter como resultado um ranking dos ODSs que mais são impactados pela logística reversa, ou seja: as maiores contribuições dessa prática para o desenvolvimento sustentável.

Tamanho da Amostra no Brasil: 6

Países de Recrutamento

País de Origem do Estudo	País	Nº de participantes da pesquisa
Sim	BRASIL	6

Outras Informações

Haverá uso de fontes secundárias de dados (prontuários, dados demográficos, etc)?

Não

Informe o número de indivíduos abordados pessoalmente, recrutados, ou que sofrerão algum tipo de intervenção neste centro de pesquisa:

6

Grupos em que serão divididos os participantes da pesquisa neste centro

ID Grupo	Nº de Indivíduos	Intervenções a serem realizadas
Especialistas em sustentabilidade	6	No máximo 2

O Estudo é Multicêntrico no Brasil?

Não

Propõe dispensa do TCLE?

Não

Haverá retenção de amostras para armazenamento em banco?

Não

Cronograma de Execução

Identificação da Etapa	Início (DD/MM/AAAA)	Término (DD/MM/AAAA)
Elaboração do texto final	01/11/2022	30/01/2023
Análise de dados	15/10/2022	01/11/2022
Coleta de dados	01/10/2022	15/10/2022

Orçamento Financeiro

Identificação de Orçamento	Tipo	Valor em Reais (R$)
Projeto	Outros	R$ 0,00
Locomoção do pesquisador até o campus	Custeio	R$ 120,00
Total em R$		R$ 120,00

Outras informações, justificativas ou considerações a critério do pesquisador:

Como a pesquisa, contato e aplicação dos questionários acontecerá de forma remota, não existem custos previstos acerca de deslocamento ou qualquer outra coisa do gênero para a coleta de dados. O acesso à internet, bem como os computadores utilizados para a condução da análise dos dados, são recursos disponíveis no laboratório de Produção Sustentável, localizado no campus da UFSCar- Sorocaba, para isso haverá apenas o custo de locomoção do pesquisador até o campus, estimado em R$ 30,00 por mês. O valor total, contemplando o cronograma (de Outubro a Janeiro) pode ser visto a seguir.

Bibliografia:

Agrawal, S., Singh, R. K. and Murtaza, Q. (2015) 'A literature review and perspectives in reverse logistics', Resources, Conservation and Recycling jo, 97, pp. 76–92. doi: 10.1016/j.resconrec.2015.02.009. Aitken, J. and Harrison, A. (2013) 'Supply governance structures for reverse logistics systems', International Journal of Operations and Production Management, 33(6), pp. 745–764. doi: 10.1108/IJOPM-10-2011-0362. Banihashemi, T. A., Fei, J. and Chen, P. S.-L. (2019) 'Exploring the relationship between reverse logistics and sustainability performance', Modern Supply Chain Research and Applications, 1(1), pp. 2–27. doi: 10.1108/mscra-03-2019-0009. Carter, C. R. and Rogers, D. S. (2008) 'A framework of sustainable supply chain management: Moving toward new theory', International Journal of Physical Distribution and Logistics Management, 38(5), pp. 360–387. doi: 10.1108/09600030810882816. Earth Overshoot Day (2020) About Earth Overshoot Day. Available at: https://www.overshootday.org/about-earth-overshoot-day/. Frei, R., Jack, L. and Brown, S. (2020) 'Product returns: a growing problem for business, society and environment', International Journal of Operations and Production Management, 40(10), pp. 1613–1621. doi: 10.1108/IJOPM-02-2020-0083. Govindan, K. and Gholizadeh, H. (2021) 'Robust network design for sustainable-resilient reverse logistics network using big data: A case study of end-of-life vehicles', Transportation Research Part E: Logistics and Transportation Review, 149(February), p. 102279. doi: 10.1016/j.tre.2021.102279. Guarnieri, P. (2014) Logística Reversa. Clube de Autores (managed). Kleindorfer, P., Singhal, K. and Wassenhove, L. (2005) 'Sustainable Operations Management', Production and Operations Management Society, 14(4), pp. 482–492. Koberg, E. and Longoni, A. (2019) 'A systematic review of sustainable supply chain management in global supply chains', Journal of Cleaner Production, 207, pp. 1084–1098. doi: 10.1016/j.jclepro.2018.10.033. Köhler, J. et al. (2019) 'An agenda for sustainability transitions research: State of the art and future directions', Environmental Innovation and Societal Transitions, 31(December 2018), pp. 1–32. doi: 10.1016/j.eist.2019.01.004. Leurent, H. and Abbosh, O. (2018) 'Driving the Sustainability of Production Systems with Fourth Industrial Revolution Innovation', World

Economic Forum (WEF), (January), p. 58. Available at: http://www3.weforum.org/docs/WEF_39558_White_Paper_Driving_the_Sustainability_of_Production_Systems_4IR.pdf. Maurice, J. (2016) 'Measuring progress towards the SDGs — a new vital science A new statistical methodology has emerged to gauge progress towards reaching the 2030', The Lancet, 388(10053), pp. 1455–1458. doi: 10.1016/S0140-6736(16)31791-3. Mensah, J. (2019) 'Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review', Cogent Social Sciences, 5(1), pp. 1–21. doi: 10.1080/23311886.2019.1653531. Morgan, T. R. et al. (2018) 'Resource commitment and sustainability: a reverse logistics performance process model', International Journal of Physical Distribution and Logistics Management, 48(2), pp. 164–182. doi: 10.1108/IJPDLM-02-2017-0068. Nations, U. (2015) The 17 Goals. Available at: https://sdgs.un.org/goals. Nosratabadi, S. et al. (2019) 'Sustainable business models: A review', Sustainability (Switzerland), 11(6), pp. 1–30. doi: 10.3390/su11061663. Piyathanavong, V. et al. (2019) 'The adoption of operational environmental sustainability approaches in the Thai manufacturing sector', Journal of Cleaner Production, 220, pp. 507–528. doi: 10.1016/j.jclepro.2019.02.093. Purvis, B., Mao, Y. and Robinson, D. (2019) 'Three pillars of sustainability: in search of conceptual origins', Sustainability Science, 14(3), pp. 681–695. doi: 10.1007/s11625-018-0627-5. Sarkis, J., Helms, M. M. and Hervani, A. A. (2010) 'Reverse Logistics and Social Sustainability', Corporate Social Responsibility and Environmental Management, 354(January), pp. 337–354. Schroeder, P., Anggraeni, K. and Weber, U. (2019) 'The Relevance of Circular Economy Practices to the Sustainable Development Goals', Journal of Industrial Ecology, 23(1), pp. 77–95. doi: 10.1111/jiec.12732. Sellitto, M. A., Camfield, C. G. and Buzuku, S. (2020) 'Green innovation and competitive advantages in a furniture industrial cluster: A survey and structural model', Sustainable Production and Consumption, 23, pp. 94–104. doi: 10.1016/j.spc.2020.04.007. Seuring, S. and Müller, M. (2008) 'From a literature review to a conceptual framework for sustainable supply chain management', Journal of Cleaner Production, 16(15), pp. 1699–1710. doi: 10.1016/j.jclepro.2008.04.020. Sorkun, M. F. and Onay, M. (2018) 'The Effects of Companies ' Reverse Logistics Motivations on Their Reverse Logistics Networks', Strategic Design and Innovative Thinking in Business Operations, pp. 3–21. doi: 10.1007/978-3-319-77622-4. Toffel, M. W. and Toffel, M. W. (2004) 'Management of Product Recovery'. Trujillo-Gallego, M., Sarache, W. and Sellitto, M. A. (2021) 'Identification of practices that facilitate manufacturing companies' environmental collaboration and their influence on sustainable production', Sustainable Production and Consumption, 27, pp. 1372–1391. doi: 10.1016/j.spc.2021.03.009.

Upload de Documentos

Arquivo Anexos:

Tipo	Arquivo
Projeto Detalhado / Brochura Investigador	Projeto_detalhado_Maquele.pdf
Projeto Detalhado / Brochura Investigador	Projeto_detalhado_Maquele.pdf
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1910029.pdf
Folha de Rosto	folha_de_rosto_Maquele.pdf
Outros	Material_complementar_Questionario_para_aprovacao_CEP_Maquele.xlsx
Folha de Rosto	folha_de_rosto_Maquele.pdf
Projeto Detalhado / Brochura Investigador	Projeto_detalhado_Maquele.pdf
Projeto Detalhado / Brochura Investigador	Projeto_detalhado_Maquele.pdf
Outros	Material_complementar_Questionario_para_aprovacao_CEP_Maquele.xlsx
Folha de Rosto	folha_de_rosto_Maquele.pdf
Outros	Carta_Autorizacao_ppgpur_assinado.pdf
Outros	carta_resposta_Maquele_Antunes.pdf
Folha de Rosto	folha_de_rosto_Maquele.pdf
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Maquele_Antunes.pdf
Outros	Material_complementar_Questionario_para_aprovacao_CEP_Maquele.pdf
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Maquele_Antunes.pdf
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1910029.pdf
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Maquele_Antunes.pdf
Outros	Material_complementar_Questionario_para_aprovacao_CEP_Maquele.xlsx
Outros	Carta_Autorizacao_ppgepso_assinado.pdf
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Maquele_Antunes.pdf
Outros	Material_complementar_Questionario_para_aprovacao_CEP_Maquele.pdf
Outros	Carta_Autorizacao_dep_assinado.pdf
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Maquele_Antunes.pdf
Comprovante de Recepção	PB_COMPROVANTE_RECEPCAO_1910029.pdf
Projeto Detalhado / Brochura Investigador	Projeto_detalhado_Maquele_Antunes.pdf

Finalizar

Manter sigilo da integra do projeto de pesquisa: Não

ANNEX D

UNIVERSIDADE FEDERAL DE SÃO CARLOS

CENTRO DE CIÊNCIAS EM GESTÃO E TECNOLOGIA

PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO DO *CAMPUS* SOROCABA (PPGEP-So)

Aluna: Maquele Antunes de Oliveira

Orientadora: Profa. Dra. Juliana Veiga Mendes

Co-orientador: Prof. Dr. Luis Antonio de Santa-Eulalia

Projeto de mestrado:

AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL

Sorocaba

2022

Versão 2 (16/08/2022)

Objetivos da pesquisa

O objetivo deste estudo é preencher as lacunas apresentadas anteriormente na introdução, reunindo os impactos das práticas de RL para a sustentabilidade e, então, relacionando-os aos ODSs para descobrir onde estão as principais contribuições da RL para o desenvolvimento sustentável. Para tanto, este estudo foi dividido em 2 partes principais e artigos específicos:

i) Em primeiro lugar, foi realizada uma revisão sistemática da literatura para reunir sistematicamente todos os impactos sustentáveis empíricos de LR relatados pela literatura, a fim de responder às duas seguintes questões de pesquisa (QR):
(RQ1) Quais são os impactos sustentáveis gerados pela RL?; e
(RQ2) Quais dimensões da sustentabilidade são as mais impactadas pela RL?;

ii) Em segundo lugar, os resultados obtidos na revisão sistemática foram usados como insumo para criação de questionário a fim de se realizar uma elicitação de especialistas que busca entender a relação entre os impactos da RL e como ela pode contribuir para a cumprimento dos ODS. Esta etapa da pesquisa está aguardando aprovação do Comitê de Ética para que os questionários sejam aplicados. Esta segunda parte teve como objetivo responder às seguintes RQ:
(RQ1) Quais ODS são os mais impactados pela adoção de RL?; e
(RQ2) Como a RL pode contribuir para o desenvolvimento sustentável?

Riscos e benefícios envolvidos na execução da pesquisa

Riscos	*Benefícios*
As perguntas não são invasivas à intimidade dos participantes, entretanto, esclareço que a participação na pesquisa pode gerar riscos e desconfortos relacionados ao conhecimento, entendimento e crença da pessoa que será entrevistada, sendo que esta pode sentir-se constrangida por não saber responder certas questões, por desconhecimento do assunto. Os procedimentos utilizados para minimizar esse desconforto, envolvem esclarecimentos prévios por parte dos pesquisadores (e sempre que for solicitado) dos conceitos não conhecidos, além de total compreensão da possibilidade da não divulgação de dados que permitam a identificação do respondente e da compreensão por parte do respondente de que a sua participação é voluntária. O tempo para responder também é um risco que pode gerar desconforto nos	*Os respondentes não terão benefícios diretos ao participar da pesquisa. Com relação aos benefícios sociais, durante a reunião intermediária, ao final da coleta de resultados e após a conclusão da pesquisa completa, os resultados serão comunicados em formas de relatório e texto para que todos os participantes tenham conhecimento sobre o tema estudado e para que se sintam motivados a contribuir com a ciência novamente no futuro.*

respondentes, portanto será esclarecido ao início do questionário.
O tempo estimado para responder ao questionário é de 1 hora. Você não deve participar deste estudo se sentir qualquer desconforto em fornecer as informações solicitadas. Caso tenha começado a participar e sinta qualquer desconforto, você pode interromper sua participação a qualquer momento. Para salvar uma via do TCLE, basta imprimir a página referente ao TCLE do questionário por meio das opções do seu navegador.

Relevância social

O projeto colabora para o desenvolvimento sustentável em suas três dimensões (ambiental, econômica e social) e incentiva a adoção de práticas de produção sustentáveis, tal qual a logística reversa – tema central da pesquisa.

Local de realização da pesquisa

A pesquisa será realizada de forma online através de envio por e-mail. O questionário é eletrônico e sua aplicação será realizada de maneira remota, sendo assim, cabe ao entrevistado decidir o seu local físico no momento em que estiver respondendo, podendo ele estar na sua casa ou local de trabalho.

Detalhamento da população a ser estudada e forma de recrutamento

Especialistas em sustentabilidade. Serão recrutados especialistas através de *snowballing*, partindo do Grupo de Pesquisa em Engenharia da Sustentabilidade (EngS). O contato será realizado através de e-mail e vídeo chamadas quando necessário (para alinhamentos e esclarecimento de dúvidas, se necessário).

Método a ser utilizado (incluindo os instrumentos utilizados para coleta de dados-questionários, roteiro de entrevista, ficha clínica, etc.)

O objetivo deste estudo é ser uma pesquisa exploratória – pois busca ir além do conceito de sustentabilidade e gerar contribuições acadêmicas para as lacunas da literatura –, mas sua característica fundamental é o interesse nas práticas de conhecimento de aplicação, uso e consequências (Gil, 2008), com foco em investigar as práticas de RL e como sua adoção contribui para o alcance dos ODS. Segundo Gil (2008) o nível de estudo é descritivo, pois visa estabelecer relações entre RL e desenvolvimento sustentável.

Este estudo utiliza métodos mistos, combinando pesquisa qualitativa e quantitativa. A abordagem qualitativa foi utilizada inicialmente para explorar o estado da arte atual e desenvolver o conjunto de impactos da LR através da revisão sistemática da literatura. Após, a abordagem quantitativa será utilizada para torná-la mensurável e criar vínculos entre as descobertas anteriores e os ODS. Para isso, a pesquisa se valerá de entrevista/elicitação com especialistas (expert elicitation) através da aplicação de questionário e seguirá o protocolo IDEA a fim de melhorar o processo aumentando sua rigorosidade e reduzindo vieses. Para a análise de dados a pesquisa utilizará estatística descritiva e demais métodos de tomada de decisão multicritério quando necessário.

O questionário a ser utilizado será encaminhado por e-mail aos respondentes e seu modelo pode ser visto no Anexo 1, ao final deste projeto detalhado e em anexo como material complementar.

Cronograma

Etapa	*Início*	*Final*
Coleta de dados	01/10/2022	15/10/2022
Análise de dados	15/10/2022	01/11/2022
Elaboração do texto final	01/11/2022	30/01/2023

Orçamento

Como a pesquisa, contato e aplicação dos questionários acontecerá de forma remota, não existem custos previstos acerca de deslocamento ou qualquer outra coisa do gênero para a **coleta de dados**.

O acesso à internet, bem como os computadores utilizados para a condução da **análise dos dados**, são recursos disponíveis no laboratório de Produção Sustentável, localizado no campus da UFSCar- Sorocaba, para isso haverá apenas o custo de locomoção do pesquisador até o campus, estimado em R$ 30,00 por mês. O valor total, contemplando o cronograma (de Outubro a Janeiro) pode ser visto a seguir.

Locomoção do pesquisador até o campus	*R$ 120,00*

Critérios de inclusão e exclusão dos participantes da pesquisa

- **Inclusão:** Vão ser incluídos os participantes que adequarem ao critério: ser um especialista na área de sustentabilidade.

- **Exclusão:** Vão ser excluídos os participantes que não se adequarem ao critério: ser um especialista na área de sustentabilidade.

ANEXO 1

Avaliação da Contribuição da Logística Reversa e seus Impactos para o Desenvolvimento Sustentável

O **TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)** foi enviado no seu e-mail junto a este questionário. Também consta no link a seguir e detalha as questões legais para a participação nesta pesquisa: (**o link será inserido aqui após a aprovação do CEP**).

☐ Ao assinala reste item declaro que recebi uma via do TCLE, li e concordo com o Termo.

Como preencher este questionário?

Para assegurar a qualidade dos dados, o questionário foi elaborado em quatro passos:

-	[Menor palpite] Em uma escala de 1 a 5, qual o seu menor palpite para o nível de correlação entre esse impacto da logística reversa e o cumprimento do respectivo ODS?
★	[Melhor palpite] Em uma escala de 1 a 5, qual o seu melhor palpite para o nível de correlação entre esse impacto da logística reversa e o cumprimento do respectivo ODS?
+	[Maior palpite] Em uma escala de 1 a 5, qual o seu maior palpite para o nível de correlação entre esse impacto da logística reversa e o cumprimento do respectivo ODS?
%	[Nível de certeza] Em uma escala 0% a 100%, quão certo você está da sua resposta?

Para dar os palpites, o questionário utiliza uma escala Likert de 1 a 5, sendo:

1 = Este impacto gerado pela logística reversa não é importante para o cumprimento do respectivo ODS;
2 = Este impacto gerado pela logística reversa às vezes é importante para o cumprimento do respectivo ODS;
3 = Este impacto gerado pela logística reversa contribui moderadamente para com o cumprimento do respectivo ODS;
4 = Este impacto gerado pela logística reversa é importante para o cumprimento do respectivo ODS;
5 = Este impacto gerado pela logística reversa é muito importante para o cumprimento do respectivo ODS.

A seguir, você encontra um exemplo do preenchimento do questionário:

	A	B	C	D
1			ODS	ODS
2	Impacto da logística reversa	-	2	1
3		☆	3	3
4		+	4	5
5		%	85	50

		ODS 1 - Erradicação da pobreza	ODS 2 - Fome Zero e Agricultura Sustentável	ODS 6 - Água Potável e Saneamento	ODS 7 - Energia Limpa e Acessível	ODS 8 - Emprego Decente e Crescimento Econômico	ODS 12 - Consumo e Produção Responsáveis	ODS 14 - Vida na Água	ODS 15 - Vida Terrestre
Reduzir a pegada ambiental, a quantidade de resíduos e a	-								
	★								

disposição em aterros. Otimizando o uso de matéria-prima e recursos naturais e o desempenho da reciclagem	+								
	%								
Melhorar as estratégias orientadas ao meio ambiente	-								
	★								
	+								
	%								
Reduzir o consumo de energia	-								
	★								
	+								
	%								
Otimizar o transporte	-								
	★								
	+								
	%								
Reduzir a poluição do solo	-								
	★								
	+								
	%								
Reduzir a poluição da água	-								
	★								
	+								
	%								
Reduzir a pegada de carbono e a poluição do ar	-								
	★								
	+								
	%								
Atender às pressões ambientais, exigências legais e governamentais e aumentar a proteção ambiental.	-								
	★								
	+								
	%								
Melhorar o atendimento e a satisfação do cliente e a imagem da empresa	-								
	★								
	+								
	%								
Aumentar o lucro e a redução de custos	-								
	★								
	+								
	%								
	-								

Aumentar a taxa de devolução de produtos usados	★								
	+								
	%								
Melhorar a qualidade do produto	-								
	★								
	+								
	%								
Aumentar a adoção de soluções de tecnologia	-								
	★								
	+								
	%								
Aumentar a competitividade do mercado	-								
	★								
	+								
	%								
Melhorar o desempenho operacional, a capacidade de utilização e as soluções de gerenciamento	-								
	★								
	+								
	%								
Reduzir as críticas da comunidade	-								
	★								
	+								
	%								
Melhorar a saúde e a segurança humana	-								
	★								
	+								
	%								
Aumentar a geração de empregos e geração renda para catadores	-								
	★								
	+								
	%								
Aumentar a responsabilidade social	-								
	★								
	+								
	%								

ANNEX E

UNIVERSIDADE FEDERAL DE SÃO CARLOS
DEPARTAMENTO DE ENGENHARIA DE PRODUÇÃO
PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

(Resolução CNS 510/2016)

AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL

Você está sendo convidado(a) a participar como voluntário(a) de uma pesquisa. Este documento, chamado Termo de Consentimento Livre e Esclarecido, visa assegurar seus direitos como participante e é elaborado em duas vias, uma que deverá ficar com você e outra com o pesquisador. Por favor, leia com atenção e calma, aproveitando para esclarecer suas dúvidas. Se houver perguntas antes ou mesmo depois de assiná-lo, você poderá esclarecê-las com os pesquisadores. Se preferir, pode levar este termo para casa e consultar seus familiares ou outras pessoas antes de decidir participar. Não haverá nenhum tipo de penalização ou prejuízo se você não aceitar participar ou retirar sua autorização em qualquer momento. O tempo estimado para responder ao questionário é de 1 hora.

Justificativa e objetivos:

O objetivo deste estudo é preencher as lacunas da literatura reunindo os impactos das práticas de RL para a sustentabilidade e, então, relacionando-os aos ODSs para descobrir onde estão as principais contribuições da RL para o desenvolvimento sustentável. Para tanto, este estudo foi dividido em 2 partes principais e artigos específicos:

i) Em primeiro lugar, foi realizada uma revisão sistemática da literatura para reunir sistematicamente todos os impactos sustentáveis empíricos de LR relatados pela literatura, a fim de responder às duas seguintes questões de pesquisa (QR):

(RQ1) Quais são os impactos sustentáveis gerados pela RL?; e
(RQ2) Quais dimensões da sustentabilidade são as mais impactadas pela RL?;

ii) Em segundo lugar, os resultados obtidos na revisão sistemática foram usados como insumo para criação de questionário a fim de se realizar uma elicitação de especialistas que busca entender a relação entre os impactos da RL e como ela pode contribuir para a cumprimento dos ODS. Esta etapa da pesquisa está aguardando aprovação do Comitê de Ética para que os questionários sejam aplicados. Esta segunda parte teve como objetivo responder às seguintes RQ:

(RQ1) Quais ODS são os mais impactados pela adoção de RL?; e

(RQ2) Como a RL pode contribuir para o desenvolvimento sustentável?

Procedimentos:

Você está sendo convidado a participar de uma pesquisa e para tal solicitamos o aceite dos termos aqui descritos. Inicialmente, assinale a opção eletrônica declarando que deseja participar como voluntário desta pesquisa. Em seguida, responda às questões apresentadas da forma mais sincera possível.

O tempo estimado para responder ao questionário é de 1 hora.

O participante que sentir qualquer desconforto, poderá interromper a participação a qualquer momento, mas somente a resposta completa do questionário terá validade para a pesquisa.

Local de realização da pesquisa:

A pesquisa será realizada de forma online através de envio por e-mail. O questionário é eletrônico e sua aplicação será realizada de maneira remota, sendo assim, cabe ao entrevistado decidir o seu local físico no momento em que estiver respondendo, podendo ele estar na sua casa ou local de trabalho.

Desconfortos e riscos:

As perguntas não são invasivas à intimidade dos participantes, entretanto, esclareço que a participação na pesquisa pode gerar riscos e desconfortos relacionados ao conhecimento, entendimento e crença da pessoa que será entrevistada, sendo que esta pode sentir-se constrangida por não saber responder certas questões, por desconhecimento do assunto. Os procedimentos utilizados para minimizar esse desconforto, envolvem esclarecimentos prévios por parte dos pesquisadores (e sempre que for solicitado) dos conceitos não conhecidos, além de total compreensão da possibilidade da não divulgação de dados que permitam a identificação do respondente e da compreensão por parte do respondente de que a sua participação é voluntária. O tempo para responder também é um risco que pode gerar desconforto nos respondentes, portanto será esclarecido ao início do questionário.

O tempo estimado para responder ao questionário é de 1 hora. Você não deve participar deste estudo se sentir qualquer desconforto em fornecer as informações solicitadas. Caso tenha começado a participar e sinta qualquer desconforto, você pode interromper sua participação a qualquer momento. Para salvar uma via do TCLE, basta imprimir a página referente ao TCLE do questionário por meio das opções do seu navegador.

Benefícios:

Os respondentes não terão benefícios diretos ao participar da pesquisa. Com relação aos benefícios sociais, durante a reunião intermediária, ao final da coleta de resultados e após a conclusão da pesquisa completa, os resultados serão comunicados em forma de relatório e texto para que todos os participantes tenham conhecimento sobre o tema estudado e para que se sintam motivados a contribuir com a ciência novamente no futuro.

Acompanhamento e assistência:

Ao longo de toda a pesquisa, os pesquisadores se colocam à disposição via meios eletrônicos (e-mail, telefone, entre outros) para prestar assistência, acompanhamento ou responder dúvidas e fornecer esclarecimentos.

Sigilo, privacidade e garantias:

i) Os resultados serão comunicados em forma de relatório e texto para que todos os participantes tenham conhecimento sobre o tema estudado e para que se sintam motivados a contribuir com a ciência novamente no futuro.

ii) Sua participação é voluntária e não haverá compensação em dinheiro pela sua participação. A qualquer momento você pode desistir de participar e retirar seu consentimento. Sua recusa ou desistência não lhe trará nenhum prejuízo profissional, seja em sua relação ao pesquisador, à Instituição em que trabalha ou à Universidade Federal de São Carlos.

iii) Todas as despesas com o transporte e a alimentação decorrentes da sua participação na pesquisa, quando for o caso, serão ressarcidas mediante a comunicação ao pesquisador responsável. Você receberá assistência imediata e integral e terá direito à indenização por qualquer tipo de dano resultante da sua participação na pesquisa.

iii) Todas as informações obtidas através da pesquisa serão confidenciais, sendo assegurado o sigilo sobre sua participação em todas as etapas do estudo. Caso haja menção a nomes, a eles serão atribuídas letras, com garantia de anonimato nos resultados e publicações, impossibilitando sua identificação. Você tem a garantia de que sua identidade será mantida em sigilo e nenhuma informação será dada a outras pessoas que não façam parte da equipe de pesquisadores. Na divulgação dos resultados desse estudo seu nome e o da sua empresa/organização não serão citados.

O Comitê de Ética em Pesquisa (CEP):

Este projeto de pesquisa foi aprovado por um Comitê de Ética em Pesquisa (CEP) que é um órgão que protege o bem-estar dos participantes de pesquisas. O CEP é responsável pela avaliação e acompanhamento dos aspectos éticos de todas as pesquisas envolvendo seres humanos, visando garantir a dignidade, os direitos, a segurança e o bem-estar dos participantes de pesquisas. Caso você tenha dúvidas e/ou perguntas sobre seus direitos como participante deste estudo, entre em contato com o Comitê de Ética em Pesquisa em Seres Humanos (CEP) da UFSCar que está vinculado à Pró-Reitoria de Pesquisa da universidade, localizado no prédio da reitoria (área sul do campus São Carlos). Endereço: Rodovia Washington Luís km 235 - CEP: 13.565-905 - São Carlos-SP. Telefone: (16) 3351-9685. E-mail: cephumanos@ufscar.br. Horário de atendimento: das 08:30 às 11:30.

O CEP está vinculado à Comissão Nacional de Ética em Pesquisa (CONEP) do Conselho Nacional de Saúde (CNS), e o seu funcionamento e atuação são regidos pelas normativas do CNS/Conep. A CONEP tem a função de implementar as normas e diretrizes regulamentadoras de pesquisas envolvendo seres humanos, aprovadas pelo CNS, também atuando conjuntamente com uma rede de Comitês de Ética em Pesquisa (CEP) organizados nas instituições onde as pesquisas se realizam. Endereço: SRTV 701, Via W 5 Norte, lote D - Edifício PO 700, 3º andar - Asa Norte -

CEP: 70719-040 - Brasília-DF. Telefone: (61) 3315-5877 E-mail: conep@saude.gov.br.

Responsabilidade do Pesquisador:

Asseguro ter cumprido as exigências da resolução 466/2012 CNS/MS e complementares na elaboração do protocolo e na obtenção deste Termo de Consentimento Livre e Esclarecido. Asseguro, também, ter explicado e fornecido uma via deste documento ao participante. Informo que o estudo foi aprovado pelo CEP perante o qual o projeto foi apresentado. Comprometo-me a utilizar o material e os dados obtidos nesta pesquisa exclusivamente para as finalidades previstas neste documento e conforme o consentimento dado pelo participante.

Contato:

Em caso de dúvidas sobre a pesquisa, você poderá entrar em contato com os pesquisadores **(24 horas por dia e sete dias por semana)**:

- **Pesquisadora Responsável:** Maquele Antunes de Oliveira
- **Instituição a que pertence o Pesquisador Responsável:** Universidade Federal de São Carlos – Programa de Pós-Graduação em Engenharia de Produção de Sorocaba (PPGEP-So)
- **Endereço:** Rua João Alcino Vieira, 571. Itapetininga-SP. CEP: 18210-738.
- **Telefones para contato do Pesquisador:** (15) 99800-4654
- **Outras formas de contato com o pesquisador:** maquele@estudante.ufscar.br ou maquele_antunes@yahoo.com

Consentimento livre e esclarecido:

Após ter recebido esclarecimentos sobre a natureza da pesquisa, seus objetivos, métodos, benefícios previstos, potenciais riscos e o incômodo que esta possa acarretar, declaro aceito participar como voluntário da pesquisa.

ANNEX F

UNIVERSIDADE FEDERAL DE SÃO CARLOS - UFSCAR

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL

Pesquisador: MAQUELE ANTUNES DE OLIVEIRA

Área Temática:

Versão: 2

CAAE: 58134622.9.0000.5504

Instituição Proponente: Universidade Federal de São Carlos/UFSCar

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.930.595

Apresentação do Projeto:

As informações contidas neste campo foram extraídas do documento "PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1910029", cujo título é “AVALIAÇÃO DA CONTRIBUIÇÃO DA LOGÍSTICA REVERSA E SEUS IMPACTOS PARA O DESENVOLVIMENTO SUSTENTÁVEL”. A preocupação global com o desenvolvimento sustentável aumentou e as práticas de produção que podem contribuir para isso ganharam destaque - sendo a logística reversa (RL) uma delas. No entanto, o tema ainda é emergente e requer novos esforços. A definição de quais contribuições a logística reversa pode trazer para a sustentabilidade ainda é inexata. O objetivo da pesquisa é ampliar a compreensão dos impactos sustentáveis que a RL pode gerar econômica, ambiental e socialmente e definir quais ODS (Objetivos de Desenvolvimento Sustentável) são os mais impactados.

Além disso, pretende-se contribuir para a produção de conhecimento relacionado à LR e sustentabilidade em suas três dimensões – onde faltam estudos –; demonstrar às empresas interessadas em aumentar sua adesão ao pacto global ODS como a adoção da RL pode beneficiá-las; identificar os principais impactos do RL para o desenvolvimento sustentável e elucidar como a adoção do RL pode ajudar no alcance dos ODS. Para tanto, a pesquisa fará uso de: (i) uma revisão sistemática da literatura a fim de reunir as evidências empíricas dos impactos da RL na sustentabilidade e (ii) elicitação de especialistas por meio do protocolo IDEA para analisar e definir quais ODS são os mais impactados pela adoção de práticas de RL.

A extração inconsciente de recursos naturais para a produção aumentou a quantidade de resíduos que produzimos e colocou em risco as gerações futuras (Guarnieri, 2014). De acordo com o Earth Overshoot Day organizado pela Global Footprint Network, nossa demanda por recursos naturais atualmente excede a capacidade de regeneração da Terra (Earth Overshoot Day, 2020), o que demonstra o déficit de sustentabilidade do nosso atual modelo de produção. Esse cenário atual elevou consideravelmente o interesse acadêmico e corporativo pela gestão sustentável da cadeia de suprimentos (Seuring e Müller, 2008), sendo impulsionado principalmente pelo crescente uso de tecnologias avançadas (Nosratabadi et al., 2019). A sustentabilidade é a integração dos aspectos ambientais, sociais e econômicos, que permitem às organizações alcançar a viabilidade econômica (Carter e Rogers, 2008). Requer mudanças drásticas em uma ampla gama de setores e ainda há muito trabalho a ser feito em pesquisa de sustentabilidade, mas a história das revoluções industriais nos mostra que os sistemas sociais, econômicos e tecnológicos podem e se transformam (Köhler et al., 2019). O desenvolvimento sustentável também tem ganhado cada vez mais atenção no espaço acadêmico, de governança, planejamento e intervenção no desenvolvimento (Mensah, 2019). O conceito de “desenvolvimento sustentável” gira em torno dos três pilares da
sustentabilidade que os interligam; o que aumenta a necessidade de conscientização dos tomadores de decisão sobre as relações, complementaridades e trade-offs entre esses pilares (Mensah, 2019). Apesar da falta de conceituação da sustentabilidade em geral, a Organização das Nações Unidas (ONU) apresentou 17 metas e 169 metas para o desenvolvimento sustentável – são os chamados Objetivos de Desenvolvimento Sustentável (ODS); no entanto – apesar das metas e indicadores serem animadores – sua fundamentação teórica não é clara (Purvis, Mao e Robinson, 2019). Adotada por todos os Estados Membros das Nações Unidas em 2015, a Agenda 2030 para o Desenvolvimento Sustentável é descrita pela ONU como um plano de ação para as pessoas, o planeta e a prosperidade (Nations, 2015). Os 17 ODS são integrados e indivisíveis e equilibram as três dimensões do desenvolvimento sustentável (Nações, 2015) (Figura 1). Fig. 1. Descrição dos 17 ODS. O ODS 12 é bastante específico para manufatura, no entanto, os sistemas de produção podem contribuir potencialmente para uma gama muito maior de ODS (Leurent e Abbosh, 2018). Práticas de economia circular e modelos de negócios relacionados podem ajudar a alcançar vários dos ODS, especialmente vinculados ao ODS 6 (Água Limpa e Saneamento), ODS 7 (Energia Limpa e Acessível), ODS 8 (Trabalho Decente e Crescimento Econômico), ODS 12 (Responsável Consumo e Produção) e ODS 15 (Vida na Terra) (Schroeder, Anggraeni e Weber, 2019). A gestão da cadeia de

suprimentos é importante para a sustentabilidade (Koberg e Longoni, 2019). A gestão de operações pode e deve contribuir para a sustentabilidade: É preciso maximizar a recuperação e reutilização de produtos; reduzindo os efeitos nocivos sobre o meio ambiente da eliminação de resíduos, extração de matérias-primas, transporte e distribuição – e também pode aumentar os lucros como consequência (Kleindorfer, Singhal e Wassenhove, 2005). Na literatura, a logística reversa (LR) é considerada uma prática sustentável (Sellitto, Camfield e Buzuku, 2020; Trujillo-Gallego, Sarache e Sellitto, 2021) e é descrita como uma área emergente de pesquisa com oportunidades para alcançar impactos consideráveis na sociedade , meio ambiente e economia (Sarkis, Helms e Hervani, 2010; Frei, Jack e Brown, 2020). A RL é a estratégia que operacionaliza a devolução de resíduos pós-consumo e visa possibilitar o desenvolvimento econômico e sustentável; caracterizando-se pelo fluxo de clientes para empresas que recebem produtos pós-consumo. Em muitas empresas, algumas práticas de logística reversa já acontecem mesmo que de forma informal, devido à necessidade de descarte de resíduos (Guarnieri, 2014). O gerenciamento de reciclagem chamou a atenção da maioria das organizações de manufatura e serviços nos últimos anos (Govindan e Gholizadeh, 2021). As motivações para a adoção da logística reversa são variadas, sendo orientadas tanto para o mercado quanto para o desejo de manter os custos baixos (Sorkun e Onay, 2018). A crescente necessidade de tornar o desenvolvimento mais sustentável obrigou muitas empresas não apenas a adotar a logística reversa, mas a torná-la cada vez mais
eficiente e eficaz (Agrawal, Singh e Murtaza, 2015). Investir na sustentabilidade da RL também é uma forma de ganhar participação de mercado promovendo uma forte reputação ambiental, ampliando o alcance entre os clientes que valorizam o desempenho sustentável (Toffel e Toffel, 2004).

Com relação aos três pilares da sustentabilidade, a recuperação de produtos ao final de sua vida útil por meio da logística reversa tornou-se significativa para as organizações devido a questões ambientais e econômicas, porém a atenção à sustentabilidade social ainda é rudimentar (Sarkis, Helms e Hervani, 2010; Banihashemi, Fei e Chen, 2019). A sustentabilidade é fundamental para vincular a RL ao desempenho e, portanto, requer exame detalhado e trabalho de confirmação (por exemplo: redes nomológicas) para examinar como a sustentabilidade e a RL se relacionam (Morgan et al., 2018). Ainda há um número limitado de artigos que estudam a LR como prática para a sustentabilidade (Aitken e Harrison, 2013; Piyathanavong et al., 2019) e as abordagens sustentáveis para a LR são tipicamente gerais, tornando necessário que mais esforços sejam feitos nessa direção (Banihashemi, Fei e Chen, 2019a). Além disso, até onde sabemos, não foram encontrados artigos que reúnam sistematicamente os impactos sustentáveis da LR e os relacionem com os ODS – mesmo com as recomendações para usá-los como medidas de sustentabilidade (Maurice, 2016).

Este trabalho apresenta duas hipóteses: H1) Quais ODS são os mais impactados pela adoção de RL?H2) Como a RL pode contribuir para o desenvolvimento sustentável?

O Objetivo Primário do trabalho é preencher as lacunas apresentadas anteriormente na introdução, reunindo os impactos das práticas de RL para a sustentabilidade e, então, relacionando-os aos ODSs para descobrir onde estão as principais contribuições da RL para o desenvolvimento sustentável. Para tanto, este estudo foi dividido em 2 partes principais e artigos específicos: i) Em primeiro lugar, foi realizada uma revisão sistemática da literatura para reunir sistematicamente todos os impactos sustentáveis empíricos de LR relatados pela literatura, a fim de responder às duas seguintes questões de pesquisa (QR): (RQ1) Quais são os impactos sustentáveis gerados pela RL?; e (RQ2) Quais dimensões da sustentabilidade são as mais impactadas pela RL?; ii) Em segundo lugar, os resultados obtidos na revisão sistemática foram usados como insumo para criação de questionário a fim de se realizar uma elicitação de especialistas que busca entender a relação entre os impactos da RL e como ela pode contribuir para a cumprimento dos ODS. Esta etapa da pesquisa está aguardando aprovação do Comitê de Ética para que os questionários sejam aplicados. Esta segunda parte teve como objetivo responder às seguintes RQ: (RQ1) Quais ODS são os mais impactados pela adoção de RL?; e (RQ2) Como a RL pode contribuir para o desenvolvimento sustentável?

Com relação à Metodologia, o objetivo deste estudo é ser uma pesquisa exploratória – pois busca ir além do conceito de sustentabilidade e gerar contribuições acadêmicas para as lacunas da literatura –, mas sua característica fundamental é o interesse nas práticas de conhecimento de aplicação, uso e consequências (Gil, 2008), com foco em investigar as práticas de RL e como sua adoção contribui para o alcance dos ODS. Segundo Gil (2008) o nível de estudo é descritivo, pois visa estabelecer relações entre RL e desenvolvimento sustentável. Este estudo utiliza métodos mistos, combinando pesquisa qualitativa e quantitativa. A abordagem qualitativa foi utilizada inicialmente para explorar o estado da arte atual e desenvolver o conjunto de impactos da LR. Após, a abordagem quantitativa será utilizada para torná-la mensurável e criar vínculos entre as descobertas anteriores e os ODS. Para isso, a pesquisa se valerá de entrevista/elicitação com especialistas (expert elicitation) através da aplicação de questionário e seguirá o protocolo IDEA a fim de melhorar o processo aumentando sua rigorosidade e reduzindo vieses. Para a análise de dados a pesquisa utilizará estatística descritiva e demais métodos de tomada de decisão multicritério quando necessário.

Objetivo da Pesquisa:
O objetivo da pesquisa está claro, tanto no projeto de pesquisa submetido, como nas informações básicas do projeto e no TCLE e estão em consonância.

É apresentado como: “O objetivo deste estudo é preencher as lacunas apresentadas anteriormente na introdução, reunindo os impactos das práticas de RL para a sustentabilidade e, então, relacionando-os aos ODSs para descobrir onde estão as principais contribuições da RL para o desenvolvimento sustentável. Para tanto, este estudo foi dividido em 2 partes principais e artigos específicos: i) Em primeiro lugar, foi realizada uma revisão sistemática da literatura para reunir sistematicamente todos os impactos sustentáveis empíricos de LR relatados pela literatura, a fim de responder às duas seguintes questões de pesquisa (QR): (RQ1) Quais são os impactos sustentáveis gerados pela RL?; e (RQ2) Quais dimensões da sustentabilidade são as mais impactadas pela RL?; ii) Em segundo lugar, os resultados obtidos na revisão sistemática foram usados como insumo para criação de questionário a fim de se realizar uma elicitação de especialistas que busca entender a relação entre os impactos da RL e como ela pode contribuir para a cumprimento dos ODS. Esta etapa da pesquisa está aguardando aprovação do Comitê de Ética para que os questionários sejam aplicados. Esta segunda parte teve como objetivo responder às seguintes RQ: (RQ1) Quais ODS são os mais impactados pela adoção de RL?; e (RQ2) Como a RL pode contribuir para o desenvolvimento sustentável?.”

Avaliação dos Riscos e Benefícios:
Os riscos e benefícios são apresentados no documento "PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1910029", no projeto de pesquisa e no TCLE e estão em consonância.

Com relação aos riscos, são apresentados como: “Os riscos e desconfortos que poderão existir estão relacionados ao conhecimento e entendimento e crença da pessoa que será entrevistada, sendo que esta pode sentir-se constrangida por não saber responder certas questões, por desconhecimento do assunto. Os procedimentos utilizados para minimizar esse desconforto, envolvem esclarecimentos prévios por parte dos pesquisadores (e sempre que for solicitado) dos conceitos não conhecidos, além de total compreensão da possibilidade da não divulgação de dados que permitam a identificação do respondente e da compreensão por parte do respondente de que a sua participação é voluntária. O tempo para responder também é um risco que pode gerar desconforto nos respondentes, portanto será esclarecido ao início do questionário. O tempo estimado para responder ao questionário é de 1 hora. Você não deve participar deste estudo se sentir qualquer desconforto em fornecer as informações solicitadas. Caso tenha começado a participar e sinta qualquer desconforto, você pode interromper sua participação a qualquer momento. Para salvar uma via do TCLE, basta imprimir a página referente ao TCLE do questionário por meio das opções do seu navegador."

Já os benefícios são apresentados como: "Os respondentes não terão benefícios diretos ao participar da pesquisa. Com relação aos benefícios sociais, durante a reunião intermediária, ao final da coleta de resultados e após a conclusão da pesquisa completa, os resultados serão comunicados em formas de relatório e texto para que todos os participantes tenham conhecimento sobre o tema estudado e para que se sintam motivados a contribuir com a ciência novamente no futuro."

Comentários e Considerações sobre a Pesquisa:
Verificar os itens "conclusões e/ou pendências" feitos pelo relator deste CEP.

Trata-se de uma pesquisa que deve seguir os preceitos éticos estabelecidos pela Resolução CNS 510 de 2016 e suas complementares.

Considerações sobre os Termos de apresentação obrigatória:
Os riscos e benefícios foram apresentados no documento "PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1910029", no projeto de pesquisa e no TCLE e estão em consonância.

No TCLE constam informações sobre: i) a forma de acompanhamento e assistência a que terão direito os participantes; ii) o acesso aos resultados da pesquisa; iii) a explicitação da garantia de ressarcimento e descrição das formas de cobertura das despesas. Tais informações devem estar presentes, tal como apresentada na Resolução 510/2016 em seu Capítulo III - DO PROCESSO DE CONSENTIMENTO E DO ASSENTIMENTOLIVRE E ESCLARECIDO, Artigo 17 e itens V, VI e VII, a saber:

“V - informação sobre a forma de acompanhamento e a assistência a que terão direito os participantes da pesquisa, inclusive considerando benefícios, quando houver;
VI - garantia aos participantes do acesso aos resultados da pesquisa;
VII - explicitação da garantia ao participante de ressarcimento e a descrição das formas de cobertura das despesas realizadas pelo participante decorrentes da pesquisa, quando houver.

Recomendações:
Vide campo "Conclusões ou Pendências e Lista de Inadequações"

Atender as orientações da Conep sobre PROCEDIMENTOS EM PESQUISAS COM QUALQUER ETAPA EM AMBIENTE VIRTUAL. Este documento pode ser acessado na página do CEP UFSCar: http://www.propq.ufscar.br/etica/cep

Conclusões ou Pendências e Lista de Inadequações:
Agradecemos as providências e os cuidados tomados pelos pesquisadores ao apresentarem a 2ª versão do protocolo de pesquisa ao CEP da UFSCar. Seguem abaixo as pendências listadas no parecer anterior do CEP e seu status (atendida, não atendida, parcialmente atendida).

1) Pendência 1 - Atendida: Os objetivos estão em consonância tanto no projeto de pesquisa submetido, como nas informações básicas do projeto e no TCLE;
2) Pendência 2 - Atendida: Os riscos estão em consonância tanto no projeto de pesquisa submetido, como nas informações básicas do projeto e no TCLE;
3) Pendência 3 - Atendida: Os benefícios estão em consonância tanto no projeto de pesquisa submetido, nas informações básicas do projeto e no TCLE;
4) Pendência 4 - Atendida: Inseriu as informações referentes sobre: i) o acesso aos resultados da pesquisa e, ii) a explicitação da garantia de ressarcimento e descrição das formas de cobertura das despesas, tal como preconizado na Resolução 510/2016 em seu Capítulo III - DO PROCESSO DE CONSENTIMENTO E DO ASSENTIMENTOLIVRE E ESCLARECIDO, Artigo 17 e itens VI e VII. Tais informações devem estar presentes no TCLE;
5) Pendência 5 - Atendida: Inseriu informação sobre o local de realização da entrevista;
6) Pendências 6 e 7 - Atendidas: Apresentou as cartas de autorização dos locais onde será realizada a pesquisa;
7) Pendência 8 - Atendida: Explicitou o tempo de duração da entrevista no TCLE;
8) Pendência 9 - Numerou as páginas do TCLE;

9) Pendência 10 - Atendida: Apresentou informações sobre o valor referente à “Identificação do Orçamento”, visto que sempre estão presentes despesas para a realização do trabalho;
10) Pendência 11 – Atendida: Explicitou no TCLE que o contato com o pesquisador pode ser realizado 24 horas por dia e sete dias por semana, tal como apresentado no documento “Modelo envolvendo aplicação de questionário semi estruturado em Educação” disponível no site http://www.propq.ufscar.br/etica/cep/modelos-de-documentos-cep;
11) Pendência 12 - Atendida: Adequou o cronograma das atividades de pesquisa, inserindo a atividade de “aprovação do projeto de pesquisa pelo CEP”;
12) Pendência 13 - Atendida: Apresentou documento novamente atualizado;
13) Pendência 14 - Atendida: Apresentou carta-resposta, contendo esclarecimentos a cada item apontado ao longo deste parecer;
14) Pendência 15 - Atendida: Esclareceu as solicitações feitas ao longo deste parecer.

Considerações Finais a critério do CEP:
Diante do exposto, o Comitê de ética em pesquisa - CEP, de acordo com as atribuições definidas na Resolução CNS nº 510 de 2016, manifesta-se por considerar "Aprovado" o projeto. Conforme dispõe o Capítulo VI, Artigo 28, da Resolução Nº 510 de 07 de abril de 2016, a responsabilidade do pesquisador é indelegável e indeclinável e compreende os aspectos éticos e legais, cabendo-lhe, após aprovação deste Comitê de Ética em Pesquisa: II - conduzir o processo de Consentimento e de Assentimento Livre e Esclarecido; III - apresentar dados solicitados pelo CEP ou pela CONEP a qualquer momento; IV - manter os dados da pesquisa em arquivo, físico ou digital, sob sua guarda e responsabilidade, por um período mínimo de 5 (cinco) anos após o término da pesquisa; V - apresentar no relatório final que o projeto foi desenvolvido conforme delineado, justificando, quando ocorridas, a sua mudança ou interrupção. Este relatório final deverá ser protocolado via notificação na Plataforma Brasil. OBSERVAÇÃO: Nos documentos encaminhados por Notificação NÃO DEVE constar alteração no conteúdo do projeto. Caso o projeto tenha sofrido alterações, o pesquisador deverá submeter uma "EMENDA".

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações	PB_INFORMAÇÕES_BÁSICAS_DO_P	08/09/2022		Aceito

Básicas do Projeto	ETO_1910029.pdf	20:44:12		Aceito
Outros	Carta_Autorizacao_ppgpur_assinado.pdf	08/09/2022 20:43:38	MAQUELE ANTUNES DE	Aceito
Outros	Carta_Autorizacao_ppgepso_assinado.pdf	08/09/2022 20:41:02	MAQUELE ANTUNES DE	Aceito
Outros	Carta_Autorizacao_dep_assinado.pdf	08/09/2022 20:39:36	MAQUELE ANTUNES DE	Aceito
Outros	carta_resposta_Maquele_Antunes.pdf	08/09/2022 20:36:33	MAQUELE ANTUNES DE	Aceito
Projeto Detalhado / Brochura Investigador	Projeto_detalhado_Maquele_Antunes.pdf	08/09/2022 20:30:56	MAQUELE ANTUNES DE OLIVEIRA	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Maquele_Antunes.pdf	08/09/2022 20:30:20	MAQUELE ANTUNES DE OLIVEIRA	Aceito
Outros	Material_complementar_Questionario_para_aprovacao_CEP_Maquele.pdf	25/04/2022 13:41:23	MAQUELE ANTUNES DE	Aceito
Folha de Rosto	folha_de_rosto_Maquele.pdf	24/03/2022 00:59:35	MAQUELE ANTUNES DE	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

SAO CARLOS, 07 de Março de 2023

Assinado por:
Sonia Regina Zerbetto
(Coordenador(a))