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JUST2CE

A Just Transition to Circular Economy

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Authors Ben Purvis, Tommaso Calzolari, José Bruno Fevereiro, Andrea Genovese, Azar MahmoumGonbadi
Revisions Mario Pansera, Katharina Gihring

EXPLORING A JUST TRANSITION TO A CIRCULAR ECONOMY

Decision Support Tool Specification

The JUST2CE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003491

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JUST2CE

A Just Transition to Circular Economy

D.4.1 – Exploring A Just Transition To A Circular Economy: Decision Support Tool Specification

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JUST2CE

A Just Transition to Circular Economy

PROJECT No. 101003491

JUST2CE will assess the current state of transition towards the Circular Economy in relevant economic sectors and analyse possible transition scenarios, as well as their outcomes and impacts. It will identify the key factors that can stimulate or hinder this transition. Natural resources are extracted and transformed into products, which are eventually discarded. As many natural resources are finite, it is important to keep materials in circulation for as long as possible. This makes the transition to Circular Economy more vital than ever but is a responsible, inclusive, and socially just transition to a Circular Economy possible or even desirable? What technical, political, and social factors can enable or hamper such transformation? The EU-funded JUST2CE project will answer these questions. It will explore the economic, societal, gender and policy implications of the Circular Economy paradigm. The project's findings will shed light on how to ensure democratic and participatory mechanisms when designing and managing such technology.

History Chart

Version	Date	Implemented by
V1.1	28/02/2023	Ben Purvis, Andrea Genovese (USFD)
	20/02/2023	Revised by Mario Pansera (UAB) & Katharina Gihring (ACEN)
V1.0	8/2/2023	Ben Purvis, Tommaso Calzolari, José Bruno Fevereiro, Andrea Genovese, Azar MahmoumGonbadi (USFD)

Disclaimer

Executive Summary

In this deliverable we present the background and specification of a Decision Support Tool (DST) which is intended to enable users to explore a range of phenomena related to the just transition to a Circular Economy. In particular, we take global supply chains as the central unit of analysis for exploration: the user is encouraged to specify a sector and geographical location and the tool is proposed to generate a 'typical supply chain' based upon underlying multiregional input-output data (MRIO). This output is intended to be displayed on a map, alongside a dashboard of additional geographical information relating to aspects of justice. The tool is also proposed to incorporate a just transition directory with further information and avenues to explore via relevant case studies and signposts to additional resources.

This report is composed of two parts. Part 1 describes the background process through which we arrived at a specification for the DST. This includes a review of the shortcomings of existing tools (also focusing on indicator systems), participatory deliberation over appropriate aims and aspects to incorporate, and a sketch of requirements for the tool. Part 2 presents a loose specification for the tool, outlining the tool's components and workflow, an overview of input-output analysis (which will form the backbone of the mapping approach employed in the tool), and the exploration of several use cases for the tool.

The tool is intended for a general user, with little prior knowledge, but an interest in justice, supply chains, and circularity. It is intended to be a learning tool, encouraging the user to consider and explore new avenues of thinking; as such, it is not to be intended as a prescriptive tool. Decoloniality is a core aspect of the underlying values of JUST2CE and the design of the DST, and thus it is anticipated that the tool will be sensitive to the needs of users in the Global South. Alongside decoloniality, the theoretical framework of the tool embeds principles of Responsible Research & Innovation (RRI), and a framework of a just transition composed of elements relating to gender, labour, and environmental justice.

D4.1 represents an initial specification of the DST prior to its development in practice; it is anticipated that this initial document will be revised and expanded as the implementation of the tool progresses.

JUST2CE

A Just Transition to Circular Economy

Table of Contents

List of abbreviations

AHP	*Analytical Hierarchy Process*
CE	*Circular Economy*
CSC	*Circular supply chain*
CTI	*Circular Transition Indicators*
DST	*Decision support tool*
EMF	*Ellen MacArthur Foundation*
GHG	*Greenhouse Gas*
IO	*Input-output*
LCA	*Life cycle analysis*
MRIO	*Multi-region input-output*
PPP	*People, planet, profit*
ROW	*Rest of World*
RRI	*Responsible Research & Innovation*
SCM	*Supply chain management*
S.D.	*Standard deviation*
TBL	*Triple bottom line*
WP	*Work Package*

[1] Introduction

The JUST2CE project aims at understanding, in a critical and thoughtful way, under which conditions a responsible, inclusive and socially just transition to a Circular Economy (CE) is possible and desirable, what technical, geopolitical and social factors can enable or hamper such transformation and how these aspects can contribute to the development of transitional policy measures. The project will identify enablers and barriers to CE in a number of key strategic sectors – selected among those indicated by the EU Action Plan for CE – such as food production and waste, water management, critical raw materials and production in complex global supply chains. The results of this analysis will be used to develop a decision support system and macroeconomics analytical tools to design new or improve existing CE practices.

The Innovation Phase of JUST2CE focuses on the design of tools for a just and responsible CE. Core to Work Package (WP) 4 is the development of an integrated decision support tool (DST). This was initially conceived as a tool that would be "capable of assessing the current and potential degree of circularity of a given unit of analysis… assess[ing] the ability of production systems to reduce resource consumption while producing a positive socio-economic impact" (Pansera et al., 2020, p42). Since the project specification, the scope and intention of the DST has developed from the framing initially conceived, based upon preliminary work across the project WPs, literature analysis, and the desire for producing a novel research output in line with the values of JUST2CE.

This document outlines the scope of the DST conceived by JUST2CE, its intended purpose and use, and the rationale for the direction in which we have decided to take it. Part 1 of this document outlines the scoping work we have undertaken to inform the design and structure of the proposed DST; Section 1 outlines how decision support has been deployed in the context of a CE. Section 2 presents the various steps we took towards understanding how or whether to use indicators for the tool, and Section 3 describes how we scoped the tool in terms of its purpose and the type of user we envision interacting with it. Section 3 concludes Part 1 with a sketch of requirements for the DST. Part 2 then explicitly outlines the specification of the DST tool building on the preliminary work from Part 1. Section 4 presents an abstracted overview of the tool, detailing its theoretical framework and workflow. We envision the tool having a dual focus, and as such present an outline of the supply-chain elements of the tool (Section 5), and an outline of the wider justice elements of the tool (Section 6).

[1.1] Decision Support for a Circular Economy

The term DST [1] has a somewhat contested and vague definition; within the academic literature it is used inconsistently across different fields. In its broadest sense, it may be conceived of as a structured approach which is aimed to support decision-making from a set of stakeholders. For instance, it could take the form of an online software tool which is focused towards stakeholders as the end user; however, what this means is also quite broad, e.g. it could be used to weigh up the costs and benefits of two alternative methods of waste disposal, or it could focus on less well structured, underspecified problems, like how a business model or behavioural practices should evolve in an uncertain future. There is thus scope to think outside the box in terms of how we understand a DST. For example it could be more like a game, like the Scenario Exploration System (Bontoux et al., 2020) that was deployed at WP3's Greek national stakeholder workshop, or a more general tool like En-Roads, which allows for the exploration of future scenarios based upon input variables.

In the context of the transition towards a CE, decision-makers need tools to evaluate the adoption of CE practices, and operationalise profitable, efficient, circular and sustainable supply chains. Decision support tools employ many CE indicators to account for a variety of impacts across boundaries between firms (Maestrini et al., 2017), concerning

[1] Note, JUST2CE initially used the term 'Decision Support System' (DSS), During the construction of this report, it was decided that 'Decision Support Tool' (DST) was more appropriate for our purposes. As such there may be some inconsistency in language use between future and past communications.

every dimension of sustainability (i.e. economic, environmental and social). CE indicators are formed by single or multiple metrics, which can be defined as the "finest level of granularity for assessment means" (Vinante et al., 2021). CE assessment metrics, indicators, methods and methodologies at the firm level have been extensively reviewed (Elia et al., 2017; Saidani et al., 2019; Sassanelli et al., 2019). These papers confirm there is a lack of agreement on what needs to be measured, of standard methods of measurement and even of shared terminology and conceptualisation of the CE. For this reason they try to categorise indicators into frameworks and taxonomies to integrate current performance assessment methods of firms' functions with CE principles.

Several research streams have developed tools to measure the adoption of CE practices at a supply chain level of analysis. The Green and Sustainable Supply Chain Management (SCM) literature (Brandenburg et al., 2014) offer insights for implementing CE at this level (Liu et al., 2018). Existing DSTs incorporate a triple bottom line (TBL) approach and life cycle perspective in the evaluation of impacts for complex and global supply chains (Acquaye et al., 2017; Genovese, et al., 2017a). Here, the evaluation of impacts makes extensive use of established methods found in environmental science (e.g. Life cycle analysis (LCA), Life cycle costing). Some variants of these methods (e.g. hybrid LCA, Multi Regional I/O Frameworks) are also able to rigorously assess the environmental performance of complex and global supply chains. These methods are used to determine supply chain hotspots (in terms of impacts) using relevant key performance indicators to identify areas to be prioritised for action.

At the level of a single organisation, CE interventions support the design of reverse supply chains, recycling, reusing or remanufacturing end-of-life products. Circular supply chains (CSCs) should take back products from customers and return them to the original manufacturer for the recovery of added value by reusing the whole product or part of it (Rubio et al., 2008). Research here has mostly concentrated on the evaluation of the economic viability of the adoption of CE practices, and has only recently begun to consider integrated multi-dimensional impact assessments (Kazemi et al., 2019). There is no clarity on what should be measured, the criteria that should be employed to select metrics, or the objectives of DST use here. Many DSTs employ economic metrics (e.g. costs, revenues, net present value) or environmental ones (emissions, energy, waste, resources consumed, resources recovered), and even social ones (jobs created by the CSC). The next subsections describe two of the most prominent DSTs: CTI and Circulytics.

[1.1.1] WBCSD CTI

Circular Transition Indicators (CTI) was developed in 2020 by the World Business Council For Sustainable Development (WBCSD) with support from KPMG. It has the goal of raising awareness, setting a baseline, and identifying opportunities in relation to the CE (WBCSD, 2020). CTI is a self-assessment framework for organisations which looks at physical material flows across the company, to determine its ability and ambition to transition to a CE, by minimising resource extraction and waste material. It focuses on three core indicators: closing product and material loops, optimising material flows, and value creation.

It is accessible through an online platform and users must undertake a seven-step process to estimate and input relevant information relating to each indicator. During this process, companies are required to select the indicators from a menu (Figure 1). For each step, the platform helps to identify relevant primary data sources and facilitate any necessary data collection. This might require contacting supply chain partners, which is the most labour-intensive part of the process. Finally, the tool provides support for interpreting the results and developing concrete actions in the decision making process such as the establishment of SMART targets to monitor progress.The final dashboard shows a set of indicators that provide insight into resource optimisation and the link between the company's circular material flows and its business performance. In this way, it creates awareness and prioritises certain actions. The algorithms behind the calculation of the indicators are open and transparently shared.

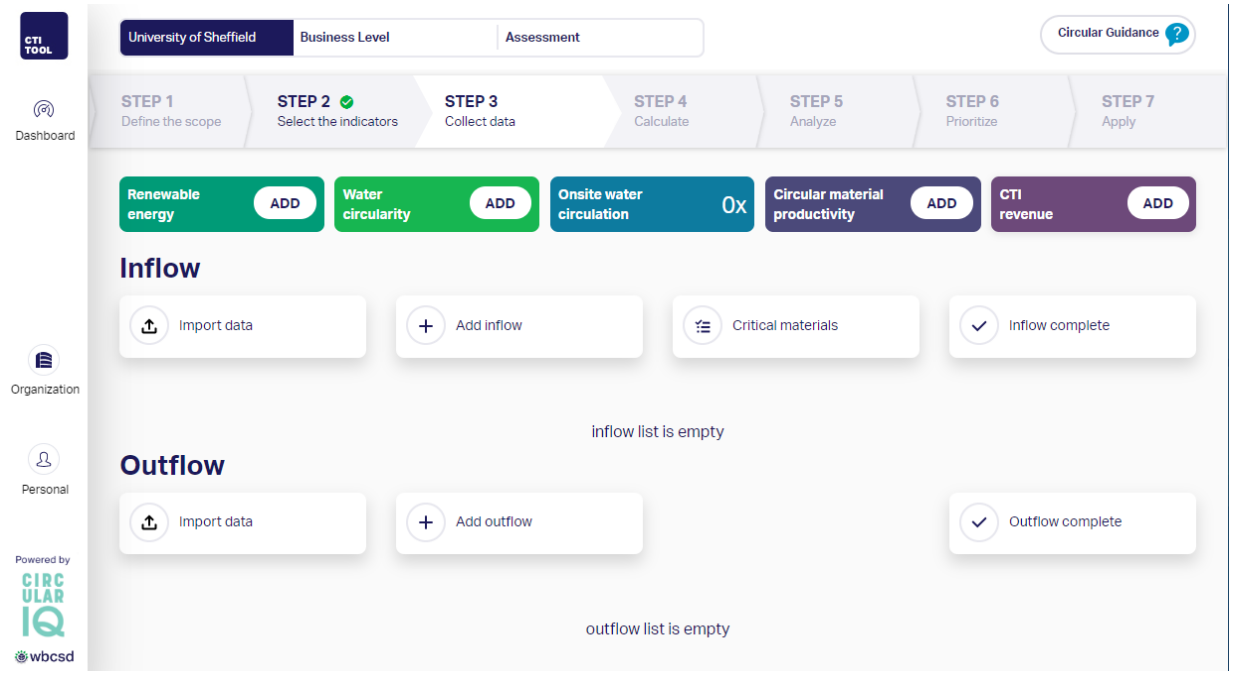

Figure 1: Data collection step of CTI.

[1.1.2] EMF Circulytics

Circulytics was developed by the Ellen MacArthur Foundation (EMF & ANSYS Granta, 2019). Although some of its final goals are similar (raising awareness, establishing a baseline, identifying opportunities), it has a broader scope than the CTI. It creates an additional focus on opportunities for future improvement, i.e. 'CE enablers', as well as organisational requirements for these. Such enablers include strategy and planning, innovation, people and skills, systems, process & infrastructure, and external engagement.

Outcome indicators provide a snapshot of an organisation's CE performance, covering material flows, service design, physical assets, water flows, energy, and finance. Each theme is measured through some predefined questions. After requiring the user to answer a questionnaire, the tool generates a weighted average score for each theme. Indicators and weights vary by sector. Given the broad range of information that all themes require, the data collection process can be a substantial task, taking up to two months. After data is submitted within the platform, results are benchmarked at an industry level.

[1.1.3] Analysis of these tools

Work by Calzolari & MahmoumGonbadi (2022) has analysed and cross-compared these two tools by applying them on a case study from the materials industry. The findings cast doubt on the suitability of a mass-based approach which attempts to incentivise quantitative improvements in the circular use of resources. It is suggested that in terms of circularity, the tools would benefit from the inclusion of metrics relating to the quality and efficiency of the recycling process, saved chemical compounds, and product lifetime extension. It is argued that a supply chain perspective is paramount for recognising the best strategies in each application, with regulatory and normative stances playing an important role in inspiring the responsible innovation of products whilst relying less on virgin materials. Finally the tools are criticised for their reductionist view of the transition to a CE. Social implications are completely disregarded, and the evaluation of environmental performance is extremely simplistic.

This critique mirrors observations from work that has been particularly critical of the ecomodernist approach which dominates the CE literature (Genovese & Pansera, 2021). Such approaches are criticised for their neglect of broader social and environmental factors, as well as a lack of reflexivity relating to values and purposes, and losers and winners (Lowe & Genovese, 2022). Further, more technical challenges and limitations relate to the definition of system boundaries and burden shifting (Hellweg & Canals, 2010), as well as data availability and the handling of complexity (Purvis & Genovese, 2023).

[2] Indicators for a Just Circular Economy

Within the JUST2CE proposal (Pansera et al., 2020) the DST was initially intended to be based upon a "dashboard of indicators" (pp 51-52). As such, initial work was focused on the exploration of indicators and assessment approaches for a CE. The methodological approach of this phase of work began with a systematic literature review of CE indicators for supply chains (published as Calzolari et al., 2022). This was followed by a survey of the JUST2CE consortium, and a 'co-production workshop' intended to understand the 'expert' views of consortium members on suitable indicators and framing. This process was intended to refine a draft set of relevant indicator categories for the DST based on the following steps:

1. Identifying the most commonly used indicator categories within the literature;
2. Seeking input from the consortium on category relevance, and suggesting additional categories;
3. Understanding how members of the consortium view the relative importance of each indicator category.

Such an approach follows what is perhaps a dominant approach for selecting indicators within the literature (Purvis & Genovese, 2023). Our findings however cast doubt on the suitability of this approach, and indeed the use of a dashboard of indicators itself. The following subsections outline our work in this area, and what this means for the scoping of the DST.

[2.1] Assessing a Circular Economy

A systematic literature review focused on CE indicators for supply chains has been published in *Environmental and Sustainability Indicators* by Calzolari et al., 2022. This work analysed DSTs, and indicator sets within the academic literature, alongside content analysis of industrial practice reports.

After being systematically collated and analysed, prior work within the literature was assessed on its coverage of economic, environmental, and social dimensions, and the most commonly used metrics within each of these categories were collected. Figure 2 shows, which has been noted elsewhere in the literature, that out of the 203 CE studies examined, most focused primarily on economic and environmental dimensions with relatively little attention given to social dimensions; only 18% of studies included any social dimension, compared to coverage of

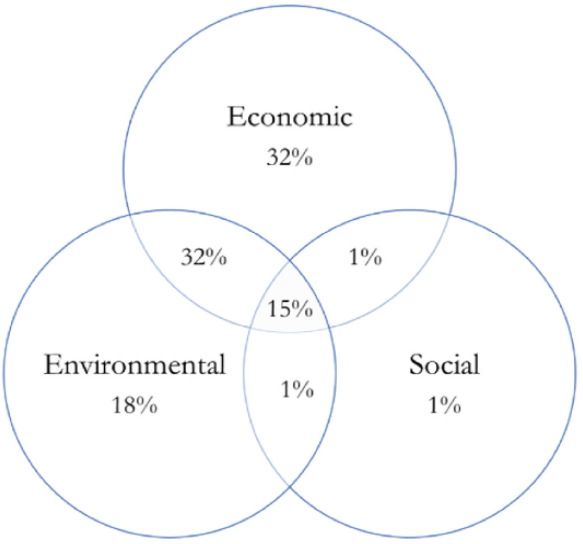

Figure 2: Dimensional coverage of indicator studies; reproduced from Calzolari et al., 2022

80% and 66% for environmental and economic dimensions respectively. Even where social dimensions are present, they are often simplistic, focusing on quantitative rather than qualitative aspects and are relatively far from elements of social justice and distributional conflicts, with the most popular social metrics relating to jobs created, and Health & Safety compliance.

Calzolari et al.'s compiled list of the most commonly employed metrics are reproduced below in Table 1, where the frequency of occurrence across the 203 analysed papers are also recorded. This results in six of each economic and social categories, and seven environmental categories. From the occurrences column, the variability of coverage may be seen, with cost and greenhouse gas (GHG) indicators being particularly common across all studies.

TBL Dimension	Category	Metrics	Description	Occurrences	%
Economic	Costs	• Operational costs • Facility location costs • Transportation cost • Reverse supply chain cost	Cost-based indicators, both at a company and at a supply chain level	112	55%
	Profits	• Total CSC profits • Profits from recovery activities including remanufacturing, recycling and disposal	Profit-based indicators, both at a company and at a supply chain level	50	25%
	Time	• Time responsiveness of the network • Delivery reliability of suppliers	Time responsiveness-based indicators, both at a company and at a supply chain level	18	9%
	Quality	• Reliability of supply • Quality level of the production • Quality of the returns	Quality-based indicators, both at a company and at a supply chain level	14	7%
	Risk	• Financial risk • Value at risk • Conditional value at risk • Variability index • Downside risk	Risk-based indicators associated to uncertainty (e.g. of demand, collection)	12	6%
	Profitability	• Net Present Value • Return on Equity • Return on Assets	Profitability-based indexes, measuring	9	4%
Environmental	Emission equivalent	• Climate Change • Greenhouse gases • Global Warming Potential	CO2 eq. emissions associated with supply chain	90	44%
	Waste	• Waste Landfilled • Recycled waste • Recovered waste • Recyclability and ease of disassembly	Residual waste produced and landfilled or recovered by supply chain activities	35	17%
	Energy usage	• Energy use • Cumulative energy demand • Renewable energy use • Energy self-sufficiency	Energy-based indicators associated with supply chain	32	16%
	Virgin resources usage	• Abiotic depletion of resource • Mineral, fossil & renewable resource depletion	Virgin resource use associated with supply chain material consumption	26	13%
	Water	• Water depletion • Water emissions • Water use	Water used or contaminated	26	13%
	Air emissions	• Particulate Matter • Respiratory inorganics	Other air emissions associated with supply chain	22	11%
	Acidification	• Terrestrial acidification • Marine acidification	Acidification potential associated with supply chain processes	19	9%
Social	CSC jobs created	• Number of fixed and variable jobs • Number of drivers hired for transportation	Employment opportunities provided by the CSC	15	7%
	Organisational H&S compliance	• Compliance with the ILO guidelines	Measures of compliance to H&S Guidelines for the jobs created in the CSC	7	4%
	Quality of work	• Work damages • number of accidents, lost • Employee turnover	Measures of quality of the jobs created	7	3%
	Training	• Average hours of training • Training on skills for employability	Indicators of the training provided to workers	4	2%
	Expenditure on Benefits for employees	• Food • Transportation • Pension	Indicators of benefits provided to the workers	4	2%
	Customer environmental awareness	• Enlightening customers to return end of used product • Customer incentives for recovery from discarded product	Indicators of environmental awareness of the customers	3	1%
	Social cost of waste	• Penalties and costs for disposal	Social cost of waste produced. Sum of disposal cost and of the cost for the recycler	2	1%

Table 1:Most common identified CE indicator categories across the academic literature; reproduced from Calzolari et al., 2022.

Following the identification of the most common indicator categories within the literature, Calzolari et al created a dummy composite index, which compiles the three most frequent metrics for economy, society, and environment (Figure 3). This is intended to illustrate the priorities that are present within the literature for CE metrics for supply chains. It is thus presented for illustrative purposes, rather than as something recommended for use in practice. The numbers (weightings) presented in the diagram indicate the relative popularity of each dimension and sub category within the literature. The weightings clearly show the dominance of nominally economic and environmental indicators, and in particular those relating to cost and GHG emissions.

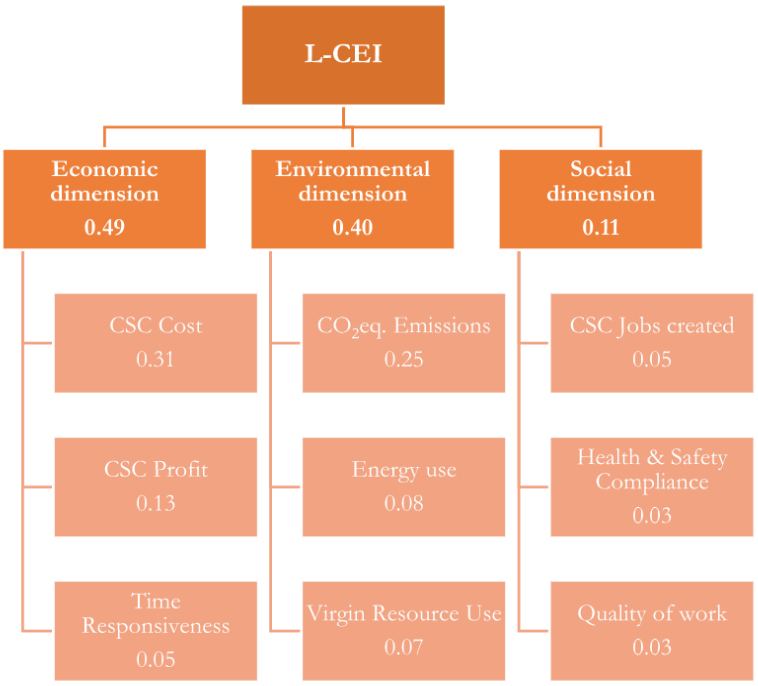

Figure 3: A dummy composite index displaying the relative prominence of categories within the CE academic literature; reproduced from Calzolari et al., 2022.

Calzolari et al's systematic literature review concludes that the current approaches within the literature are not adequate for analysing the whole CSC. Calzolari et al. observe that most studies focus only on recycling or similar imperatives, with a lack of attention given to social dimensions. In this way existing approaches based upon CE metrics are not adequate for the structural change required for a just transition. Whilst this limitation is noted in terms of the coverage of identified metrics, it is also important to note the problems of reductionism that are inherent in metric based approaches as a whole (Gasparatos et al., 2008). We should 2be careful about how we handle such simplifications, particularly in relation to trade-offs, rebound effects, and the breadth of the domain scope. A further element to consider is the depoliticisation within indicator frameworks, and the danger in stripping out context, coherence, political nuance, and normative considerations in favour of a list of popular metrics. These challenges are revisited in Section 2.4.

[2.2] Consortium Survey

In May and June 2022, WP4 circulated a survey across JUST2CE's consortium mailing list. Overall this elicited 35 usable responses. The survey questions were designed to explore how the 'just CE' is understood across the consortium, and build on Calzolari et al's (2022) analysis of CE supply chain indicators, employing a Delphi-like technique to investigate consensus across the consortium. The preliminary analysis of these findings were presented

at the WP4 workshop in Thessaloniki. The survey design and results are detailed below under each individual question.

[2.2.1] Q1 - What is your understanding of the term 'A Just Circular Economy'?

"An alternative economic model, focused on sufficiency, harmony with nature and social justice"

"A circular economy that goes beyond economic growth but takes into consideration the environmental and societal aspects so growth is realised across all spheres"

"A discursive strategy attempting to critique, amend or subvert the modalities by which powerful actors and institutions such as the EU and state governments seek to govern populations and the environment"

"A regenerative arrangement of the human social metabolism, in which each person is expected to contribute according to their means and capacities and is provided according to their needs"

Prior to the dissemination of WP1's preliminary findings relating to combining CE with environmental, gender, and labour justice (Barca et al., 2022) we had judged it necessary to build a picture of whether there was a shared understanding of a just CE across the consortium. This question thus took long form text responses which we coded thematically (Braun & Clarke, 2006) in Nvivo. The Word Cloud presented in Figure 4 displays recurrent terms used across the written responses. Many participants mentioned the dimensions of environment, economy, and society unprompted, as well as responses mentioning products, materials, and resources.

Figure 4: Word Cloud of responses to Q1 relating to how members of the JUST2CE consortium understand a 'just CE'.

The most recurrent themes across the written responses for this question related to social justice, the need for participation, environmental sustainability and justice, R-imperatives, and a focus on primary production. Other frequent themes included holism, i.e. thinking of the interconnectedness of human and ecological systems, equality and equity, fairness, and sufficiency.

Key divergences in the written responses related to the nature of the concept, whether it represented an alternate economic system or model, a construct or tool used to shape narratives in the present, or a set of practices that could be implemented. These understandings are not necessarily mutually exclusive, yet they illustrate the breadth of ways in which the term can be conceptualised and operationalised. A second area where consortium members expressed a range of views relates to the economic growth orientation, whether shifting focus away from growth, explicitly denouncing its incompatibility with a transition towards a truly more sustainable society, or implicitly accepting that growth may be able to be decoupled from adverse environmental and social impacts. Thus, even within our consortium where we might expect a more common understanding, we find a plurality of views. We can link this plurality of understandings to the nature of CE as an umbrella term which has grown to incorporate many different narratives, and thereby become something of an empty signifier (Genovese & Pansera, 2021).

[2.2.2] Q2 - What are your thoughts on the suitability of the dimensions 'People, Planet, Profit' as a framing device to be used by the DST?

"I am wary that this framing is reductive and is too close to the original bottom line approach. I recognise that these elements may be relevant and comprehensible to stakeholders though"

"Profit is either a misleading definition or a wrong dimension to be considered"

"I believe that these three dimensions are easily understandable by everybody who is going to use the DSS since they coincide with the most extended manner of representing sustainability"

"I think these should not be considered separate categories, but in terms of their relationships. Frequently, the pursuit of Profit is obtained at the expense of People and Planet, two categories that are very much related. Justice is the main factor that explains how these categories can interact in a balanced way "

"I find this frame not well aligned with the key concepts and dimensions (already framed in D2.1 and WP1) of JUST2CE project"

Question 2 seeks opinion from the consortium on the framing of 'people, planet, profit' (PPP) for use in the indicator dashboard. There are two matters for consideration here. First is the broader conceptualised three dimensions or pillars of sustainability (environmental, social, economic), and then their presentation under the labels presented as a TBL (Elkington, 1997). The broader tripartite framing is something of a default in the mainstream CE literature. This does not mean we should accept it uncritically, but it forms the most logical starting point.

We decided to explore the PPP formulation due to its business orientation and a preemption of the traditional DST audience. This marks a shift from the economic/environmental/social formulation employed by Calzolari et al, 2022. Feedback to this has primarily been negative and we are therefore likely to explore alternate framings (see Section 2.4).

Responses to Q2 were variable; most participants were critical of the PPP framing though nevertheless many of these described it as a pragmatic choice or an adequate starting point. Responses questioned exactly what these open terms mean, and how the relationship between them could or should be considered. For example, several respondents explicitly noted that they felt these three elements should not be regarded as of equal importance. A particular source of concern was the profit dimension, and how it can be reconciled with elements of justice.

Respondents also offered several alternative framings that should be considered instead, these encompassed drawing on the frameworks articulated in the work of JUST2CE:

- an overarching framework relating to concepts of justice (e.g. labour, gender, environment)
- reframing profit in terms of resources or production
- considering broader time, space (reginal, national, and north-south), and inter-organisational dimensions.

[2.2.3] Q3 - Which of these categories do you think are relevant for assessing the contribution of an organisation and its supply chain to a just Circular Economy?

The next series of questions under Question 3, take the indicator categories identified through Calzolari et al's systematic review and ask participants whether they think they are relevant for our purposes in creating an indicator dashboard for the DST. A written response box was provided to solicit further categories that respondents would add to each PPP dimension. We amended a number of the category names in order to provide descriptive detail; for example, 'risk' was updated to 'Supply chain risk or uncertainty (e.g. raw materials availability; reliance on critical materials)'. The following sections analyse each listed dimension individually.

[2.2.3.1] Q3a - People

Of the dimensions presented, the selection of those deemed relevant by respondents was broad without strong agreement. No category was selected by all participants, with the most frequently picked category, **jobs created**, selected by 78% of respondents, followed by **customer environmental awareness** 76%, **social cost of waste** 76%, **quality of Work** 67%, **worker training** 64%, **H&S compliance** 61%, and **employee benefits** 61%.

Over half of participants provided write-in responses which were analysed for recurrent themes. Several of these were judged to relate to the already prompted categories of quality of work (n=6: 'modern slavery'; 'reliance on degraded overseas labour'; 'reducing unpaid work'; 'employee satisfaction'; 'use of child & migrant labour'; 'different working conditions in different countries'), and worker training (n=3: 'employee environmental awareness'; 'level of knowledge of work processes'; 'leadership training'). Four additional categories were identified relating to **worker participation** (n=7: 'worker participation in production management'; 'organisational structure'; 'internal practices of democracy'; 'participation of employees in decision making'; 'workers control'; 'participatory management process'; 'grade of interaction among the hierarchy within the organisation'), **gender & equalities** (n=6: 'gender equality issues'; 'inclusion of vulnerable groups'; 'gender distribution'; 'gender balance'; 'access of marginalised groups'; 'key dimensions e.g. age, and gender'), **stakeholder/customer/community participation** (n=7: 'wider stakeholder engagement'; 'implementation of participatory planning approaches'; 'inclusion of vulnerable groups'; 'modes of customer engagement and feedback'; 'participation of customers in decision making'; 'considering the "people"'; 'organisation has formal links with local stakeholders'), and **social/community benefits** (n=5: 'social/community benefits'; 'value of firm's production for society'; 'social and environmental conflicts on place'; 'share of workers/community in profits'; 'extent the organisation is reducing local and global inequalities').

Based on these results, we decided to present an updated list of people categories, combining the original most frequently observed categories from Calzolari et al, with the categories proposed in the survey responses. This resulted in the following list:

- **Jobs created (JC)**: Jobs created across the supply chain
- **Customer Environmental Awareness (CEA)**: e.g. information on disposal methods, incentives for recovery
- **Social cost of waste (SCW)**: e.g. community impact, personal health impacts
    - (combining the categories of Social cost of waste, and social/community benefits)
- **Participatory planning (PP)**: e.g. worker participation in production management, involvement of key stakeholders and communities, participation in decision making
    - (combining the worker & community participation write-in categories)
- **Gender & equalities (G&E)**: e.g. gender balance, opportunities for marginalised groups
- **Quality of work (QW)**: e.g. percentage of employees on open-ended contracts, unionisation rates

The social indicator categories identified by Calzolari et al that were least popular with the survey participants were thus removed at this stage.

[2.2.3.2] Q3b - Planet

The selection of categories in the planet dimensions among participants displayed a significant amount of agreement relative to the people dimension. All categories were selected with a high frequency: **waste produced** 100%, **GHG emissions** 97%, **energy usage** 94%, **air pollution** 91%, **water used or contaminated** 88%, **virgin resource usage** 82%, **acidification** 79%.

A fewer number of write-in responses were received, which were on the whole a lot more diverse and divergent. Notably, 'circularity' was mentioned by only one respondent. Themes that occurred multiple times within the responses encompass: **global supply chain factors** (n=6: 'planetary boundaries'; 'outsourced impacts'; 'extraction from emerging economies'; 'unequal exchange of flows'; 'proximity of actors'; 'distance raw material and products need to travel to their destinations'), **land use aspects** (n=3: 'land use'; 'green area care'; 'regeneration'), and **displacement of primary production** (n=2).

Due to the high degree of perceived relevance of the planet categories from Calzolari et al, we decided to retain these six categories in our second list iteration. Additionally due to the divergence of the write-in categories suggested, none of these were taken forward. This resulted in the following list of planet indicator categories:

- **Waste produced (WP)**: Waste produced across the supply chain
- **GHG Emissions (GHG)**: Emissions produced by supply chain activities
- **Energy Usage (EU)**: Energy usage across the supply chain
- **Air pollution (AP)**: Air pollution produced by supply chain activities
- **Water consumption (WC)**: Water used and contaminated across the supply chain
- **Virgin resource usage (VRU)**: Virgin resource usage across the supply chain

[2.2.3.3] Q3c - Profit

For the profit dimension the selection of relevant categories displayed some agreement, though it appeared several of the presented categories were unpopular. The selection rate was as follows: **cost of production** 97%, **supply chain risks** 84%, **quality** 81%, **profits** 68%, **time responsiveness** 65%, **return on investment** 55%.

There were 11 write-in responses, with recurrent themes relate to **ethical and equitable investments,** and aspects of **profit distribution** (e.g. "who does the company invest in?"; "share of workers/community in profits"; "how is profit shared/distributed/invested?"; "profit distribution share between different countries").

We thus synthesised the following list of economic categories to bring forward. Note, due to the distribution of perceived relevance, it was difficult to justify a sixth category, and thus we opted to retain only 5 categories.

- **Cost of Production (CP)**: Cost of production at company and supply chain level
- **Supply chain risks (SCR)**: e.g raw materials availability, reliance on critical materials
- **Products quality (PQ)**: e.g. defect rates of end products
- **Equitable investments (EI)**: e.g. ethical investment practices
    - (Derived from write-in responses)
- **Surplus distribution (SD)**: e.g. worker & community share in profit
    - (Derived from write-in responses)

[2.3] Consortium Co-Production Workshop

We used the time allocated to WP4 within the 2022 Consortium meeting in Thessaloniki (30th June - 1st July 2022), to hold a discursive workshop in order to garner the consortium's views on the indicator categories selected from the survey results. In order to best capture the breadth of views across the consortium, and understand how members judged the importance and priorities of individual categories relating to the just transition to a CE, we decided to frame this workshop around an application of the Analytical Hierarchy Process (AHP).

AHP is a quantitative technique, commonly employed to structure and facilitate complex decision making processes (Saaty, 2008). It employs 'pairwise comparison matrices' which ask the participant to compare components and assign a numerical weighting to quantify their relative importance. Table 2 demonstrates an example pairwise comparison matrix used to compare the dimension of PPP. AHP employs the 'fundamental scale' designed by Thomas Saaty, which uses the integers 1 to 9 representing the prompts from '1 = equal importance' to '9 = extremely more important'. Reciprocal values are used to indicate that the column is more important than the row, whereas integers indicate that the element in the row is more important than the element in the column.

	People	**Planet**	**Profit**
People	1		
Planet		1	
Profit			1

Table 2: Example pairwise comparison matrix comparing people, planet, and profit matrices. The decision maker fills in the white squares with a numerical value between 1 and 9, or its reciprocal value.

The workshop began with a brief presentation of the survey outcomes and an introduction to AHP. Following this, the members present were split into groups (3 in person, and 1 online), and each group, aided by a facilitator, were presented with several tasks to work through relating to pairwise comparison matrices for the identified indicator categories. Participants were each given a worksheet which presented four pairwise comparison matrices, one as reproduced in Table 2 comparing PPP; and individual category matrices for each respective dimension using the categories selected following the survey analysis. Each worksheet contained a set of instructions detailing the process, the qualitative description of the numerical values, and the short descriptions of each identified category as outlined above in Section 2.2.3.

The participants were asked to fill in these matrices responding to the following prompts: which of the two elements is more important in the context of the transition towards a Just CE, and how strongly? Participants were asked to conduct this exercise individually, reflecting on their own perspectives. At this stage, the facilitators (each of whom had prior experience with using AHP) acted to answer any technical questions or difficulties with filling in these matrices. Individuals were given around 25 minutes to fill in the matrices (the online group ran for longer due to the inability to proceed with group activities in the online environment).

Following the individual matrix activities, the three face-to-face groups were asked to derive a collective group matrix based on their individual matrices. This was done by deliberation and group discussion as guided by the group's facilitator, and aided by consideration of each participant's individual matrices. Due to time constraints, this deliberative group process was only performed for the first matrix comparing PPP dimensions (Table 2). Each individual matrix was collected for further analysis, and the group facilitators were asked to make notes relating to how members of their group approached the tasks and where any disagreements and causes for concern arose. The workshop concluded with a discussion among all participants to garner member's views on these activities and techniques. The following sections outline main findings from this process.

[2.3.1] Workshop findings - Quantitative: Consistency

Each participant's matrices were digitised and compiled within a master spreadsheet. Our first task was to check each matrix for 'consistency'. Consistency adjustment is a routine analysis within the AHP paradigm, whereby the matrices are checked for areas of logical inconsistency in assigning numerical values. Whilst we must be careful drawing conclusive conclusions from these quantitative checks, we consider within our analysis, consistency to represent a proxy for how much participants had difficulty comparing elements. Thus a high consistency represents easier choices within comparison, and a lower consistency represents a more difficult choice. Consistency is determined by computing the 'consistency index' of the matrix using the principal eigenvalue, and comparing this index to a random index (i.e. the index of a matrix filled in with a randomly assigned set of uniform values). Should the consistency index be much smaller than the random index, the matrix is judged to be suitably consistent. Usually the threshold of 0.1 is selected for this (Karapetrovic & Rosenbloom, 1999).

Overall, the consistency across all matrices was 72%, this represents a fairly good rate of consistency. Nevertheless, the presence of logical inconsistencies as a standard observation within the AHP process highlights some of the inherent challenges relating to comparing and weighting indicators. We should thus be cautious of uncritically centring multi criteria decision-making approaches within our DST framework.

Whilst 72% of the PPP matrices were consistent, the consistency of the other matrix typologies varied. In particular, the people matrices were the least consistent at only 60%, whilst the planet matrices scored highly at 88%. The profit matrices had a collective consistency rate of 68%. These lower levels of consistency can be linked to more difficulty in comparing elements and deciding which categories are most important. Interestingly, these scores align with the results of the survey, in which the people dimension observed the most disagreement over the importance of categories, whereas the planet element saw strong agreement. It is notable that a number of participants filled in their planet matrices in a manner indicating that they viewed all elements as equally important.

Following these consistency checks and the identification of inconsistent matrices, we used an algorithmic method to 'fix' the identified consistency matrices to allow for further standard analysis. Whilst the preferred approach for this involves a deliberative process between the decision maker and a facilitator, we did not have the time available for this. Instead, we used an online calculator (Goepel, 2018) to determine consistency of each element, before manually adjusting the most inconsistent element 1 point on the scale to improve consistency. This process was repeated until the overall consistency of the matrix met the 0.1 threshold. This algorithm is intended to maximise consistency whilst minimising the change to the matrices in terms of the judgements made, thus aiming to preserve the overall preference structure.

[2.3.2] Workshop findings - Quantitative: Ranking of Elements

Once all the adjusted matrices met the consistency threshold, we were able to calculate the weightings of each element in each matrix. This is done by multiplying the scores in each row together and calculating the nth root, and then normalising this value to derive each weight (Render et al., 2017). Each weight is thus calculated as a percentage, with importance summing to one. This provides a picture of how each participant has ranked each item in regards to its importance for inclusion in the DST. By calculating these weights for each participant we are able to examine divergences and convergences across the consortium.

Tables 3-6 display the headline weights of each element averaged over all consortium participants. We also display the standard deviation (S.D.), and minimum and maximum individual values for comparison.

	Mean	S.D.	Max	Min
People	43.78%	10%	63.70%	27.85%
Planet	45.46%	12%	66.31%	25.83%
Profit	10.75%	9%	33.33%	5.13%

Table 3: Weights of each people/planet/profit dimension averaged over all exercise participants.

An immediate observation from Table 3 is that as a whole, participants judged people and planet to be roughly equivalent in importance, with profit being judged the least important dimension by some way. Apart from two participants that judged all these elements to be of equal importance, all other participants indicated profit to be the least important, often by a large amount (i.e. using a 9). Of the remaining filled in matrices, seven participants judged People to be the most important element, six selected Planet, and seven judged the two to be equally important. This shows that whilst the mean scores average out, this does not illustrate the broad spectrum of responses presented across participants of whom nearly 60% did not identify people and planet as equally important.

It is interesting to compare these findings to Calzolari et al's (2022) summation of the frequency of each dimension's occurrence across the literature (Figure 3), whereby the economic/profit dimension is observed in 49% of studies and the social/people in only 11%. This emphasises that frequency of occurrence in the literature should not be considered as an expression of value judgement that the consortium might assent to.

The results of the individual category matrices (Tables 4-6) are more difficult to parse. The standard deviation remains high such that it is difficult to draw clear conclusions on preferences across the consortium. This, as the variation across individual matrices can be seen, shows that there is little agreement across the consortium as to which individual categories are most important. This mirrors the qualitative feedback gathered in the closing section and the observations from group facilitators.

People Categories	Mean	S.D.	Max	Min
Jobs created (JC)	13.10%	0.09	33.23%	2.61%
Social cost of waste (SCW)	21.60%	0.10	48.62%	3.23%
Customer Environmental Awareness (CEA)	10.01%	0.10	40.50%	2.04%
Participatory planning (PP)	18.65%	0.11	50.46%	4.18%
Gender & equalities (G&E)	18.20%	0.07	29.99%	5.24%
Quality of work (QW)	18.45%	0.10	40.33%	2.56%

Table 4: Weights of each people category averaged over all exercise participants.

Planet Categories	Mean	S.D.	Max	Min
Waste produced (WP)	13.95%	0.06	25.52%	3.94%
GHG Emissions (GHG)	21.76%	0.09	39.50%	5.28%
Energy Usage (EU)	14.00%	0.06	26.71%	4.86%
Air pollution (AP)	16.41%	0.05	32.13%	5.93%
Water consumption (WC)	17.26%	0.04	25.00%	9.25%
Virgin resource usage (VRU)	16.62%	0.10	52.88%	2.56%

Table 5: Weights of each planet category averaged over all exercise participants.

Profit Categories	Mean	S.D.	Max	Min
Cost of Production (CP)	11.38%	0.08	35.53%	2.42%
Supply chain risks (SCR)	17.90%	0.12	43.41%	3.74%
Products quality (PQ)	17.55%	0.13	56.54%	4.11%
Equitable investments (EI)	22.91%	0.13	46.92%	2.90%
Surplus distribution (SD)	30.26%	0.19	65.71%	6.99%

Table 6: Weights of each profit category averaged over all exercise participants.

Nevertheless, there are some observations that can be drawn from these results (though of course we must be careful of drawing inferences with such variance of results):

- The categories added following the survey stage (PP, G&E, EI, and SD) performed well within their respective categories. Notably, the Surplus Distribution (SD) and Equitable Investments (EI) topped the profit category. This again reveals the limitations of drawing directly from frequency of occurrence within the literature.
- The variance and deviation in the Planet dimension is notably lower, as can be seen by the lower standard deviation values and a more equal distribution of means.

We see consistency here with the results from the survey, where responses were more aligned in the choice of important planet indicators, whilst divergence was seen in the choice of important people indicators. This may be influenced by the permeation of environmental indicators, particularly GHG emissions, across popular discourse. The social dimension itself, on the other hand, is notably underconceptualised, and there are few prominent indicators that have become the subject of global policy initiatives.

Using these calculated mean weightings we were able to develop a master list, Table 7, which ranks each category across the total participant list. This was done by factoring in the derived weights of the PPP dimensions, multiplying these by the weights of the individual indicator categories within these dimensions, and then normalising.

GHG Emissions (GHG)	0.098
Social cost of waste (SCW)	0.095
Participatory planning (PP)	0.082
Quality of work (QW)	0.081
Gender & equalities (G&E)	0.080
Water consumption (WC)	0.078
Virgin resource usage (VRU)	0.075
Air pollution (AP)	0.074
Energy Usage (EU)	0.063
Waste produced (WP)	0.063
Jobs created (JC)	0.058
Customer Environmental Awareness (CEA)	0.044
Surplus distribution (SD)	0.033
Equitable investments (EI)	0.025
Supply chain risks (SCR)	0.020
Products quality (PQ)	0.019
Cost of Production (CP)	0.013

Table 7: Weights of each individual category, normalised for dimensional weighting. People categories are indicated in red, planet in green, and profit in yellow.

The ranking in Table 7 shows that all the economic categories scored lower than any other category. The social elements representing more quantitative metrics relating to the activities of firms, namely jobs created and customer environmental awareness also performed relatively poorly.

[2.3.3] Workshop findings - Quantitative: Ranking of Elements

The quantitative findings of the workshop go some way to illustrate the plurality of views across the consortium, and these may be contributed by the qualitative observations from the group facilitators and the final discussion held after the workshop activities.

Most participants found the task of filling in their individual matrices difficult. Part of this was technical and due to unfamiliarity of the technique, which may be one of the reasons that the first large matrix filled in (People) was on average more inconsistent than subsequent matrices. Yet the difficulty also related to the task itself and the challenge of comparing a diverse set of elements, and then translating thoughts into numerical terms. Referring back to the consistency of matrices, discussed above, it is notable that nearly all the matrices were inconsistent, even if most of them met the acceptability threshold. These difficulties relate to AHP as a method, and more broadly the epistemological issues relating to comparing qualitatively different items, something which has been critiqued in the academic literature in relation to indicator approaches (Gasparatos et al., 2008; Kaika, 2017; Turcu, 2013).

Participants articulated frustration at the relatively vague definitions given for each dimension and category, leaving each title somewhat arbitrary and up to divergent interpretation. This impacted the perceived ease with which participants approached the matrix exercises, and may have been one of the sources of inconsistent matrices. The difficulties this presented at an individual level were compounded in the group discussion section when participants discovered that members of the group had competing interpretations of several terms.

One area where groups struggled to reach consensus on was whether planet was more important than people. The differing views here appeared to be as much epistemological and axiological, with participants raising the dependence of the social sphere on the ecological sphere. Others in opposition argued that the reason we want a healthy planet is for people, and thus the people dimension should be judged more important. Regardless of the individual values articulated, it was clear that there was broad consensus that people and planet are closely linked, and that both should be judged much more important than profit.

The discussion also circled back to some of the doubts articulated in the survey phase about the framing of PPP. In particular, several participants articulated their feeling that the profit title was not adequate due to its centering of profit generating economic activity at the expense of other modes of production.

One final area that emerged during the discussion was the baseline of comparison. Many of the participants were based in Northern European countries, and one participant raised the bias that this situatedness may introduce. In particular, there was a discussion around whether similar rankings would be obtained in a majority Global South context, or whether a greater emphasis on economic dimensions may be seen. Context is important for comparing elements, and part of this is the geopolitical context of where the decision maker is located. This is something that the process articulated in this report has not suitably accounted for, other than the observation that the literature reviewed possesses a large eurocentric bias. This issue is thus important for WP4 to consider within the design of the DST, particularly as the JUST2CE project explicitly aims to embed decolonisation and issues of global justice within its frameworks.

[2.4] An Indicator Dashboard for a Just Transition to a Circular Economy?

We have systematically reviewed the literature on existing indicators, and gathered feedback and consideration from members of the JUST2CE consortium on the suitability of common indicator categories, their framing, and how different categories of indicator can be compared. The results of these latter steps have demonstrated some of the

difficulties inherent to an indicator approach, particularly in relation to the selection of which factors are most important. Even across a consortium of like minded researchers with many shared values, despite broad agreement on several issues such as the prominence of profit-oriented metrics, there are also many areas in which a consensus has been difficult to reach. The difficulties that have arisen during the above described exercises allows us to draw some conclusions which inform the route along which to take the DST.

Firstly, the weighting of indicators in terms of relative importance, a technique which is routinely applied in indicator based approaches, is a highly subjective exercise. We have observed that even within the JUST2CE consortium where we might expect a broad alignment of values that there was a stark lack of agreement in terms of which elements to prioritise. Reading the max and min columns of Tables 3-6 shows the variability of participant's views as to the importance of each category identified within the literature. It is only at a more abstract level when we discuss PPP that we see more consensus. Even here though, we have documented the disagreements relating to whether people or planet is the more important dimension. Whilst the approach of averaging over the consortium may smooth out these disagreements and leave us with a table of weights (Table 7), such an approach erases the underpinning values and theoretical frameworks relating to participant's justification of their prioritisation. We can argue too that even individual weights are largely arbitrary, and there is no reliable method for standardising each participant's understanding of what 'moderately more important' or 'extremely more important' may mean.

For these reasons, we argue against employing methods that weight or compare a range of different indicators using quantitative multipliers. The upside of weighting however is that it can often be employed to reduce the complexity of information presented to the user of the tool. This is a trade-off that we have to pay close attention to.

The second major conclusion that we have drawn relates to the method of indicator selection. There are a range of views within the academic literature on how best to select indicators for a specified task. There is also important discourse on the epistemological drawbacks of metrics and indicator approaches, particularly relating to elements that are not easy to quantify (this is a common reason for neglect of social dimensions). In this initial approach we followed what is arguably the typical approach of indicator selection, by deriving a set of commonly used indicators from the literature and then using a deliberative process to refine this indicator set. Further typical refinements might relate to pragmatic choices based on data availability. An alternate approach entirely involves first developing a theoretical framework for the problem, and then selecting relevant themes of interest based upon theory, rather than arbitrary choices of popularity or expediency. Such an alternative approach would be suitable within JUST2CE as we can draw on the work already ongoing within the other work packages.

These findings lead us to ask whether we might diverge from the use of indicators entirely. This is a question that we have explored in detail in a forthcoming article (Purvis & Genovese, under review) in relation to a wide range of literature which has problematised indicator based approaches from both philosophical and practical objections. Here it is sufficient to state that we don't feel indicators are a necessity for the development of a DST. In the next section we thus turn to a more detailed sketch of questions relating to the DST scope, including its intended purpose and expected use cases. Through this, we are able to arrive at a theoretical framework based upon need and the principles of the JUST2CE project.

[3] Scoping the DST Purpose: end users and use cases

Whilst the initial JUST2CE proposal (Pansera et al., 2020) sketches out some expectations for the role of DST, it leaves much space for scoping the DST purpose in line with the preliminary findings of the literature surveys and other WPs. As such a period of time has been spent identifying and outlining the intended scope of the DST in collaboration with the whole of the consortium, through a combination of democratic participation across the topic, and the consideration of several proposals developed and put forward by WP4. This work has primarily focused on the following core questions:

- Who is the intended **end user of the tool?**

- What is the **unit of analysis?**
- What is the intended **use case?**

The participatory exploration of these questions entailed an open ended question within the consortium survey, and two workshops dedicated to various exploratory questions relating to the DST scope.

[3.0.1] Q4: What sort of purpose should a Decision Support Tool serve? How could it guide a just transition towards a CE?

The survey is described in Section 2.2 and was completed in May and June 2022. As a supplementary question we asked for participants' views on the scope of the DST. This was an open text response, and we received 25 written answers. The responses were broad and overall demonstrated a lack of consensus across the consortium on the user, use case, and unit of analysis. The responses were mostly quite vague, demonstrating only a loose conception of what the DST could do and how it should align with the wider aims of the project. Whilst not suggesting any clear directions for the DST, the responses demonstrate an openness to shaping a novel and innovative tool that can align with the project's objectives.

There was a rough divide in the responses between the **DST as a learning tool**, and the **DST as an assessment tool**. Responses in the former category discussed the need to help users think about negative consequences, change their ways of thinking, or reflect about their role in broader social systems or the global environment. Assessment is discussed in reference to evaluating negative consequences of current business models, processing information, concretely suggesting interventions to move to better practices, and benchmarking in comparison to other actors or practices. Other operative phrases used include 'reflection', 'creating a change in mindset', 'providing insight', 'providing information', 'guiding decisions', 'showing trade-offs' and 'highlighting risks'.

Many of the responses referenced the wider project goals and ideals, articulating the need for a broad approach taking into account social and environmental dimensions, and issues of justice. Whilst most responses did not mention users or use cases, the following were articulated outside the generic terms of 'user', 'practitioner', and decision maker': 'organisations', 'companies', 'public institutions', 'the general public', 'consumers', 'multi stakeholder engagement'; 'business models', 'supply chains', 'company procedures' and 'consumer products'.

[3.0.2] WP3/WP4 Workshop: Integrating Responsible Innovation into DST

This workshop, held during the consortium meeting in Thessaloniki, was conceived as a joint session between WP3 and WP4 to lead a discussion on how principles of Responsible Research & Innovation (RRI) can be embedded within the design of the DST. The initial structure was sketched by Tess Doezema (TD) which formulated a series of research questions informed by the four dimensions of RRI of Stilgoe et al. (2013): anticipation, reflexivity, inclusion and responsiveness. This was refined relative to the aims of WP4 in collaboration with Ben Purvis (BP), resulting in the following discussion guide. The workshop was then held in a hybrid format facilitated by TD and BP who used the prompted questions to generate discussion amongst the consortium. A partial transcription of the workshop was produced from which the following discussion points have been highlighted.

There are many ideas as to who the end user might be, these are summarised in Section 3.1. Considerations in determining this user base included motivation to use the tool, it was noted that several possible end users may not have interest in using the tool. We thus should consider a natural user base that would not require significant ongoing engagement in order for them to use the tool. Thus the tool should satisfy a curiosity on the part of the user, and its design should be such that the user is able to explore the tool in their own time. Whilst then specific stakeholders were discussed such as business owners and policy makers, caution was raised as to how realistic it would be to actively engage these users in practice. This is also a question of **context**, and again we should be clear that our resources demand a general tool rather than one that can perfectly map to a specific geographical or institutional context.

In differentiating our tool from other 'competitor' tools, it is important to emphasise that our main novelty lies in the utilisation of the concept of a **just transition**. This draws on the expertise and values of the project consortium and the ongoing work in WP1 relating to gendered, labour, and ecological justice. These three elements form a natural fit from which to develop a theoretical framework. A related element core to JUST2CE is the consideration of Global north/south relations, and unfair or unequal exchange. This is something that needs to be carefully thought about when developing a 'general' tool, and we need to be mindful of the situatedness of the WP4 team in a Western European research environment. It was thus emphasised that issues of **decolonisation** should be embedded in the design of the tool, with the need to reflect upon what groups we prioritising and marginalising in its design and presentation.

Some thought was also given to how the tool should work and its design process, and the ambition to validate ideas with the end user throughout the development process. This is something that it may be possible to draw from the connections of the other WPs and partners, specifically some of the case studies investigated within WP2. At the time of writing, this dialog has so far been secondary only, with ideas for the DST discussed with the researchers who work with primary contacts.

Other areas that were discussed included data demands, variation of needs across sectoral and geographical contexts, the flexibility of the tool, and the legacy of the tool following the end of the project funding period. The basic premises of the tool were also uncovered and questioned including what we mean by 'supporting decisions', and whether the tool should or needs to map supply chains.

[3.1] Who is the End User?

There was initially a lack of consensus across the consortium on who the end user of the tool should be, despite an openness to exploring (and pursuing) a broad range of options. Through informal discussions, the survey, and several structured workshops, suggestions for end users were collated. Ten categories of user typologies were outlined from these collated suggestions from within the consortium:

1. Companies: Startups, Entrepreneurs, SMEs, Co-operatives, Industrial parks
2. Policy Makers: Public sector organisations/bodies; Local authorities, e.g. Sheffield City Council
3. Civic organisations: Chambers of commerce; International Greek Exporters Association, SEVE
4. Non-Governmental Organisations: COP26 Coalition; European Environmental Bureau; PAGE, UN-leaded Partnership for Action on Green Economy; Chatham House; E3G; SEI
5. Social and Solidarity Economy Organisations / 'Civic bottom-up initiatives'
6. Researchers and Academics
7. Workers: Trade Unions; Informal economy actors
8. Consumers
9. Communities
10. Activists

Discussions relating to the identification of this broad spectrum of potential users concerned the innovativeness of the tool, resources within the project, prior connections, and values. This discussion coalesced into a list of constraints for the selection of the user and use case.

[3.1.1] Constraint 1: Resources

This is perhaps the most important constraint as it delimits what is feasible within the finite time and person months available for the task ahead. It is important to not only consider the varied tasks that must be undertaken to meet the JUST2CE deliverable deadlines and objectives, but human resources and relevant expertise for these tasks. Core here

are the resources of Energy@Work who will be using their expertise in software development to deliver the beta version of the tool, and SEERC and ACEN who will lead on the testing and adoption of the tool.

As per the Project Proposal, the following person months have been committed:

- Task 4.1 - Mapping methods review and planning (M1 - M12) [USFD (6); UNIPARTH (2), UAB (2), CES (0.5)]
- Task 4.2 - Indicators review and planning (M1 - M12) [USFD (6); UNIPARTH (2), UAB (1)]
- Task 4.3 - DSS Specification design and development (M10 - M18) [USFD (6); UNIPARTH (2), UAB (1), E@W (2)]
- Task 4.4 - Implementation and deployment (M13 - M27) [E@W (PM 9); USFD (8)]
- Task 4.5 - Testing (M25 - M29) [USFD (2); SEERC (6), E@W (1)]
- Task 4.6 - Ensuring the DSS adoption commitment (M28 - M36) [SEERC (4); USFD (2), ACEN (4)]

Whilst there are significant person-months allocated, we should be mindful of the limited scope of what can be delivered in this time, particularly without time allocated to a significant scoping stage, and the resources required to engage stakeholders/end users of the tool. It is thus necessary to **be realistic in ambition** and contain the scope of the tool so far as possible. To aid in this **synergies with other WPs and the sharing of resources** are necessary. The resources for the legacy of the tool after the project ends should also be considered.

[3.1.2] Constraint 2: Data requirements

The tool, in its basic sense, will take user input, process it, and provide an output. The input could range from the user playing with some preconfigured sliders (see e.g. En-ROADS), to answering a series of questions, to inputting company accounts and materials data (see e.g. Circulytics). This may be considered as **user input data**. The DST design should be sensitive to the type and volume of data that the user would be required to input into the tool. Considering what data is available to the user, what type of data would the user be willing to input and what volume of data would the user be willing to input, as well as how long the user wants to engage with the tool. These questions also need to be mindful of how much time is reasonable for the user to spend inputting data into the tool, and issues relating to the sensitivity of data, both from the perspective of data handling, but also from the perspective of the user's willingness or desire to share potentially sensitive data in this way.

It is also possible or likely that the tool will require **secondary data** which is pre-programmed into the tool and are combined with the input data in some way to produce an output. This could be for example qualitative best practice reports, numerical materials data from databases such as ecoinvent, or benchmarking results from previous studies. Consideration of secondary data should be sensitive to what data is available freely for use in this way, whether it is possible or desirable to account for missing data through e.g. statistical techniques, and how much trust to put into and communicate in relation to this secondary data.

[3.1.3] Constraint 3: Ethical dimensions

The project has ethical approval for a variety of activities, including human based research. This ethical approval comes with a number of constraints relating to the collection and processing of personal data, and obtaining informed consent. The project's ethical approval is not equipped to deal with issues of potential illegal or legally grey activities. This has implications for e.g. interaction with actors in informal economies, as well as activities that may come up against anti-trade union laws. Care needs to be taken if there is potential for the tool to be used to incite illegal activity, or if data collected from stakeholders may implicate them in illegal activity. The approach to this should be based upon principles of justice and care to the extent that this is possible within the rigid institutional ethical frameworks employed in European academic settings.

As well as keeping within the values of the project, it is important to minimise the possibility of the results from the DST being used in a negative way. This has been previously considered in Deliverable 3.2 (Celebi et al., 2022) in relation to the framing of RRI, specifically the 'anticipation' of unintended consequences. Such negative uses of the

tool could range from greenwashing, to victimising participants, or identifying individuals or organisations. To minimise this risk, it is important to include a clear statement of use which users must accept before being able to use the tool.

[3.1.4] Constraint 4: Values of the project

The originality of the project is captured in its critical approach to the CE and a rejection of business as usual, greenwashing, and depoliticised technoscience. It also explicitly brings in consideration of decolonisation, and labour, gender, and ecological justice, which have hitherto been marginalised within the mainstream CE literature (Genovese & Pansera, 2021). The DST should thus endeavour to centre these values in its design, and not compromise them in its efforts to engage stakeholders. It is thus necessary to consider how to develop a novel tool that goes beyond a standard technocratic approach, reinforcing business as usual practices. This has implications for which stakeholders would wish to engage with a tool that represents our values, whilst these values may marginalise some stakeholders through our critical approach to their business practices, it may on the other hand empower actors who sit outside the 'usual suspects' for stakeholder engagement (Colvin et al., 2016). A difficulty to grapple with then is how the contested nature of the domain may be represented within a piece of software.

[3.2] High Information vs Low Information Users

The consideration of each of the user categories identified, alongside the constraints outlined above, led to the reduction of the scoping exercise into the choice between two pathways which we have categorised in terms of the information available to the user. We thus identify **high information users** as those with access to detailed information & data relating to the supply chain & problem in question such as a company board; **low information users** are then those with limited or no access to detailed information at this scale such as workers, or communities.

[3.2.1] DST Workshop Two

In a second consortium wide workshop, which was attended by approximately 24 participants, the initial work to categorise potential users was presented, alongside an outline of the key constraints identified. Following the presentation, the participants were split into two groups of 10-12 participants each with an attempted methodological and institutional diversity across each group. A facilitator guided each group through several structured questions considering the needs of low information and high information users respectively. Google 'Jamboards' were used to collect written responses from participants alongside the discussion. This activity lasted for approximately 45 minutes before a debrief where each group presented back what was discussed.

[3.2.1.1] Break Out Group 1: Low Information Users

The initial discussion surrounded the placement of potential users into the categories of 'high and low information'. This was problematised as reductive, and the difficulty of placing individual users or groups of users within rigid categories was noted. It was highlighted that within each category or indeed user groups, such as 'companies', individual users could have a wide range of different and conflicting priorities, questions, values, levels of information available to them, etc. Other potential ways of categorising users were thus discussed, including: north/south; internal vs external to the production process; small vs big companies; and sectoral differences. These were all noted as being relevant to the dichotomy of high/low information; for example, it was suggested that small companies might not have access to so much data/information, or that it would be more equally distributed hierarchically than within a big company; it was suggested that the concentration of information in the service sector may differ from the industrial sector, considering e.g. teams within the service sector working on a particular project.

In discussing the 'types of decision that the DST could support', several types of users were explored. Consumers or lay users were discussed, and how a tool might help them explore better the impacts of their practices including what products to buy, and how to make decisions about waste disposal. The limitations of the tool were noted here in

terms of the difficulties of being able to offer tailored responses for every context specificity. For workers, the use case of taking over operations was presented, with the scenario of workers wishing to consider what is being produced and why, and questioning the impacts of this within various value systems. Questions here include where are the suppliers located? Which issues are associated with these contexts? What are environmental, gender, labour dimensions that should be aware of? In terms of the work of WP4, it was also questioned what *we* as a consortium wish to achieve with our tool. This links to the project values outlined as a constraint.

Input into the DST was discussed broadly. Mostly this was conceived in terms of a questionnaire, starting by the user answering a series of questions, or a pathway, determining who they are as a user and a broad description of their use case. The dichotomy between high and low information users was also re-problematised: it was suggested that 'low information users' might know a lot of information that could perhaps be verified by a high information user. Other information may be available publicly or to users within the organisation such as information about the workforce, gender, types of contracts; information about the supply chain and where materials come from; data about material and energy input, and where they are sourced from.

The nature of output was discussed more so than its form. It was generally agreed that the tool should not be prescriptive, solve specific problems, or tell the user what to do. Indeed, this was thought to not be a feasible prospect anyway. Instead the DST was conceived as a learning tool, to help the user explore a problem, introduce dimensions that perhaps had so far been unexplored, and offer suggestions of broad alternative approaches. Thus outputs could be: case study examples of alternative practices or processes; a series of questions to ask themselves or dimensions to engage with; less tangible outputs, i.e. there is no output per se, but the process of using/playing with the tool imparts something. The practicality of implementing suggestions was also raised, how feasible would it be to implement alternative practices or shift business models.

[3.2.1.2] Break Out Group 2: High Information Users

Also in this group, the initial discussion surrounded the placement of potential users into the categories of 'high and low information'. However, being the focus on 'high information users', contributors were able to point to good examples of potential users endowed with an adequate level of information; these included: C-level managers of industrial organisations; senior officers from transnational NGOs; civil servants from planning departments of national and local governments. It was also clarified that different categories of users should be provided access to the different routes within the DST, as this might also enhance its performance as a learning tool.

In discussing the 'types of decision that the DST could support', the group demonstrated a good awareness of potential functionalities of the tool. Mainly, participants stressed the need for the DST to propose alternative scenarios and courses of action, also providing an estimation of their potential impacts. Specifically, participants pointed out that the DST could provide the user with an identification of the main hotspots, in terms of waste creation, across a supply chain; also, associated mitigation measures could be proposed, along with barriers to their implementation and potential unintended consequences of CE practices implementation (such as rebound effects). The DST should also help users to identify the potential violation of biophysical constraints that could be violated by the supply chain under investigation. Furthermore, it was mentioned that it would be good if the DST could provide information about labour legislation, trade union rights and employment protection in countries involved in transnational supply chains to be mapped, in order to raise awareness about potential unjust and unfair labour practices.

In terms of data to be provided to the DST, users agreed on the need to feed the system with a very detailed supply chain map, including flows of materials and energy and locations of suppliers. Also, information on the workforce of the company and their characteristics (contracts; gender and other issues) was seen as crucial. Estimations of revenues and profits, and their distribution was also seen as important. It was agreed that data will be mainly quantitative; however, the importance of qualitative data was also highlighted, and it was not ruled out that some type of non-quantitative data might be involved in the DST at some level.

Regarding the nature of the output, participants highlighted that a score of the level of "justice" in the CE solutions adopted by the unit of analysis would be a desirable feature. Again, it was mentioned that hotspot identification (in terms of places in the supply chain where most of the waste is being created; places where "irresponsible" practices are being employed - for instance exploitative work practices) would be a fundamental feature of a *results* section. Also, interesting features were proposed, such as a linkage of the DST with the Environmental Justice Atlas, in order to display potential issues linked to sourcing of materials and manufacturing activities.

It was also clarified that results should be displayed through a user-friendly graphical interface, including graphs, maps and some sort of self-generated reports. An archive of previous reports being generated by the same user should be available; in this way, longitudinal comparisons would be possible.

[3.2.1.3] Plenary Discussion

In the short plenary discussion following the breakout sessions, a summary of the discussions were fed back from each group. We also discussed how these findings compared and contrasted. Both groups problematised the categorisation of high vs low information, but were able to proceed from a pragmatic perspective. It was acknowledged how the broad category of low-information users made it difficult to pin down answers to the pre-structured questions; in the high-information group the problem was conceived as more well defined.

[3.2.1.4] Implications, Conclusions and Next Steps

The Workshop was useful for receiving feedback and critical discussion on the refined framing of potential users into high and low information users. The presentations, and discursive critique have narrowed from the initial discussions on the scope of the DST outlined at the start of Section 2.4. A crucial aspect of this is understanding the limitations and constraints we face, and managing expectations for the tool.

[3.3] A Sketch of Requirements

Following the extensive discursive and theoretical exploration of the potential scope for the DST described above, it is necessary to make decisions relating to the direction in which to progress the design and development of the tool. The collapsing of specific user categories into a (somewhat artificial) dichotomy between high information and low information users was able to focus the consideration on the specifics of how the tool will be engaged with in practice. The detailed constraints are also key for pinning down the scope in a meaningful way to deliver a tool that is realistic in its ambition but also novel and in line with the critical values and perspectives taken on by the JUST2CE project.

[3.3.1] Primary Use Case: general principles

Whilst we have departed somewhat from the vision for the DST as initially conceived in the project proposal (Pansera et al., 2020), its purpose remains in line with the wider project aims, and we outline it in broadest terms as follows.

- The tool is primarily **intended for learning**, and **prompting the user to consider issues judged pertinent** by JUST2CE, that they may not have previously considered in the context of supply chains and a CE.
- The tool should give the user an opportunity to explore supply chains, appreciate their global nature, and examine justice and north-south relations which underpin them.
- The user is considered as a **low-information**, general user. Minimum prior knowledge is required or expected other than a general curiosity for the subject matter of CE & supply chains.
- The user should not be expected to engage with the tool for a significant amount of time to get something from it.

- The tool should be accessible to users in the global south who may e.g. have unstable internet connections, access the tool on a mobile device, or require translation of text.

[3.3.2] Intended End Users

We have examined a number of specific user typologies, including workers, communities, and the management of businesses. These were analysed alongside the set of the constraints that we believe limit the choices that can be taken in the DST design. From specifics, we arrived at the distinction between high information and low information users, with the distinction relating to the amount of data or knowledge they have access to in relation to the supply chain they wish to investigate.

We have ultimately chosen to opt for a 'general' 'low-information' user for a number of reasons related to the constraints outlined in Section 3.1. Primarily we are particularly limited by time and person-month resources, these present significant barriers to a more co-productive scoping phase that would be necessary for engaging meaningfully with the needs of particular stakeholder groups. Such a co-productive scoping phase is judged necessary for any approach that seeks to actively engage specific stakeholders such as those identified above. This is a choice too however, as the primary data direction does cut off the access of many potential users. The higher level approach does however mean the tool will be more accessible to a wider selection of stakeholders, going beyond the 'usual suspects' of policy makers or business owners.

Engagement of a wide range of users is something that will begin following the development of the DST beta. Our colleagues at ACEN & SEERC will utilise their networks to ensure we are able to engage a diversity of users with the tool.

Additionally, the high-information approach would demand other intensive activities such as generating interest among potential users. Each user's case will also be somewhat unique, and the resources needed to process this may be difficult. Here we are particularly constrained by the lack of access to local knowledge, and data may need preprocessing and cleaning.

[3.3.3] Data Use

In the selection of 'low-information' users, we have already made some decisions about the sort of data that we will or won't be handling. This discounts the submission of primary data from the user in the form of detailed accounts or LCA data. Instead the tool should rely on secondary datasets that are preprogrammed into the tool. For reasons relating to the expertise of the team, and drawing on shared resources across the consortium, we decided to reject a more micro-focused approach relying on LCA data and databases, and instead focus on macro global supply chain level data. This aligns the tool well with the efforts of WP5 and would allow a sharing of resources. The use and meaning of Input-Output (IO) data is thus discussed in Section 5.

[3.3.3] Axiological Approach

As detailed in Section 2, our exploration of indicators and endeavours to develop a dashboard cast doubt on the suitability of an indicator dashboard entirely. We have been through a learning process from the ideas developed in the initial proposal document, and no longer believe that centring the DST on a dashboard of indicators is novel or suitable for our intentions. Many of the justice concerns we wish to allow exploration of within the tool cannot be well captured by indicators.

Since the tool is intended for learning and exploration, rather than something prescriptive, explicit assessment is unsuitable here. Where indicators may have some value for our purposes is in complementing a broader tool centred on a more qualitative presentation of opportunities for learning.

[4] Outline of the Tool

This section details a broad sketch of the intended design for JUST2CE WP4's DST. This follows from discussions and workshops facilitated by WP4 with the wider consortium, the outputs of the other WPs (particularly D1.3, D1.4, D1.5, and D3.2), and internal WP4 discussions relating to data requirements, purposes, and capabilities of our team, outlined in the preceding sections.

[4.1] Theoretical Framework

Drawing on the stated aims of JUST2CE, the core dimensions of the tool should relate to the global mapping of supply chains, labour justice, environmental justice, gender justice. It should also embed the core Responsible CE principles of Anticipation, Inclusion, Reflexivity, and Responsiveness (see D3.2: Celebi et al., 2022), and embed itself within a decolonial approach.

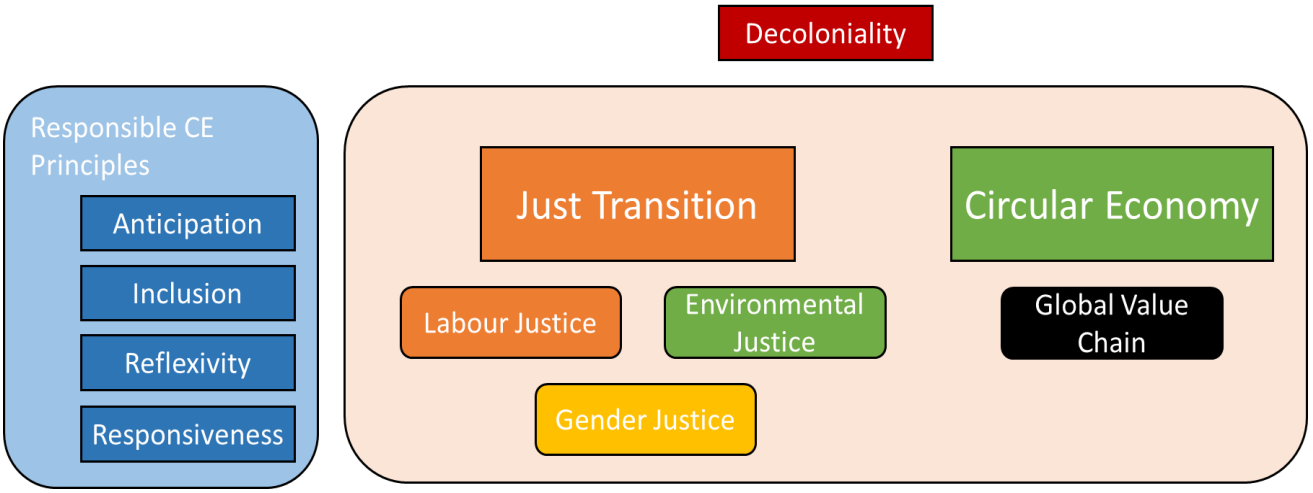

Figure 5: Sketch of the theoretical components informing the DST developments. Each box represents a discrete concept or body of literature on which the framework is based.

[4.1.1] Responsible CE Principles

RRI forms a core building block of JUST2CE, being central to WP3, and intending to guide the development the outputs of WP4 and WP5. We follow the understanding articulated in Purvis et al. (2023), of RRI "as a process which emphasises the centrality of social actors and local communities as active participants in the development of new practices". Here we directly draw on the 'anticipation, inclusion, reflection, and responsiveness' framework of Owen et al (2013).

Anticipation is understood as contemplation of future developments relating to the wide-ranging effects of current research and innovation activities. From the perspective of the DST development, this means anticipating how the tool may be used and analysing both intentional and unintentional impacts that its use may have. This has already been discussed above, in terms of some of the constraints outlined in Section 3.1. We should anticipate the possibility of the tool being used in ways that are contrary to our values, and mitigate for this. This is already reflected in how we now intend the tool to have a general usership, it may also necessitate a statement on the tool's website relating to principles for use.

Inclusion relates to the expansion of stakeholder dialogue beyond the 'usual suspects' (e.g., C-level company managers and high level policy-makers) and narratives of top-down governance towards the involvement of a broader

range of participants including the public (Ravn et al., 2015). This has been reflected in our decision to develop a more general accessible tool that may be used by a wide range of stakeholder groups (including, for instance, trade unionists, citizen committees, grassroot campaign groups), rather than taking on a more consultative approach which targets typical 'higher power/influence' stakeholders or businesses. The outreach phase of the tool's roll out will bear in mind the importance of inclusion as it relates to our values.

Reflexivity necessitates the ability to develop a critically reflective approach to our work, being aware and open about limitations, and the political nature of any framing we take. We have already communicated the political elements of our project, and how this brings a novelty to the tool we are developing. We must also be mindful of the implications of this framing and how it situates our tool within the wider discourse and other toolkits. It is also important to be up front about this explicit claim to politics.

Responsiveness relates to the openness to shift direction based upon emerging results and perspectives. We have already documented how our perspective on the 'dashboard of indicators' has evolved based upon findings from the consortium deliberation. A period for refining the tool based upon feedback and consideration from users has also been built into the development work plan for the tool.

[4.1.2] Decoloniality

Decolonisation forms a key pillar of the JUST2CE project, and derives from "acknowledging that racial, political, and social hierarchical orders of colonialism are still largely in place, having been absorbed into succeeding social orders in the post-colonial world (Quijano 2000; Bhopal, 2018; Yancy, 2017)" (Girei et al, Working Paper). In this way we understand decoloniality as a process aimed at contesting and replacing colonial modes of power as they function in the production and legitimation of knowledge (Maldonado-Torres, 2011). Within the context of a CE, this can relate to uncovering the 'eco-modernist' agendas of mainstream discourse (Genovese & Pansera, 2021), and focusing on South-North relations and global socioeconomic inequalities (Muchangos, 2022).

In the context of developing a DST, we thus need to be mindful of the implicit logics that are embedded within our choice of framing, as well as core questions relating to the intended purpose of the tool. This has already been discussed above in terms of considering how the needs of potential users may differ globally. It is also necessary to confront issues relating to data coverage disparities between the global north and south, and how this has the potential to bias any tool we develop. Confronting some of these issues will require ongoing dialogues between the design team and our partners from ACEN who will help with the testing of the tool in the African context.

[4.1.3] A Just Transition

The framing of a just transition is integral to the theoretical framework of JUST2CE where it has been conceptualised in terms of three dimensions relating to **labour**, **gender**, and **environmental justice**. Here we follow the understanding articulated by Velicu & Barca (2020) in which the just transition framework is intended to overcome the historical opposition between environmental and labour justice movements. Thus the framing of a just transition to a CE prompts us to look beyond r-imperatives and technological 'fixes', instead foregrounding the need for transformation of wider social structures (Purvis et al, 2023). This politicised framing of the just transition, draws on anticapitalist and ecofeminist roots to centre marginalised communities and bodies which are discounted in mainstream approaches (Velicu & Kaika, 2017).

[4.1.4] Global Supply Chains

Whilst the CE can and has been considered in the context of various phenomena across different scales of analysis, our focus in terms of the DST is on global supply chains. This has been reflected in terms of the setup of the project and the expertise of the WP4 team.

Global supply chains and inter-firm relationships play a crucial role in the transition towards a CE (Calzolari et al, 2022). Traditionally supply chains have operated within a linear paradigm based on the extraction of primary resources. A recent trend within the SCM literature has begun to consider CSCs where emphasis is placed on 'closing the loop' of products and materials (MahmoumGonbadi et al., 2021). In CSCs, companies cooperate to deliver goods and services to customers, as well as providing feedback loops which allow for self-sustaining methods of production and the reuse of materials (Bocken et al., 2013; Webster, 2017).

This perspective prompts a broader holistic consideration of what a just transition to a CE might mean, responding to criticism that CE interventions are often constrained locally (be it at product, or company level), and thus blind to impacts and even rebounds at wider scales. The consideration of the global scale also prompts questions relating to decoloniality and unequal exchange.

[4.2] Workflow

We conceive the following broad workflow of the user's interaction of the tool:

1. The user is asked what sector and region they are interested in exploring
2. The tool **generates a 'typical supply chain'** displayed on a global map,
    a. This is done by performing a lookup from a preselected IO data table. The column which represents the flows into the selected sector and region is returned, and the relative weights of each flow displayed on the map interface.
3. A **just transition overlay** is generated relating to aspects of a just transition, linked geographically to the prominent flows which have been returned.
    a. This may encompass indicators, the Atlases, signposts, and case study details.
4. A **library or archive of just CE practices** is also available for the user to explore.
    a. This will incorporate findings from the other JUST2CE WPs, and will signpost to other resources.

The above four steps represent the core functionality of the tool as we initially conceive it. We have considered additional functionality that we may wish to explore once the above steps have been implemented.

5. After the representation of the supply chain typical map, the user could be given the possibility to **reflect on the level of knowledge they have about their own specific supply chain** (if relevant).
    a. For instance, the user might be asked questions related to typical supply chain constructs such as Supply Chain Visibility (e.g., "to what extent do you know your tier 'n' supplier"?), Supply Chain Integration ("do you share inventory data with your suppliers?"; "do you share information about production planning with your suppliers/customers").
    b. Responses indicating lower levels of attainment across these dimensions might raise an alert, in the sense that the user/organisation might not know a lot about the presence of irresponsible and unsustainable practices across their supply chain.
    c. This is potentially a risky situation, so we could formulate a recommendation for the user to embark in a mapping exercise of their supply chain to get a better knowledge about it, starting from the typical maps derived from the usage of the tool.
    d. The intentionality here is to open up to the user points of exploration; we are not intending to evaluate their practice, but suggest e.g. 'Have you thought about Y', testing the limits of knowledge of their supply chain
6. Small **shocks could be introduced for technical coefficients and for final demand** (e.g., "let's consider a scenario where the final demand for products from sector y increases/decreases by x%")
    a. This will require live calculations to be performed on the baseline matrices, and may be computationally expensive. See the presentation of RaMa-Scene in the next section.

[4.3] Additional Elements

There exists a need to also consider additional more clerical elements which should be included with the tool. A non exhaustive list of examples is detailed as follows:

- Licensing information
- A statement of usage (to ensure the tool is used ethically as intended)
- A guide to using the tool
- A more detailed manual, or specification of the tool's design, implementation, and structure
- Details of back end data

[5] Generating a Typical Supply Chain Map

The core functionality of the DST will focus itself around the generation of a 'typical supply chain map' for a given sector in a given location. This step will rely on the use of IO data from Multiregional Input-Output (MRIO) databases. Based on the selection of a country and sector by the user, the tool will perform necessary lookups from relevant databases. The results will be displayed visually on a map, perhaps similar to that displayed in Figure 6. This graphical presentation is intended to provide the user better visibility of the supply chain, and prompt them to think about issues of global labour, gender, and ecological justice.

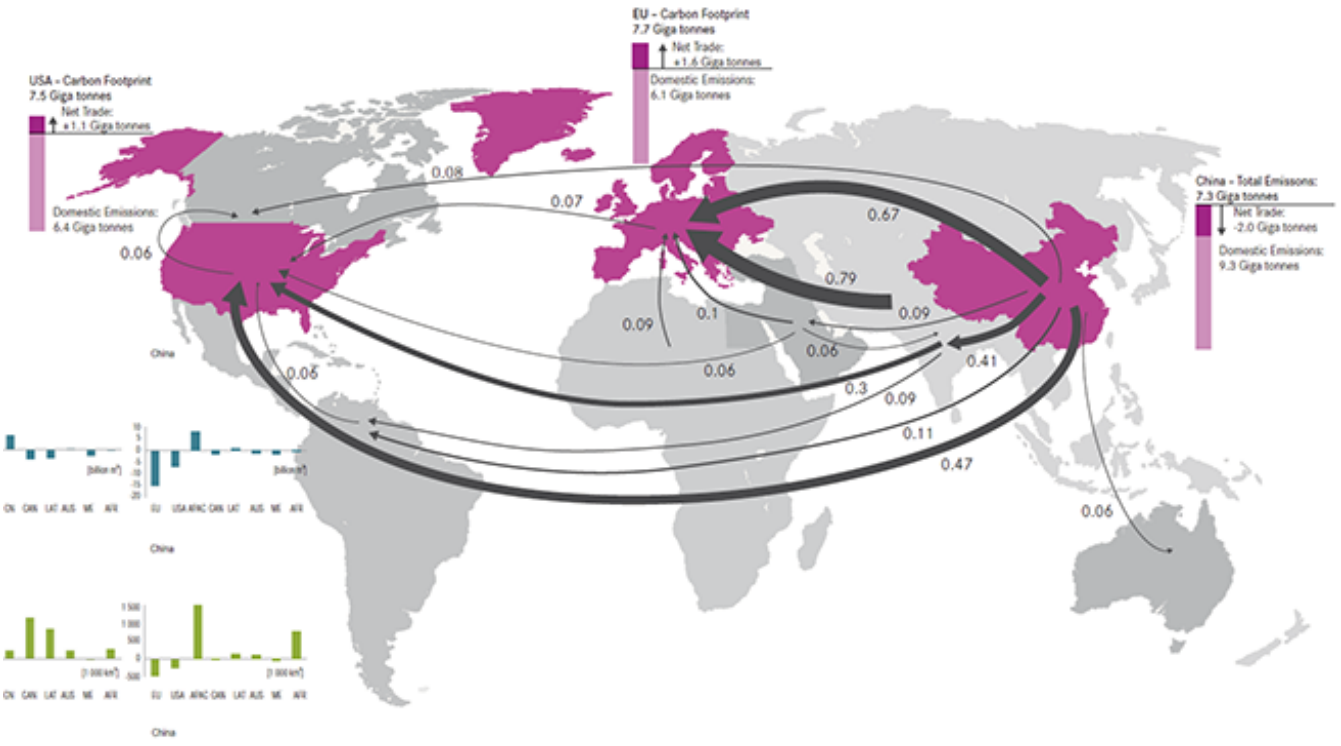

Figure 6: visual representation of GHG emission magnitudes captured in trade, derived from IO table data. Reproduced from Tukker et al. 2014.

[5.1] Overview of Input-Output Analysis

IO analysis was developed from the late 1930s by Wassily Leontief, as an analytical framework for investigating the interdependence of industries within an economy (Miller & Blair, 2009). The paradigm is built upon tabulated information concerning flows of products from each sector, the producer, to each of the other sectors, including itself, considered consumers. Table 8 presents a stylised representation of such an IO table.

	Sectors	Intermediate Demand			Final Demand	Total Output
		Agriculture Sector	Manufacturing Sectors	Service Sector		
Domestic Production	Agriculture Sector	z_{11}	z_{12}	z_{13}	f_1	x_1
	Manufacturing Sector	z_{21}	z_{22}	z_{23}	f_2	x_2
	Service Sector	z_{31}	z_{32}	z_{33}	f_3	x_3
Imports		m_1	m_2	m_3	mf	m
Value Added	Profits	π_1	π_2	π_3		π
	Wages	w_1	w_2	w_3		w
Government	Indirect taxes	t_1	t_2	t_3		t
	Total Outlays	x_1	x_2	x_3	f	x

Table 8: stylised representation of an IO table. José Bruno Fevereiro (2022).

The value of production (output) of each sector is represented in the *rows* of the table and is disaggregated into its 'destinations', i.e. whether its output is demanded by other sectors **('Intermediated Demand')** as inputs to their own production process or if it's demanded for final use (**'Final Demand'** components- Household or Government Consumption, Investment or Exports). Each sector's expenditure is represented by the *columns*. A sector revenue is spent on intermediate inputs purchased from other sectors **('Domestic Production' block)**, paid to workers as wages or distributed as profits to capitalists **('Value-Added' block)** or paid as indirect taxes to the state **('Government' block).** In a single country, **'Imports'** demanded either as inputs in production or directly as final demand are represented in a single row. The rows of such a table describe the distribution of a producer's output throughout the economy. The columns describe the composition of inputs required by a particular industry to produce its output.

In a multiregional setting, the IO tables of multiple countries are combined into a single table, where the imports and exports vectors are disaggregated according to sectors and countries of origin and destination. As represented in the table in Table 9 below.

2 x 2 country with 3x3 industries MRIO		Country A			Country B			Country A	Country B	
		Intermediate Demand			Intermediate Demand			Final Demand		Total Output (at basic prices)
Country	Sectors	Agriculture	Manufacturing	Services	Agriculture	Manufacturing	Services			
Country A	Agriculture	Intermediate inputs demanded by sectors located in country A from sectors located country A			Intermediate inputs demanded by sectors located in country B from sectors located country A			Domestic final demand for goods produced in country A	Foreign final demand for goods produced in country A	Total output of Country A
	Manufacturing									
	Services									
Country B	Agriculture	Intermediate inputs demanded by sectors located in country A from sectors located country B			Intermediate inputs demanded by sectors located in country B from sectors located country B			Foreign final demand for goods produced in country B	Domestic final demand for goods produced in country B	Total output of Country B
	Manufacturing									
	Services									
Value Added	Profits	Value added in Country A			Value added in Country B					
	Wages									
Total Outlays (at basic prices)		Total outlays per sector in country A			Total outlays per sector in country B					

Table 9: stylised representation of an MRIO table (in basic prices). José Bruno Fevereiro (2022).

[5.2] Input-Output Analysis for Supply Chains

The use of IO tables is a recognised approach for measuring global value chains at the macro scale. This complements a micro-level approach which focuses at the firm level, documenting sourcing decisions and the organisation of production networks (Johnson, 2018). The following subsections detail the mathematical foundations and notation which form the basis of IO analysis, an understanding of this is necessary for the processing of IO data within the tool.

[5.2.1] National IO accounts

Following the national accounts identity we have that **Total Output** (x) is equal to total demand, which in its turn is equal to **intermediate demand** (Z) plus **final demand** (f_d)[2]:

$$x = Z + f_d \qquad (1).$$

From information provided in IO tables, following Miller and Blair (2009), we can calculate the **technical coefficients**, that is, how much of input i (e.g aluminium) is necessary to produce 1 unit of commodity j (e.g. aircraft):

$$a_{ij} = \frac{z_{ij}}{x_j} = \frac{value\ of\ aluminium\ bought\ by\ aircraft\ producers\ in\ year\ t}{value\ of\ total\ production\ of\ aircrafts\ in\ year\ t} \qquad (2).$$

Compiling the technical coefficients for all cells in the intermediate demand block of the IO table into a **technical coefficient matrix** (A) , we can rewrite the national account identity equation as:

$$x = Ax^{-1} + f_d \qquad (3).$$

If we manipulate the equation to isolate the total output vector (x), we arrive at the IO analysis fundamental equation:

$$x = (I - A)^{-1} f_d \qquad (4).$$

[2] In line with notation convention, smallcase letters represent vectors and uppercase letters represent matrices.

This equation describes the amount of total output (x) required to be able to satisfy a given final demand (f_d), this is achieved by pre-multiplying the final demand (f_d) vector by the so-called **Leontief inverse matrix** $(L = (I - A)^{-1})$, also referred to as the total requirements matrix, where I is an identity matrix with 1 in the diagonal and 0 in the other elements. As such the Leontief inverse captures the impact of final demand throughout the entire supply chain.

[5.2.2] Multi-regional extension

The extension of the IO analysis into a multi-regional setting, aside from increased dimensionality of the matrices, proceeds along similar lines. Hence, given the technology and structure of production in n regions the necessary gross output needed to satisfy a given amount of final demand in each region can be found using equation 4. However, to highlight the structure of multiregional setting, equation 4 can be expressed less compactly as:

$$\begin{bmatrix} x^A \\ \vdots \\ x^N \end{bmatrix} = \left(\begin{bmatrix} I & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & I \end{bmatrix} - \begin{bmatrix} A^{AA} & \cdots & A^{AN} \\ \vdots & \ddots & \vdots \\ A^{NA} & \cdots & A^{NN} \end{bmatrix} \right)^{-1} \begin{bmatrix} f^A \\ \vdots \\ f^N \end{bmatrix} \quad (5).$$

Here, x^A and x^N are the gross output vectors $(n\,x\,1\,dimension)$ of country A and n^{th} country, respectively; I is the identity matrix $(n\,x\,n)$, A^{AA} is the $(n\,x\,n)$ technical coefficient matrix which captures how many inputs produced by sectors located in country A are needed to produce one unit of output by sectors located in country A; $A^{AN}$is the $(n\,x\,n)$ technical coefficient matrix which captures how many inputs produced by sectors located in country A are demanded to produce one unit of output by sectors located in country N; $A^{NA}$is the $(n\,x\,n)$ technical coefficient matrix which captures how many inputs produced by sectors located in country N are needed to produce one unit of output by sectors located in country A; $A^{NN}$is the $(n\,x\,n)$ technical coefficient matrix which captures how many inputs produced by sectors located in country N are needed to produce one unit of output by sectors located in country N. Lastly, f^A and f^B are the final demand vectors $(n\,x\,1)$ of country A and n^{th} country, respectively.

It is important to note that a change in the technical coefficient of a given sector in a given country (a_{ij}) overtime can occur due to geographical re-location of the sourcing of the input from one country to another, and not only due to a change in production technology (or in the intra-sectoral composition of output).

[5.2.3] Impact analyses

One of the most useful applications of IO analysis is to make use of the information in an IO table to assess the impacts on the economy and environment of technological changes or changes in final demand. Through the use of the Leontief inverse we can derive a number of summary measures to depict the impact of changes in final demand on different variables, which are generally known as IO multipliers. Here, following a treatment that considers all final demand components as exogenous, we present some simple IO multipliers which capture direct and indirect effects of increases in final demand, but not (keynesian) induced effects of subsequent changes in final demand associated with the increase in income [3]. As we will see, the most immediate multiplier one can derive is the output multiplier. However, with minor modifications to the basic framework IO analysis framework, one can estimate impacts regarding value added, employment, pollution, raw material consumption, energy use, and waste treatment (among others) associated with changes in final demand (f_d) and in technology (A) .

[3] For a thorough discussion regarding the different types of IO multipliers, see Miller and Blair (2009, ch.6).

[5.2.3.1] The simple output multiplier

The so-called simple *output multipliers* capture the total output required in each sector required to meet 1-unit of final demand for commodity i. Hence, the simple output multiplier of sector j is given by the column sum of the the elements of the Leontief inverse ($L = (I - A)^{-1}$):

$$m_j = \sum_{i=1}^{n} l_{ij} \qquad (6).$$

Where l_{ij} represent each element of the Leontief inverse. For a n-sector model we can represent the sectoral output multiplier as a row vector m' obtained by:

$$m = i'L \qquad (7).$$

Where i' denotes a row vector with 1 in all elements. Once we know the simple output multiplier we can estimate the change in total output associated with any given change in the final demand (column vector) [4].

$$\Delta x = m\,\Delta f_d \quad (8).$$

[5.2.3.2] The environmental multiplier

Environmental impacts, such as GHG emissions or raw material consumption associated with given levels and composition of final demand, can be analysed if one has information on the sectoral breakdown of total emissions or total raw material consumption. With this information emission or raw material consumption coefficients can be calculated [5]. For example, we can calculate emission coefficients (e) as:

$$e_j = \frac{ghg_j}{x_j} = \frac{Total\ GHG\ emissions\ in\ the\ aircraft\ producers\ sector\ in\ year\ t}{value\ of\ total\ production\ of\ aircrafts\ in\ year\ t} \qquad (9).$$

Compiling the coefficients for each sector into a row vector e and pre-multiplying it by the Leontief inverse and the final demand (column) vector (f_d) one is able to obtain the pollution multiplier, which captures total GHG emission generated along the entire supply chain associated with 1-unit of final demand:

$$e\ *= e(I - A)^{-1} \qquad (10).$$

And, consequently, we can estimate the change in total output associated with any given change in the final demand (column vector) [6].

$$\Delta x = e\ *\ \Delta f_d \qquad (11).$$

[4] Under the typical assumptions of the 'open' Leontief model of constant returns to scale, constant prices, and of exogenous final demand (i.e. no induced effects).
[5] Note, however, that it is of paramount importance that values of total output overtime are deflated by appropriate price indexes, in order for these coefficients not to artificially fall over time due to inflation of the value of total output.
[6] Under the typical assumptions of the 'open' Leontief model of constant returns to scale, constant prices, and of exogenous final demand (i.e. no induced effects).

[5.2.3.3] The employment multiplier

A similar procedure can be conducted to obtain the employment level associated with given levels of final demand and technology. With information on employment and total output, one can calculate the direct labour coefficient, i.e. the amount of labour required directly by the sector to produce one unit of its total output:

$$n_j = \frac{N_j}{x_j} = \frac{Total\ Employment\ in\ the\ aircraft\ producers\ sector\ in\ year\ t}{value\ of\ total\ production\ of\ aircrafts\ in\ year\ t} \quad (12).$$

Compiling the coefficients for each sector into a row vector n * and pre-multiplying it by the Leontief inverse we obtain the simple employment multiplier, which capture the direct and indirect employment created by 1-unit of final demand:

$$n\ *= n(I - A)^{-1} f_d \quad (13).$$

The final demand (column) vector (f_d) one is able to obtain the total emission generated along the entire supply chain associated with with given levels of final demand and its composition.

[5.2.3.4] The value added multiplier

The value added multiplier captures the impact of 1-unit of final demand on value added in each sector. Starting from the computation the value added coefficient (v), i.e. the amount of value added generated per unit of total output in each sector:

$$v_j = \frac{va_j}{x_j} = \frac{Total\ value\ \ in\ the\ aircraft\ producers\ sector\ in\ year\ t}{value\ of\ total\ production\ of\ aircrafts\ in\ year\ t} \quad (14).$$

A similar procedure can be conducted to obtain the Value Added (GDP) level associated with given levels of final demand and technology. With information on value added and total output, one can calculate the direct labour coefficient, i.e. the amount of labour required directly by the sector to produce one unit of its output:

$$l_j = \frac{L_j}{x_j} = \frac{Total\ Employment\ in\ the\ aircraft\ producers\ sector\ in\ year\ t}{value\ of\ total\ production\ of\ aircrafts\ in\ year\ t} \quad (15).$$

Compiling the coefficients for each sector into a row vector l and pre-multiplying it by the Leontief inverse and the final demand (column) vector (f_d) one is able to obtain the total emission generated along the entire supply chain associated with with given levels of final demand and its composition:

$$l\ *= l(I - A)^{-1} f_d \quad (16).$$

[5.3] Data Sources

The construction of an IO table requires the collation of raw data from various sources, including country-level supply and use data, time series production and expenditure data, and disaggregate bilateral trade data (Johnson, 2018). As such, the process of construction is an intensive process that requires the use of various pre-processing techniques and statistical processes. For this reason, there is no one accepted process for the construction of IO tables, and thus major data sources tend to be constructed using different techniques. We have identified a number of data sources that provide multi regional IO tables, these are summarised in Table 10.

Database	Time coverage	Sectoral coverage	Country coverage	Licensing
Eora	1990-2016 (/2021)	26-400 based on country data availability	189 countries, 1 Rest of the World (RoW)	free licence for academic use, but does not cover use in the development of software
Exiobase 3	1995-2011 (/2020)	200 products, 133 industries	EU (28), 16 major trading partners, 5 RoW regions	Open
OECD ICIO tables	1995-2018	45	66 countries, 1 RoW	Open
Eurostat FIGARO	2010-2020	64	EU (27), 18 main trading partners, 1 RoW	Open
GTAP	-2014	65	121 countries, 1 RoW	Proprietary & expensive

Table 10: Summary of MRIO databases.

We have no budget for purchasing a licence for a proprietary database, which rules out using both Eora and GTAP. Our second requirement is for the best sectoral and country level coverage in order to present the user with more options for exploring a supply chain that is relevant for them. It is important to consider the decolonial element here and how all of these databases are skewed towards Global North data. This is a core limitation that we need to confront in the development of the tool. We thus intend for the structure of the tool to be designed in such a way that alternate data structures can be plugged in and unplugged in a flexible manner to accommodate different versions, e.g. if updates are released, as well as country extensions.

Based on these cross comparisons, and our requirements, it was decided to initially use EXIOBASE 3 as our primary datasource. Again we emphasise the intention for flexibility so that these databases may be unplugged and alternate sources used. The following section illustrates EXIOBASE 3 in further detail. Whilst much of this detail is specific to EXIOBASE 3, it illustrates many of the generic properties that these data structures have.

[5.3.1] EXIOBASE 3

Out of the MRIO databases outlined in Table 10, EXIOBASE 3 is the database with the highest level of sector detail at the level of all countries included for calculations of demand-based indicators. It also aims to cover a large number of environmentally sensitive activities in this coverage (Giljum et al., 2019).

The core time-coverage is from 1995-2011, with nowcasting estimations extending the time-series up until 2016. Sectoral Coverage presents 200 products/commodities and 163 industries, of which 33 products refer to the extraction of biotic and abiotic raw materials. In terms of regional detail, EXIOBASE has a clear focus on the EU. The EU-28 and their 16 most important trading partners are explicitly modelled in EXIOBASE 3, representing about 95% of global GDP. The rest of the world is aggregated into five separate RoW regions. Totalling 49 countries/regions. Data is supplied in txt. format.

The EXIOBASE download site at Zenodo contains details of the full dataset files and formats. Due to the size and complexity of the MRIO here, the table as represented in abstract in Table 8, is split across a number of separate files, with the economic core comprised of the following:

- Z - matrix of the flow/transactions, intermediate inputs
- A - matrix of inter-industry technical coefficients, (direct requirements matrix)
- Y - matrix of the final demand components by product

- x - vector of the gross/total output
- unit - vector describing units of the flow data

Two sets of extension data are also included:

- Satellite data - representing uncharacterized stressors - e.g. CO2 emissions, land use per category
- Impact data - representing characterised stressors - e.g. total GWP100, total land use

[5.3.2] EXIOBASE 3rx

EXIOBASE 3rx is an extension to EXIOBASE 3, described within Bjelle et al. (2020). This dataset increases country resolution from 49 regions to 214 by estimating IO tables for countries whose statistical offices don't produce one. Proxy data in the form of generic estimates of coefficients of the supply (i.e., market share relationships) and use matrices (intermediate use and final demand coefficients) give an initial estimate of the product/industry transactions. The coefficients are then reconciled to globally balanced estimates of trade data, estimates of product outputs for every country and macroeconomic data on value added, taxes, exports, imports, final consumption and gross capital formation. Due to the size of the resultant matrices (42800x42800 for the Z matrix), data is supplied in MATLAB format.

[5.4] Methods

[5.4.1] Data storage

As detailed in Section 5.3, we have chosen to use EXIOBASE as the primary database due to its comprehensive sectoral coverage. Nevertheless, we hope the tool can be designed in a way that allows for flexibility in terms of plugging in alternative data sources, including updates to the original database. This is intended as backend functionality, and these sources may have to be manually reformatted. These data structures will be stored online. The following folder structure shows the imported data structures for the year 2019 from Exiobase 3 (Figure 7).

Name	Owner	Last modi...	File size
Satelite	Jose B Ramos Torre...	13 Dec 2022	–
Impact	Jose B Ramos Torre...	14 Dec 2022	–
x- Total Output vector.csv	Jose B Ramos Torre...	13 Dec 2022	449 KB
finaldemands-codes.csv	Jose B Ramos Torre...	13 Dec 2022	420 bytes
industries-classification.csv	Jose B Ramos Torre...	13 Dec 2022	10 KB
products-classification.csv	Jose B Ramos Torre...	13 Dec 2022	11 KB
unit of account of industries flows.csv	Jose B Ramos Torre...	13 Dec 2022	414 KB
Y- Final demand components by product.csv	Jose B Ramos Torre...	13 Dec 2022	15.9 MB
Z- Intermediate inputs.xlsx	Jose B Ramos Torre...	13 Dec 2022	600.2 MB
A- Technical Coefficient matrix.xlsx	Jose B Ramos Torre...	13 Dec 2022	598.6 MB

Figure 7: Folder structure for Exiobase data for a given year.

[5.4.2] Pre-processing data

It is expected that we may wish to pre-process data before storing it online, rather than using raw datasheets imported directly from Exiobase. The details of exactly what format these should be stored in will be finalised as the tool is developed.

[5.4.3] User defined lookup

In selecting a baseline scenario to explore, the user sets the parameters of a lookup. This will provide a year, country/region, and sector. From these defined parameters, the tool will lookup within the 'A' coefficient matrix, and extract data for the relevant column.

[5.4.4] Mapping

A visual world map is generated which highlights the main contributors to the sector in question (cf. Figure 6). It is likely we will need to exclude some data here to make the visualisation readable, e.g. by highlighting only the 20 highest contributing countries/sectors, or those that represent a certain threshold (e.g. 90% - which could be tuned by the user) of inputs. We may want some hover functionality or equivalent so the user can click the relevant country for further details (e.g. sectoral breakdown, headlines from justice elements).

[5.5] Related Tools

A number of existing tools for visualising global supply chains are relevant to outline here.

[5.5.1] Supply Chain Explorer

Supply Chain Explorer has been developed by the team behind the 'Eora global supply chain database', Supply Chain Explorer, is designed to allow users to explore sectoral and geographically resolved inputs flowing into a given sector. The user selects a country, sector, and footprint measure (e.g. $USD, embodied GHG emissions), from drop down lists. The tool then maps 'Total footprint' and 'Final consumers' in a visual network plot (see Figure 8). The tool uses the Full Eora database, a global multi-region input-output (MRIO) database (Lenzen et al., 2012). The user can click on each input, to explore successive tiers of the supply chain.

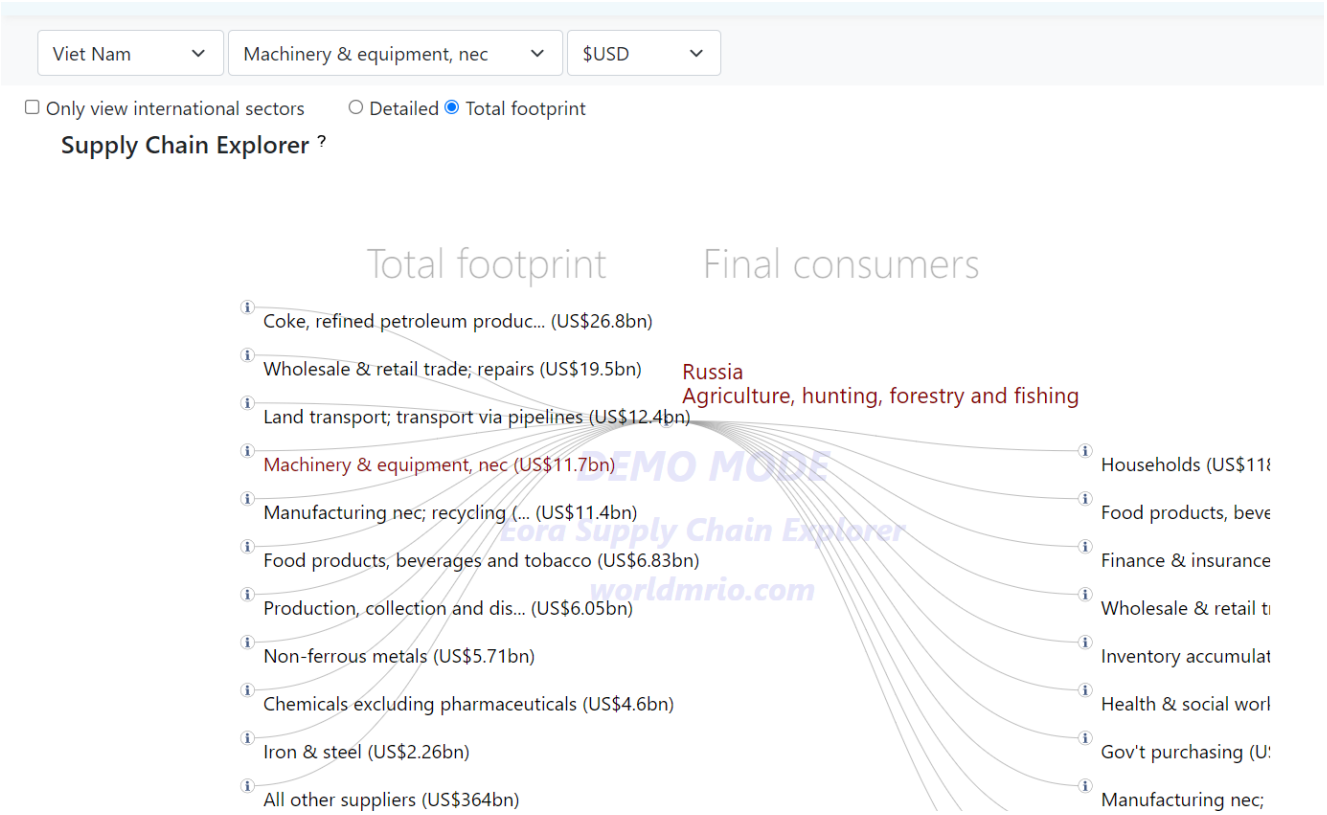

Figure 8: Screenshot of the Eora Supply Chain Explorer.

[5.5.2] Exiobase 3 Visualiser

The 'Environmental Footprints' website hosts several data explorer and visualisation tools relating to global supply chains. Among these, the Exiobase 3 Visualisation displays aggregated (MRIO) data relating to the impacts of a given sector (and region) as a global density map, a time series plot, and pie chart. It does not allow the spatiality of the supply chain to be explored directly, but a selected sector may be compared to the same sector in other locations, and its impact in terms of several indicators (GHG emissions, material, energy, and land use, etc).

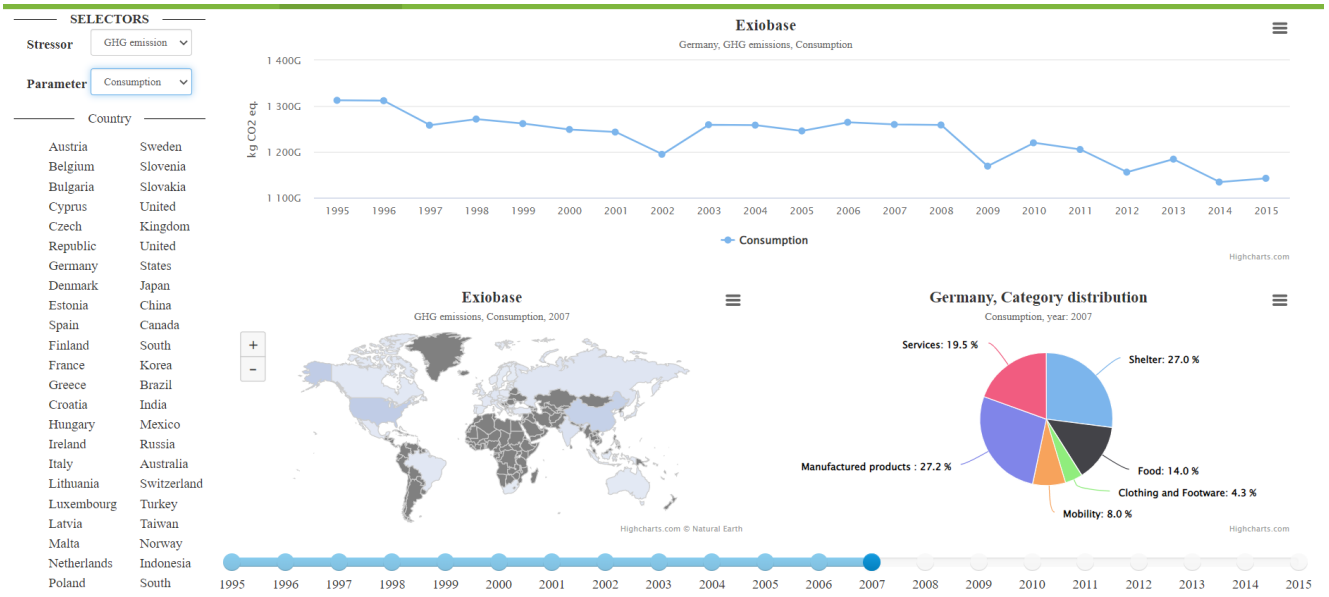

Figure 9: Screenshot of the Exiobase data visualiser.

[5.5.2] RaMa-Scene

RaMa-Scene is a web platform aimed at allowing the user to visualise the diverse economic and environmental impacts of CE interventions (Donati et al., 2021). It uses the monetary EXIOBASE 3 MRIO database as its underlying datasource, which is modified to, amongst other things, allow secondary raw materials to be available within the IO system.

Using a series of drop-down forms, the user defines a baseline scenario which reproduces the preprogrammed IO data, the user is then given the opportunity to define a counterfactual scenario which models CE interventions through a series of coefficient changes. The counterfactual matrix is generated using a Leontief inverse of the original matrix, as described in Çetinay et al. (2020), and Donati et al. (2021). This requires computational power and is calculated by the tool on-the-fly. The tool presents two ways for visualising the impacts of CE interventions: 'hotspot analysis' where impacts are distinguished by sector and region, and 'contribution analysis' where total impacts along the supply chain are totalled by product category and region.

The user interface for the tool is shown in Figure 10. The two central visualisations allow for comparison of the baseline and counterfactual scenarios, which for illustrative purposes display both the hotspot display (left) in terms of contributing sectors, and regional contribution (right). The tool is somewhat complex to use as a lay user, however there is a manual, video tutorial, and various user guides available.

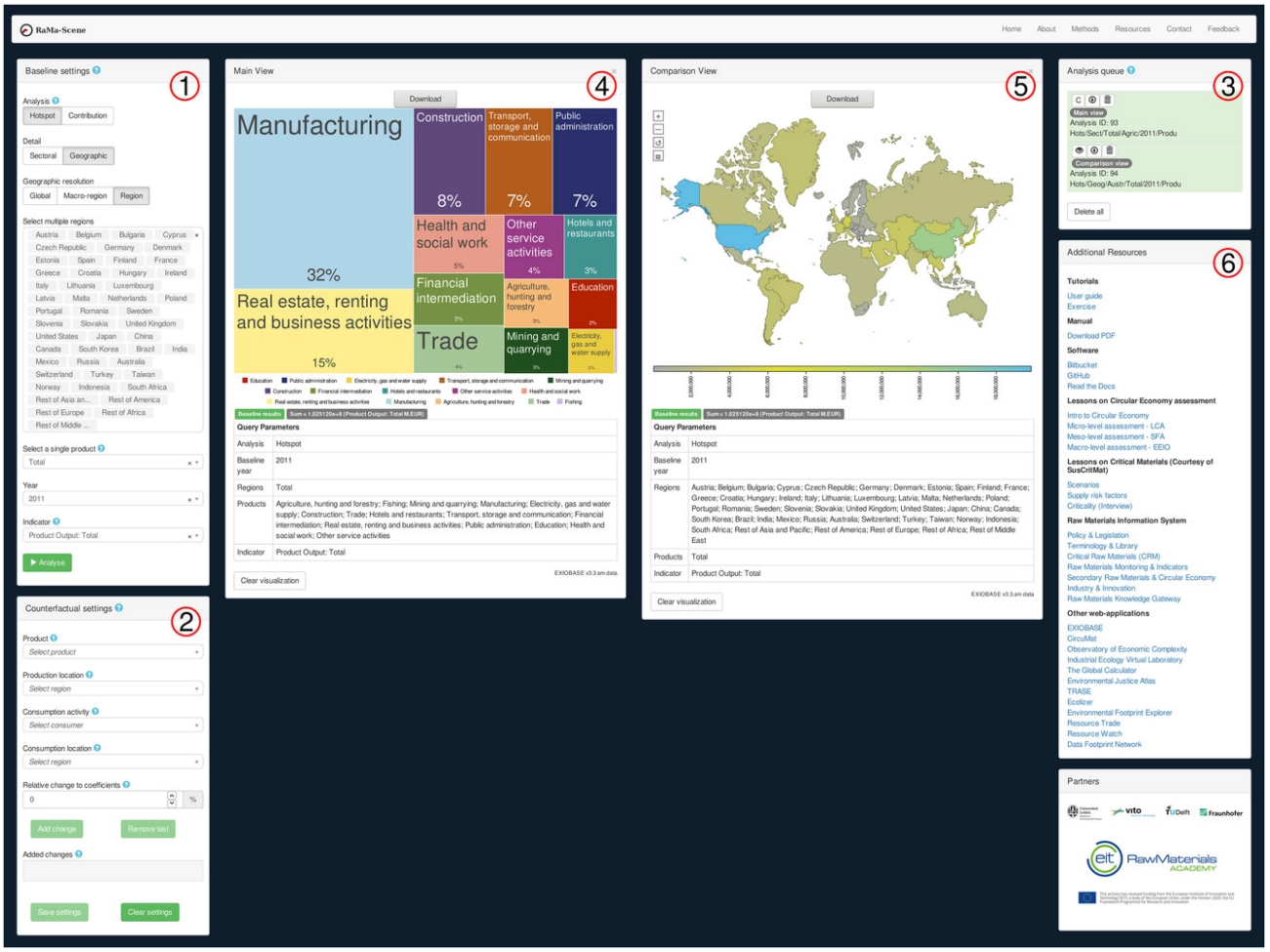

Figure 10: RaMa-Scene interface, reproduced from Donati et al (2021).

[6] A Just Transition

A core purpose of the tool, identified by the consortium in discussions, is the role of the tool as a learning environment, helping the user explore a problem, and introducing dimensions that perhaps had so far been unexplored. Section 4.1.3 outlines the core elements of the 'just transition' discourse and how they are embedded within the theoretical framework of the tool. As indicated here, and presented within the framework of the JUST2CE project, we base our understanding of the just transition on three dimensions of justice: labour justice, gender justice, and environmental justice.

In line with the approach identified from Sections 2 and 3, we chose not to develop a dashboard of indicators as initially conceived for this aspect of the tool. Instead we wish to take a more qualitative approach which hangs on the desire for the DST to be a learning tool for encouraging users to think about new issues and ways to reframe existing problems. It is thus intended to integrate elements of justice seamlessly into the tool, through the existing visualisations (i.e. **the map**), and **a directory** that signposts users to additional tools and resources.

[6.1] Related Tools

Several existing tools present themselves as models for how we can incorporate justice elements into our DST.

[6.1.1] Global Atlas of Environmental Justice

The EJAtlas, or Global Atlas of Environmental Justice documents and catalogues social conflict around environmental issues through a collaborative mapping initiative (Temper et al., 2015). The Atlas maps conflicts across 10 main categories including waste management, mineral ores & extraction, and water management, with various details included on each conflict and references to relevant sources such as legislation and research. The map is a collaborative output with contributions from academics, citizens, activist groups, and NGOs, and moderation by an editorial team who 'factcheck' submitted information. A comment box is included in each conflict page to promote discussion among users.

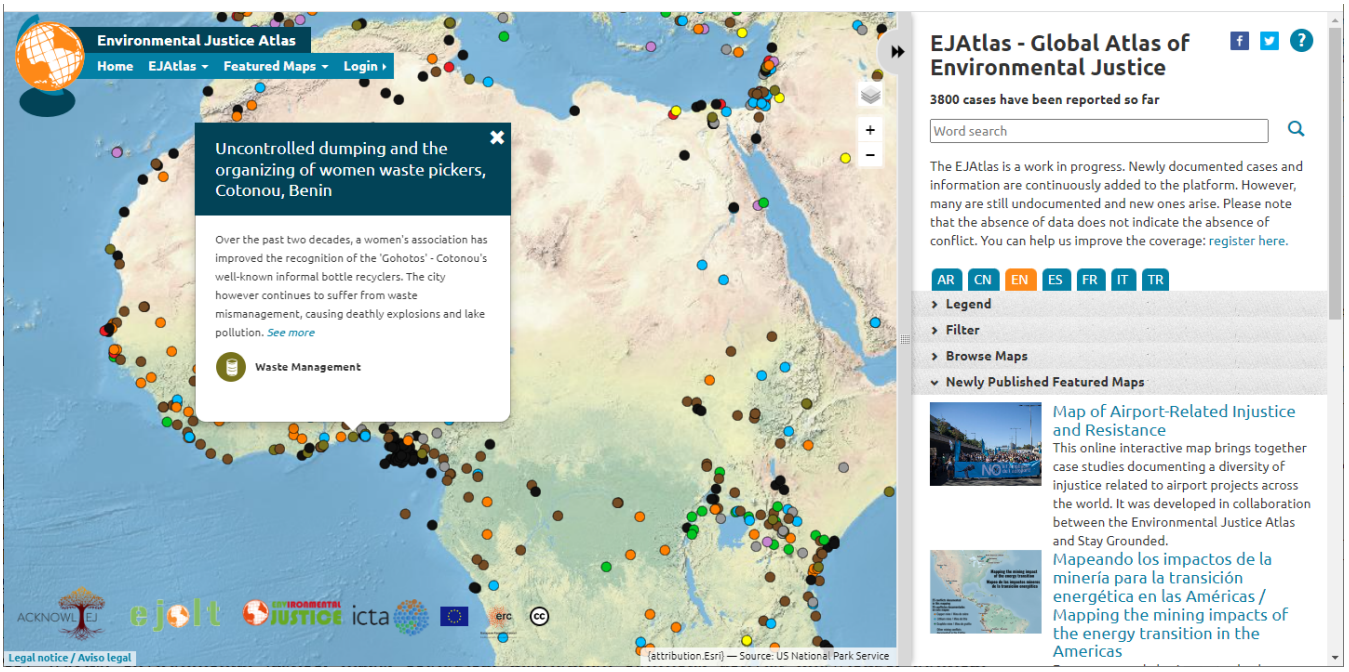

Figure 11: Screenshot of the Global Atlas of Environmental Justice showing a pop up 'see more' box for a waste management conflict in Benin.

[6.1.2] Our World In Data

Our World in Data is a collaborative project between researchers at the University of Oxford, and the non-profit Global Change Data Lab. It presents its goal as "making the knowledge on the big problems accessible and understandable" (Our World in Data, 2023), drawing on existing datasets relating to 'global problems' and presenting interactive charts and maps alongside summaries of research findings. Whilst its scope is vast and has been developed over a number of years by a large team, the site provides a potential model for the presentation of information related to core justice elements in a directory format.

[6.2] Incorporation of Justice Elements

We propose two functionalities for embedding and incorporating justice elements within the tool, described as follows.

[6.2.1] Map overlay

Similar to the Global Atlas of Environmental Justice, we propose to incorporate spatially resolved 'hotspots' within the map which is generated from the IO tables as described in section 5. This will embed the *Global Atlas of CE practices*, which is being developed within WP1. There is also potential to directly embed elements from the EJAtlas depending on permissions.

Despite our rejection of a dashboard of indicators, we are also exploring the possibility of including a number of indicators (at a country level) that might illustrate key elements relating to just transition principles. This will need to be further explored in a critical way, and we need to be mindful of not overloading the user with information. Several relevant composite indicators have been identified here:

- Environmental Performance Index: Yale, composite of 40 indicators
- Child Labour Data (unicef): Percentage of children engaged in child labour
- Indicators for Child Labour (ILO): Percentage of children engaged in child labour
- Global Rights Index (ITUC): 'degree of respect for workers rights' - composite indicator, Geographical ranking
- World Bank Gender Database: a wide set of indicators related to gender issues (including, for instance, women participation in the labour market and gender pay gap).

Any resultant selection should be presented discursively, opening up new possibilities for consideration, rather than encouraging reductionism. For this reason we are somewhat wary of this approach and will need to explore it further in the development of the tool.

[6.2.1] A just transition directory

Separate from the spatial visualisation element of the tool we intend to create a resource library, perhaps similar in style to Our World in Data but with a more qualitative focus. This is an area for further reading and signposting for the user who wants to understand core elements of the just CE transition as we see them. It is also a space where we can showcase and direct to other outputs from JUST2CE, such as information and findings from our case studies. The scope of this directory should include all the core elements illustrated in Figure 5.

[6.3] Environmental Justice

Deliverable 1.2 (Meira et al., 2023) presents WP1's literature review relating to global environmental justice in the context of a CE. The core findings for this review are as follows:

- To be conducive to global environmental justice, the CE must adopt a **degrowth approach**, seeking to decrease the energy and material throughput of the global economy.
- The CE needs to be reformulated as both a **response to ecological unsustainability** and a **form of debt reparation** from the Global North to the Global South.
- It is important to consider **distributional justice**, paying attention to who is shouldering the cost of the transition.
- The need to pay attention to the **inclusivity of decision-making processes**, in particular the representation of marginalised groups.
- The need to give careful consideration to the experience, knowledge, needs and perspective of **waste-pickers.**

[6.4] Gender Justice

Deliverable 1.3 (Martínez Álvarez & Barca, 2023) defines a gender just CE as one "based on a redefinition of value that includes unpaid services provided in households, communities and nature to sustain the social and environmental context of human life". The core findings of the report, which adopts a Feminist Ecological Economics perspective are as follows:

- The interconnectedness of **social and environmental reproduction** through **care work**. This work is gendered; women tend to be overrepresented in the unvalued (or low-value) economy.
- Gender justice cannot be achieved without transforming value away from the preferencing of commodity production.
- Wealth should be measured in terms of social provisioning and re-productivity rather than the growth of productivity.
- **The CE must become care-oriented, closing the loop between productive and reproductive work**.

[6.5] Labour Justice

JUST2CE's Deliverable 1.4 (Guillibert et al., 2022) presents the core findings of WP1's literature review relating to labour justice in relation to the CE. This work, on which we draw to inform the framing of labour justice issues for the DST, identifies the following five points which illustrate core gaps in the CE literature:

- The importance of the agency or **power of workers' decisions**, impacts of a CE transition on **reproductive and unpaid labour**, the place of non-citizen and **immigrant workers** within the CE.
- Moving beyond considering labour in terms of the quantity of jobs created to consider: the **quality of jobs**, worker **participation** in organisational strategies, **gender inequalities**, **racism**, and **neocolonialism**.
- How different sectors might be impacted by the transition to a CE: the difference between capital-intensive and labour-intensive industries.
- The comparison of theoretical CE models to concrete applications.
- Considering employment effects at a global scale rather than simply national or regional.

[7] Use Case Demonstration

In this final section we explore a number of use cases for the tool, assessing the capabilities we have, and exploring potential issues and limitations that we may face. In doing so, we explore a number of sectors, across both Europe and Africa, drawing on the JUST2CE case studies.

[7.1] Use Case One: Taranto, Italy

The Taranto Plan case study focuses on the transition away from steel making towards tertiary economic activities. The Plan represents a significant effort to confront the jobs vs environment dilemma, and the financial, market, environmental and public health problems on the local scale of a steel based linear economy.

In this use case, we envision a user who wishes to explore the steel supply chain in the context of Taranto.

1. The user is prompted to enter a location and sector
    a. Note: The standard Exiobase 3 database has data for Italy; The following products classifications are relevant: 'Basic iron and steel and of ferro-alloys and first products thereof', and 'Secondary steel for treatment, Re-processing of secondary steel into new steel' as well as the industries classifications: 'Manufacture of basic iron and steel and of ferro-alloys and first products thereof', and 'Re-processing of secondary steel into new steel'

b. The tool will therefore require capabilities to search the relevant products/industries classifications for the user to identify the relevant row to extract. In this case, a search for 'steel' should be sufficient, and the tool could provide a prompt of the available results to allow for selection.
    i. In some cases this may not be straightforward for the user to pick a category, and thus keywords and information on each category may be necessary to include as metadata to allow a search.

[7.2] Use Case Two: ZimPhos, Zimbabwe

The case of ZimPhos, a chemical manufacturer in Msasa, Zimbabwe, is the subject of one of WP2's case studies (Midterm report). ZimPhos is Zimbabwe's sole producer of phosphate fertilisers, aluminium sulphate for municipal water treatment, sulphuric acid and other industrial chemicals. It operates a large factory complex where phosphatic fertilisers are produced using phosphate rock supplied from Dorowa Mine. It has managed to make a successful symbiosis with the construction company St Gobain.

In this use case, we envision a user who wishes to explore the ZimPhos supply chain.

1. The user is prompted to enter a location and sector
    a. Note: in this case, Zimbabwe is absent from the standard Exiobase 3 database, this necessitates one of two options: a) the 'RoW Africa' region is used, b) an alternate database such as Exiobase 3rx is instead plugged in.

[7.3] Use Case Three: General User

In this case, we consider a lay user who opens the tool without a specific case or supply chain they wish to investigate. Here the user has several options of how to interact with the tool, and these should be pre-empted so it is easy for such a user to intuitively explore the tool.

1. The user may wish to explore the just transition library directly, and avoid the supply chain exploration element.
    a. The library should therefore be accessible independently of the other elements of the tool, and should be clear to navigate to and explore.
2. The user may wish to explore various global supply chains.
    a. A pre-loaded example may be useful here, so that the capabilities of the tool can be demonstrated without the user having to input any data or options.
        i. This may serve a useful example for other users too who have more specific goals.

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