User requirements concerning sustainability assessments of pharmaceuticals

D4.1 – Stakeholder views, needs & wishes on sustainability assessment of APIs

WP:	**4**
Document Type:	**PU**
Version:	**Final**
Project Information:	Towards a sustainable pharmaceutical production
Grant Agreement n°:	101057816
Project Dates:	**June 1st 2022 – May 31st 2026**

Horizon Europe Grant Agreement N° 101057816
TRANSPHARM RESTRICTED – Under Consortium Agreement, Confidential until June 1st 2031

Funded by the European Union

DOCUMENT INFORMATION

Project Name	TransPharm
Deliverable Title/Number	D4.1
Description	Stakeholder views, needs & wishes on sustainability assessment of APIs
Lead beneficiary	Ecologic Institute
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Contributors	TransPharm Consortium
Contractual delivery date:	30/09/23
Actual delivery date:	24/10/23
Sensitivity	PU

DOCUMENT APPROVAL

NAME	ORGANISATION	ROLE	ACTION	DATE
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Chris Stevens	UGent	Coordinator	Verification	23/10/2023

DOCUMENT HISTORY

VERSION	DATE	MODIFICATIONS	AUTHORS
V1	01/09/23		Rodrigo Vidaurre
V2	18/10/23	Includes comments of project partners, updates to figures.	Rodrigo Vidaurre
VF	24/10/2023	Final version submitted	Nathalie De Coensel

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NATURE OF DELIVERABLE	
R	Document, report (excluding the periodic and final reports)
DEC	Websites, patents filing, press & media actions, videos, etc.
DEM	Demonstrator, pilot, prototype, plan designs
OTHER	Software, technical diagram, algorithms, models, etc.
ETHICS	Deliverables related to ethics issues.
DATA	Data sets, microdata, etc
DMP	Data Management Plan
SECURITY	Deliverables related to security issues

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ACRONYM/ABBREVIATIONS	
AMR	Antimicrobial resistance
APIs	Active Pharmaceutical Ingredients
BSI	British Standards Institution
CSR	Corporate Social Responsibility
CDMO	Contract Development Manufacturing Organization
EDQM	European Directorate for the Quality of Medicines & HealthCare
ERA	Environmental Risk Assessment
EU	European Union
GPs	General Practitioners
IC	Impact Categories
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
OTC	Over-The-Counter

PEF	Product Environmental Footprint
PSCI	Pharmaceutical Supply Chain Initiative
SDG	Sustainable Development Goal
SMI	Sustainable Markets Initiative
UN	United Nations
UNEP	United Nations Environment Programme
WHO	World Health Organization
EU	European Union

Suggested citation

Heni, Y.; Vidaurre, R.; Rechlin, A.; Araujo, A. (2023): User requirements concerning sustainability assessments of pharmaceuticals. Ecologic Institute, Berlin.

Acknowledgements

The authors would like to thank all the interviewees for their time and valuable input, as well as the consortium partners from WP4 for their contribution and support.

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement N° 101057816.

Disclaimer

ABSTRACT

This report presents findings from stakeholder engagement activities regarding new methodologies to assess the sustainability of pharmaceuticals over their entire life cycle.

The results show that stakeholders have a large range of overarching objectives and purposes for using such an assessment, as well as a large range of decision-making processes the assessments would influence. A sustainability assessment framework needs to be capable of accommodating these different realities and use cases for it to find successful uptake. Developing an approach that can be used in a modular fashion, which at the same time provides generic recommendations and use guidelines for those stakeholders who do not have strongly individualised requirements, could be the way forward. The need for modularity covers not only the impact categories playing a role in an assessment, but also the system boundaries, the level of aggregation of results, and the geographical level of analysis.

Engagement activities showed widespread consensus between stakeholders on the need for full transparency (or as much transparency as possible) in such an assessment framework, covering not only outputs, but also the methods, limitations, assumptions and decisions taken within the assessment process. Other key needs identified were harmonizing individual elements of the assessment framework with existing reporting approaches or requirements (including regulatory ones such as ERA) and having reliable numbers feeding into an assessment, thus managing uncertainty and of avoiding incorporating elements with high levels of uncertainty in the assessment.

A promising option for establishing a sustainability assessment for pharmaceuticals could be starting with a leaner approach, which incorporates impact categories which are closer to maturity, and that is capable of gradual expansion over time to address all relevant impact categories.

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EXECUTIVE SUMMARY

Medicines are essential to human health and the wellbeing of a growing and ageing global population. However, their active pharmaceutical ingredients (APIs) are a risk to the environment, both in the production processes (e.g. through use of resources and greenhouse gas emissions) and after use, potentially impacting aquatic ecosystems and water resources. The research project **TransPharm - Transforming into a sustainable European pharmaceutical sector**, aims to address this challenge by developing more sustainable and greener APIs that simultaneously reduce the environmental footprint and the dependence on third countries for API production.

This report presents findings from stakeholder engagement regarding new methodologies to assess the sustainability of pharmaceuticals over their entire life cycle.

Stakeholder engagement activities show a very large range of uses of an assessment system for pharmaceuticals. Stakeholders' overarching objectives and purposes for using such an assessment, as well as the decision-making processes the assessments would influence, were shown to be incredibly varied. This variability can even be observed within organisations of a same stakeholder group. For instance, interviewed health sector organisations implement sustainability strategies following mandates linked to their national legislation. These place different priorities and give different weights to different sustainability aspects, such as achieving net zero emissions vs. addressing the issue of pharmaceuticals in the environment.

We conclude that the TransPharm sustainability assessment framework needs to be capable of accommodating these different realities and use cases for it to find successful uptake. Developing an approach that can be used in a modular fashion, which at the same time provides generic recommendations and use guidelines for those stakeholders who do not have strongly individualised requirements, could be the way forward. The need for modularity covers not only the impact categories playing a role in an assessment, but also the system boundaries, the level of aggregation of results, and the geographical level of analysis.

Stakeholders showed widespread consensus on the need for full transparency (or as much transparency as possible) in such an assessment framework. It should not only cover outputs, but also the methods, limitations, assumptions and decisions taken within the assessment process. This transparency is not just a 'nice-to-have', but impacts the possibility of stakeholders making use of the TransPharm sustainability assessment or discarding it for other tools. An example are procurement agencies and health insurance companies, who may need to be in a position to justify their procurement decisions if these are legally challenged, thus requiring highly transparent assessments to be able to back up their decision-making processes in case they have to go to court.

Other key needs identified were harmonizing individual elements of the assessment framework with existing reporting approaches or requirements (including regulatory ones such as ERA) and having reliable numbers feeding into an assessment, thus managing uncertainty and of avoiding incorporating elements with high levels of uncertainty in the assessment.

A promising option for establishing a sustainability assessment for pharmaceuticals could be starting with a leaner approach, which incorporates impact categories which are closer to maturity, and that is capable of gradual expansion over time to address all relevant impact categories.

1 INTRODUCTION

Medicines are essential to human health and the wellbeing of a growing and ageing global population (Taylor, 2015). Therefore, they play a crucial role in achieving the United Nation's (UN) Sustainable Development Goal (SDG) of 'Good Health and Well-Being'. Yet, healthcare contributes 4% of global greenhouse gas emissions, with pharmaceuticals accounting for 12% of it (Health Care Without Harm, 2019). Pharmaceuticals comprise a wide variety of chemical compounds designed to guarantee safe and effective therapies. The active pharmaceutical ingredients (APIs) are those substances designed to exert an effect on targets in the patients. However, APIs are a risk to the environment, both in the production processes (e.g. through use of resources and greenhouse gas emissions) and after use, potentially impacting aquatic ecosystems and water resources (Roig and D'Aco, 2015). Hence, despite being essential for human health, medicines impact the environment, relating to UN SDGs of 'Life under Water' and 'Clean Water and Sanitation.' At the same time, European health and industrial policy has led to the outsourcing of production steps to lower-cost regions, affecting stability and supply reliability. With shortages frequent in EU member states, the balance between prices, supply stability, and environmental impact is a challenging task (European Commission et al., 2021).

The research project **TransPharm - Transforming into a sustainable European pharmaceutical sector**, aims to address this challenge by developing more sustainable and greener APIs that simultaneously reduce the environmental footprint and the dependence on third countries for API production. The project started in June 2022 and runs for four years. It is funded under the European Union's Horizon Europe research and innovation programme.

One of TransPharm's objectives is to provide new methodologies to assess the sustainability of pharmaceuticals over their entire life cycle. Therefore, work package (WP) 4 aims to develop and test a holistic, comprehensive framework for the integrated sustainability assessment of pharmaceuticals, covering their entire lifecycle and with a clear emphasis on environmental aspects. The development of the framework is supported by the concept of Life Cycle Thinking, which is a way of thinking that goes beyond the traditional focus on production site and manufacturing processes to include environmental, social and economic impacts of a product over its entire life cycle (Leal Filho et al., 2021). The to-be-developed **TransPharm sustainability assessment framework** will aim to support decision-making in choosing more sustainable options in the transition to a more sustainable pharmaceutical sector.

The framework will be generic in its applicability, hence allowing for crossover between industry actors, pharmaceutical drug types and stakeholders. It is important that it may cover the wide scale of impacts associated with the pharmaceutical sector. At a later stage, the framework may be adapted to a more detailed spatial differentiation e. g. site-specific or region-specific settings.

The details of the methodological framework, including system boundaries, functional unit, impact categories (IC) and others, will be defined during the course of the project.

In order to maximise the applicability on the one hand and the impact of such a framework on the other hand, it is important to address the views, needs and wishes of potential end-users in relation to such a sustainability assessment of pharmaceuticals. For this reason, task 4.1.2 of the TransPharm project aimed to explore these views, needs and wishes of stakeholders by involving them from early on in the development phase.

This report presents findings from stakeholder engagement in a bottom-up approach, asking key stakeholders about their views, needs and wishes regarding the desired sustainability assessment of pharmaceuticals. Chapter 2 renders the methodological approach regarding data collection and evaluation. The stakeholder positions on a sustainability assessment framework for pharmaceuticals as they have resulted from the stakeholder engagement process are presented in Chapter 3. This includes stakeholders' affiliations and their position in the pharmaceutical life-cycle (3.1). Further, we provide insights into which sustainability dimensions and impact categories were considered important and should be taken into account in the framework (3.2). Stakeholders were asked in regards of their aspired aim and application of an environmental or overall sustainability assessment (3.3). Methodological aspects such as geographical level(s), level of integration and harmonization, weighting of assessment results or the desired outcome of an assessment were also covered (3.4). Furthermore, the involvement and potential roles of stakeholders were likewise discussed (3.5). Lastly, stakeholders were asked about their views and needs in terms of data availability and transparency (3.6). These results of the stakeholder engagement process are then further condensed and discussed in Chapter 4, while Chapter 5 summarises the previous considerations and offers recommendations for further steps and the integration of the views, needs and wishes presented.

2 METHODOLOGY

TransPharm's WP4 aims to develop an integrated sustainability assessment for pharmaceuticals. The basis of this assessment is a comprehensive, holistic framework for assessment that is being developed in WP4.1 and which is supported by the framework of Life Cycle Thinking (LCT). Using LCT has the major benefit of avoiding trade-offs between different steps of a product's lifecycle. The TransPharm holistic framework will use a combination of a top-down approach with a bottom-up approach, as recommended by Weiland (2006) and Saidani et al. (2017).

To make TransPharm's WP4 outputs useful for relevant actors in the pharmaceutical life cycle, it is important to consider the views and needs of the potential end-users. This report presents findings from stakeholder engagement, in a bottom-up approach, both in relation to the holistic framework for assessment as for the final output of the integrated sustainability assessment. In the engagement activities, key stakeholders were asked about their views, needs and wishes

regarding the desired sustainability assessment of pharmaceuticals. The data collected from stakeholders shall help shape WP4's outputs so as to increase applicability, relevance, and thus uptake of WP4's products.

Stakeholders were presented with draft elements of the holistic assessment framework (lifecycle overview as well as impact categories) and asked to provide feedback on them.[1] Aspects related to the integrated sustainability assessment of pharmaceuticals were discussed in abstract terms, without following a concrete template. Stakeholder consultation at this early stage in the process aims to align the cornerstones of the holistic framework with stakeholder requirements and to steer path-dependent developments at an early stage, according to feedback.

2.1 Data collection

As part of a common workshop between the PREMIER and the TransPharm projects (Nijmegen, April 4-6, 2023), preparatory interactive sessions with stakeholders were held in which we gathered stakeholder views on prerequisites and cornerstones for a holistic framework to develop a comprehensive life cycle assessment (LCA) for green pharmaceuticals.

The outcomes of these interactive sessions helped shape the approach chosen for the in-depth interviews, which collected detailed stakeholder feedback from 25 interview partners in 21 interviews. Interview results provide a much higher granularity in the opinions and rationales of stakeholders, and they form the basis of this report. The following section provides more details on the process followed.

2.1.1 Targeted stakeholder interviews

The overall process entailed the following steps:

1. Development of a questionnaire,
2. Stakeholder mapping,
3. Selection of a balanced mix of interview partners based on the stakeholder mapping,
4. Conducting the interviews,
5. Analysis, evaluation and presentation of the results.

The **questionnaire** (Annex I) was developed in close consultation with WP 4.1 project partners. Thematic guiding questions for the interviews as well as the workshop (cf.) were based on the most important aspects for a holistic assessment framework identified from literature (Emara et al., 2018; Pharmaceutical Group of European Union, 2021; Ruiz, 2022; Siegert et al., 2019b, 2019a;

[1] *Deliverable 4.2 of TransPharm, "Conceptual holistic framework for sustainability assessment of pharmaceuticals", presents the finalized framework.*

Van Wezel, 2022; Yang et al., 2021) and partners' expert knowledge. In total, 20 questions were developed, both qualitative and quantitative in nature. The aim was to allow for a direct comparison on key aspects, while leaving enough room to draw on the experts' knowledge. Questions 18-20 address the topic of barriers and opportunities for take-up of greener pharmaceuticals. These three questions feed into WP5, and are not analysed in this report.

Important groundwork for developing a holistic sustainability assessment, is a refined understanding of the pharmaceutical life cycle. To this end, project partner UGent, in close cooperation with all partners, developed a map of the life cycle (for version current at moment of writing see Figure 2). The result was presented to stakeholders in the Nijmegen workshop and enhanced according to the feedback provided. The enhanced version was presented to interview partners in Question 3; interviewees provided further observations and proposed alterations to this overview. The answers to Question 3 have been provided to UGent for further refinement of the life cycle map, and are only briefly considered in the present report.

The remaining 16 questions are grouped in this report as follows:

1. Sustainability dimensions and impact categories (Q1, Q2, and Q11, cf. Section 3.2),
2. Aim and application of the holistic sustainability assessment (Q4 to Q7, cf. Section 3.2),
3. Methodological aspects (Q10 and Q12 to Q15, cf. Section 3.4),
4. Stakeholders' "buy-in" (acceptance of and willingness to actively support and participate) (Q8 to Q9, cf. Section 3.5),
5. Transparency and data availability (Q16 to Q17, cf. Section 3.6).

To understand which **stakeholder groups** should be contacted for the interviews, we used the draft map of the pharmaceutical life-cycle as mentioned above and identified 11 groups along the pharmaceutical life cycle who could provide valuable input for the development of an integrated assessment of pharmaceuticals:

1. Health sector organisations
2. Pharmacists, general practitioners (GPs) & patient organisations
3. Pharma companies
4. Industry associations
5. Other companies working in the pharmaceutical sector (suppliers, consultancies, among others)
6. Authorities and regulators (EU, national and regional)
7. Universities and research organizations
8. NGOs
9. Water sector
10. Multilateral organisations

11. Life Cycle Inventory (LCI) repositories.

Stakeholders were identified and mapped using several sources:

a. Scientific, private sector and governmental publications
b. The consortium´s network
c. Association´s publicly available membership lists.

Aiming for a total of approx. 20 interviews and considering the large number of identified stakeholder groups, the group LCI repositories were disregarded. The rationale for this step was that this group provides data to the intended audiences, but is not likely to carry out, make use or be affected by the outcome of sustainability assessments.

To achieve a balanced mix of interviewees from the remaining 10 stakeholder groups, the candidates were contacted to be evenly distributed and ensuring complementary fields of knowledge. Despite several attempts, the team was unable to secure an interviewee from multilateral organizations (e.g., World Health Organization (WHO), European Directorate for the Quality of Medicines & HealthCare (EDQM), United Nations Environment Programme (UNEP), OECD), leading to a total of 9 stakeholder groups participating in the interviews.

Due to the limited number of interviews and the process of contacting organisations, only people from the field of pharmacists and general practitioners (GPs) were interviewed within the stakeholder group "*Pharmacists, GPs & patient organisations*". This group will therefore be referred to in the rest of this report as *"Pharmacists and GPs"*. Section 3.1 presents an overview of the types of organization and number of participants per group (cf. Figure 1).

2.2 Data evaluation

Interviews were carried out using standard videoconferencing software and recorded. Transcripts of the recordings were produced in three steps:

- Draft versions of interview transcripts were produced by a speech-to-text transcription app using the audio recordings of the interviews.
- The draft transcripts were checked manually for errors, corrected and completed.
- Transcripts were then anonymised by removing identifiers related to the stakeholder, their organisation, and their EU Member State.

Interview participants expressly consented to the interviews being recorded and to the use of the speech-to-text transcription app used to transcribe the recordings. Their consent took place at the beginning of the recordings. The procedure was approved by Ecologic Institute's data protection officer.

The data generated in the interviews was predominantly qualitative in nature. The qualitative data analysis conducted was abductive in nature (straddling a middle ground between deductive and inductive approaches; cf. Thompson J., 2022). On the one hand, the analysis follows theoretical understandings on the topic, which are contained in the questions themselves (particularly in Questions 4 – 7, 10, 14, 17) as well as in the draft project outputs such as impact categories (Question 11) and pharmaceutical lifecycle. On the other hand, the analysis engaged inductively with the empirical data generated, identifying relevant patterns and themes in the different responses to one and the same question and summarising the data available for these patterns/themes.

Analysis was conducted per question. For each question, data was condensed and restructured into a synthesis of the meaningful information provided in the responses.

3 STAKEHOLDER POSITIONS ON A SUSTAINABILITY ASSESSMENT SYSTEM FOR PHARMACEUTICALS

3.1 Overview of stakeholder affiliations and their position in the pharmaceutical life-cycle

The 21 interviews of the interview campaign involved 25 interviewees representing organizations classified according to 9 distinct stakeholder groups. The distribution of interviews among the 9 stakeholder groups is presented in Figure 1.

In addition to the variety of stakeholder groups, interviewees had diverse backgrounds and held a variety of positions, ranging from project management in a national procurement organization, through material and chemistry scientists working in academia, to a general practitioner involved in developing guidelines for fellow GPs.

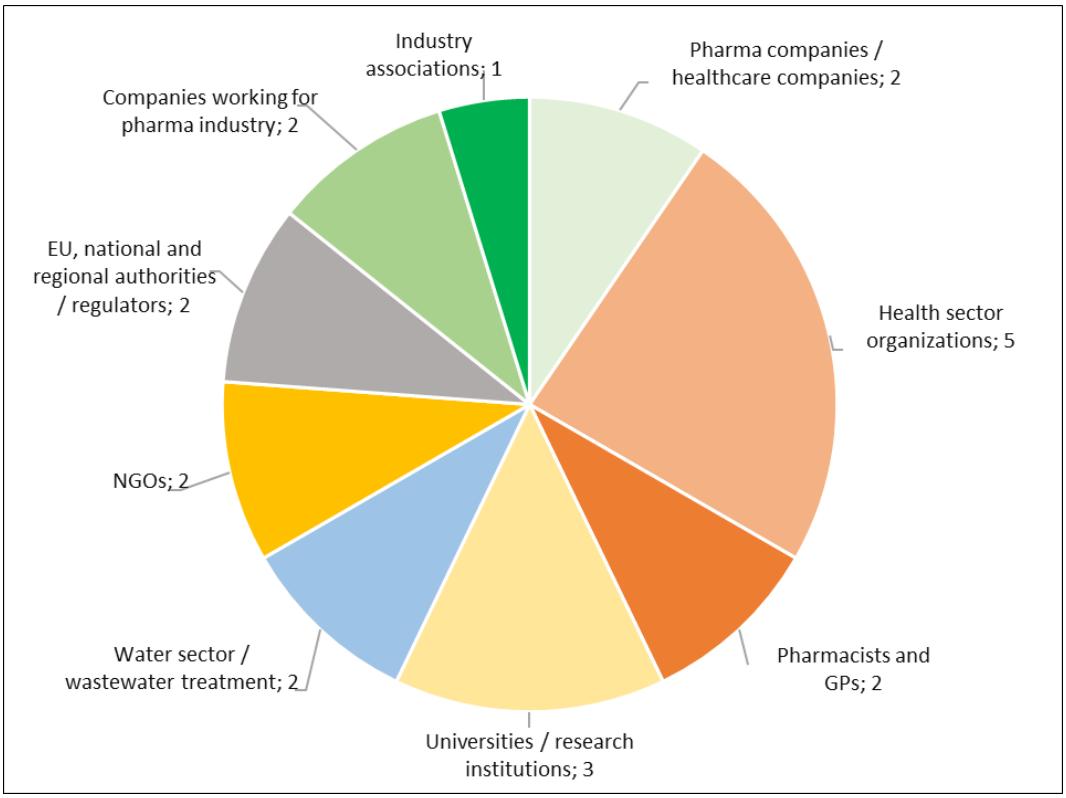


Figure 1: Overview of stakeholder affiliations of interviewees.
Numbers indicate number of interviews per group, total interviews = 21.

Interviewees were requested to indicate in which stage(s) of the pharmaceutical (as conceptualised by UGent, 2023 in Figure 2) their organization is active. The results are depicted in Figure 2, in which the numbers inside the red dots indicate the number of interviewed organizations active in a particular stage. As shown in the figure, the interviews covered quite comprehensively the pharmaceutical cycle, with one noticeable gap related to the marketing of pharmaceuticals.

Additionally, some interviewees identified relevant aspects not currently represented in the life cycle graphic. According to those interviewees, the aspects 'education', 'research' and 'standardization' should be added to the overview of the pharmaceutical life cycle under 'overarching processes and drivers'.

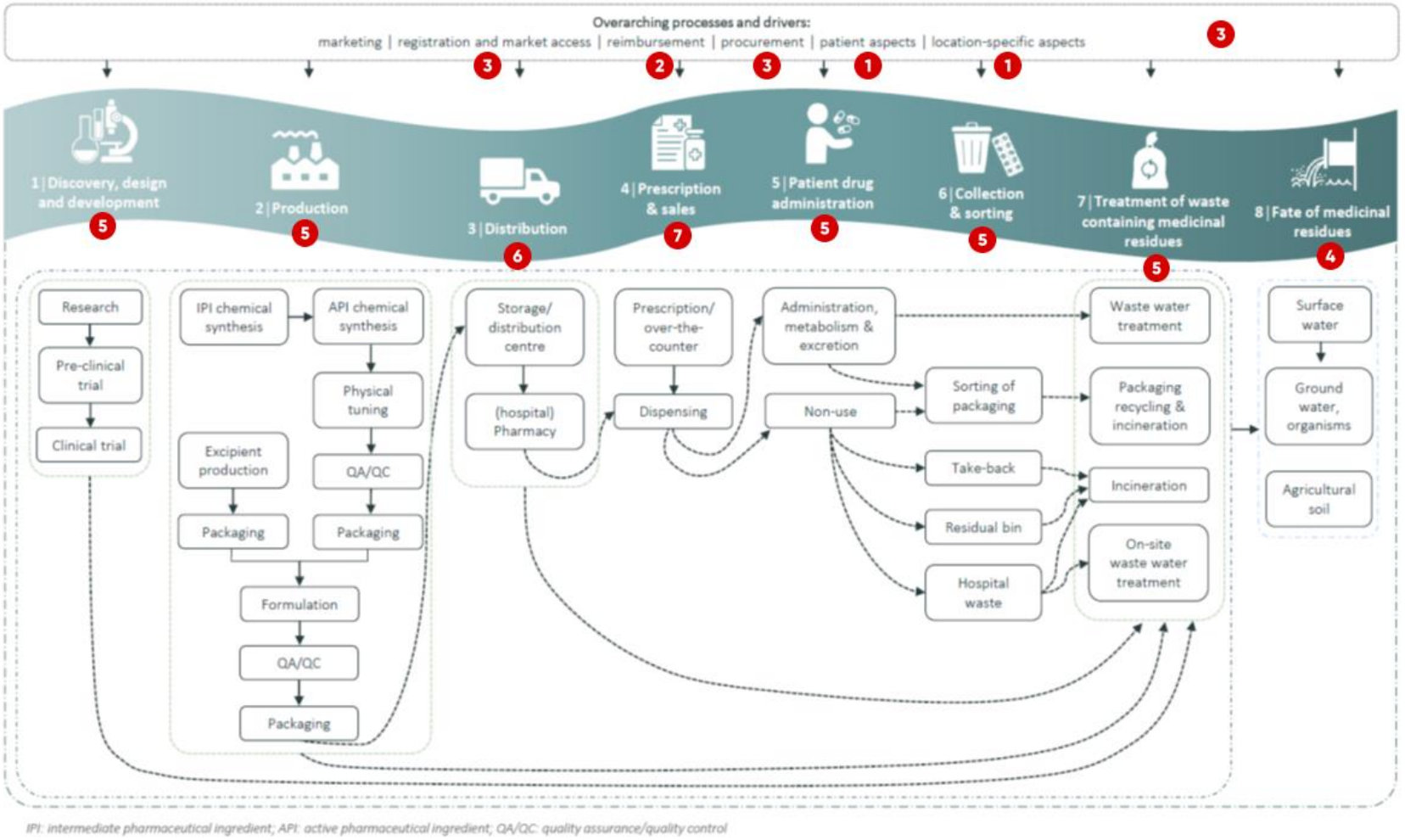


Figure 2: Overview of interviewed stakeholders' positions in the pharmaceutical life cycle.
Number in red icons indicates number of interviewees reporting their organization being active in this area. Numerous responses for one organization were often provided (total sum thus higher than n=21).

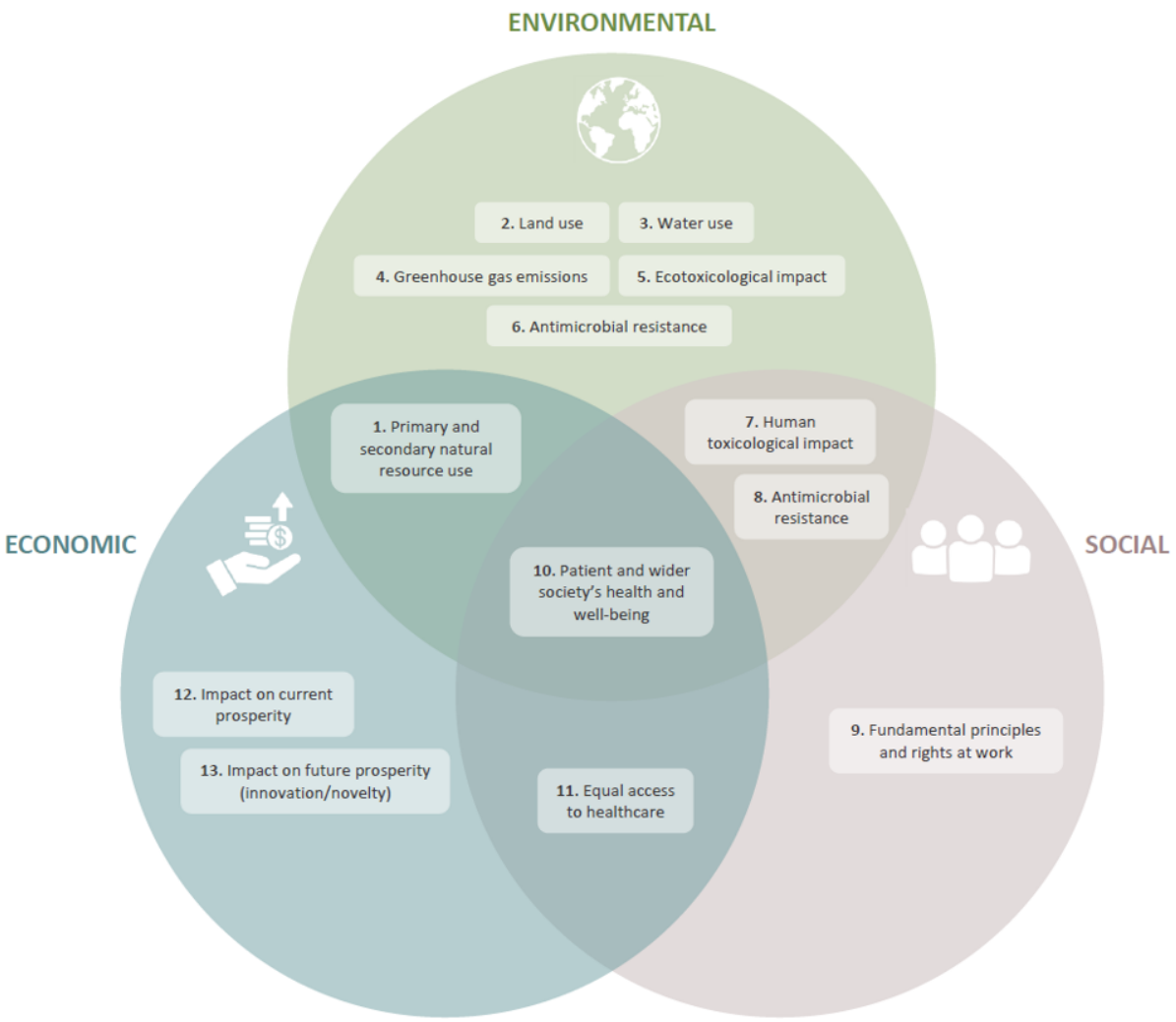
3.2 Sustainability dimensions and impact categories

A key topic the interview campaign wanted to get input for were (a) the sustainability dimensions, and (b) the impact categories within these dimensions which stakeholders consider relevant to their organisations' work. Stakeholders were asked for their views on three dimensions of sustainability, following the framework of Barbier (1987):

1. environmental
2. social
3. economic

Stakeholders were also presented with 13 draft impact categories proposed for uptake in the TransPharm sustainability assessment (developed by Sustainable Systems Engineering (STEN) research group within the TransPharm project, UGent, 2023). In the interviews, definitions of these impact categories were provided to stakeholders and they were located within the different sustainability dimensions. The categories are based on validated impact categories from EU and national projects.

Figure 3 provides an overview of these draft impact categories, their definitions, and their alignment within the three sustainability dimensions.



1. Amount of primary natural resources (e.g. renewable resources, fossil fuels, nuclear energy, metal ores, minerals, atmospheric resources) used, including secondary natural resources (obtained from reuse and recycling practices). This is related to the degradation of resources such as soils, land and water, and air pollution with toxic substances, and thus closely related to climate change and biodiversity loss.
2. Damage to ecosystems due to the occupation of a certain area, its transformation or a combination of both impacts. Land use is a strong driver for biodiversity loss and land use competition.
3. Total water consumption, used to evaluate the impact of the extraction of water, which has a potential for damaging ecosystems.
4. Greenhouse gas emission are increasing the radiative forcing of the atmosphere, which leads to an increment of the global average temperature affecting ecosystems.
5. The toxicological potential of substances (e.g., active pharmaceutical ingredients, excipients, microplastics) emitted to air, soil and water to impact ecosystems.
6. Antimicrobial resistance can lead to a decreased ability to treat infections in the environment.
7. The toxicological potential of substances (e.g., active pharmaceutical ingredients, excipients, microplastics) emitted to air, soil and water, to impact humans.
8. Antimicrobial resistance can lead to a decreased ability to treat infections in people.
9. The "freedom of association and the effective recognition of the right to collective bargaining"; being free "of all forms of forced or compulsory labour"; "of child labour"; "of discrimination in respect of employment and occupation"; and "working in a safe and healthy environment".
10. The burdens (e.g., side-effects) and benefits (e.g., decrease in disability-adjusted life years) associated with the pharmaceutical, which are directly linked to the health and social/financial well-being (e.g., increased social connection, lower out-of-pocket costs) of the patient. This also refers to the impact on health and social/financial well-being (e.g., decreased productivity loss) of the wider society (e.g., health care providers, social network) as a result of the patient using the pharmaceutical.
11. Equal access of vulnerable groups (e.g., women, people with low socioeconomic status) to pharmaceuticals and healthcare (e.g., ability to see a doctor due to social and time restrictions, reading prescriptions).
12. Expenditures (e.g., capital, operational, and end-of-life expenditures) and revenues (e.g., sales of the pharmaceutical, incoming fees, jobs created) related to the lifecycle of the pharmaceutical.
13. Impact of the pharmaceutical on future prosperity (e.g., hindering research, development, innovation (R&D&I) in the pharmaceutical and/or healthcare sector due to patent protection).

Based on validated impact categories developed by EU and NL projects:

1. *Gaasbeek & Meijer (2013). PROSUITE. Handbook on a novel methodology for the sustainability impact assessment of new technologies.*
2. *Harmens & Goedkoop (2021). ORIENTING. Critical evaluation of social approaches.*
3. *Health Care Without Harm (2023. Procuring for greener pharma.*
4. *Van Wezel (2022). Exploration of an assessment framework for medicinal products based on sustainability. Internship report for RIVM.*
5. *ILO Declaration on Fundamental Principles and Rights at Work.*

Figure 3: Overview of proposed Impact Categories to be considered in the TransPharm sustainability assessment (STEN research group, UGent, 2023).

3.2.1 Stakeholder input regarding sustainability dimensions

Questions 1a and 2 focused on stakeholders' views regarding which sustainability dimensions a sustainability assessment system for pharmaceuticals should include.

Question 1a asked interview participants, whose organisations were *currently* working on the topic of sustainability of pharmaceuticals, which of the three dimensions play a role in their work. 20 of the 21 interview partners provided responses. A representative of a health sector organisation provided no response as their organisation, although developing initiatives on the topic, has as yet no legal mandate which would enable them to include sustainability criteria in their decisions concerning pharmaceuticals. Responses are summarised in Figure 4, both for all stakeholders and according to stakeholder groups.

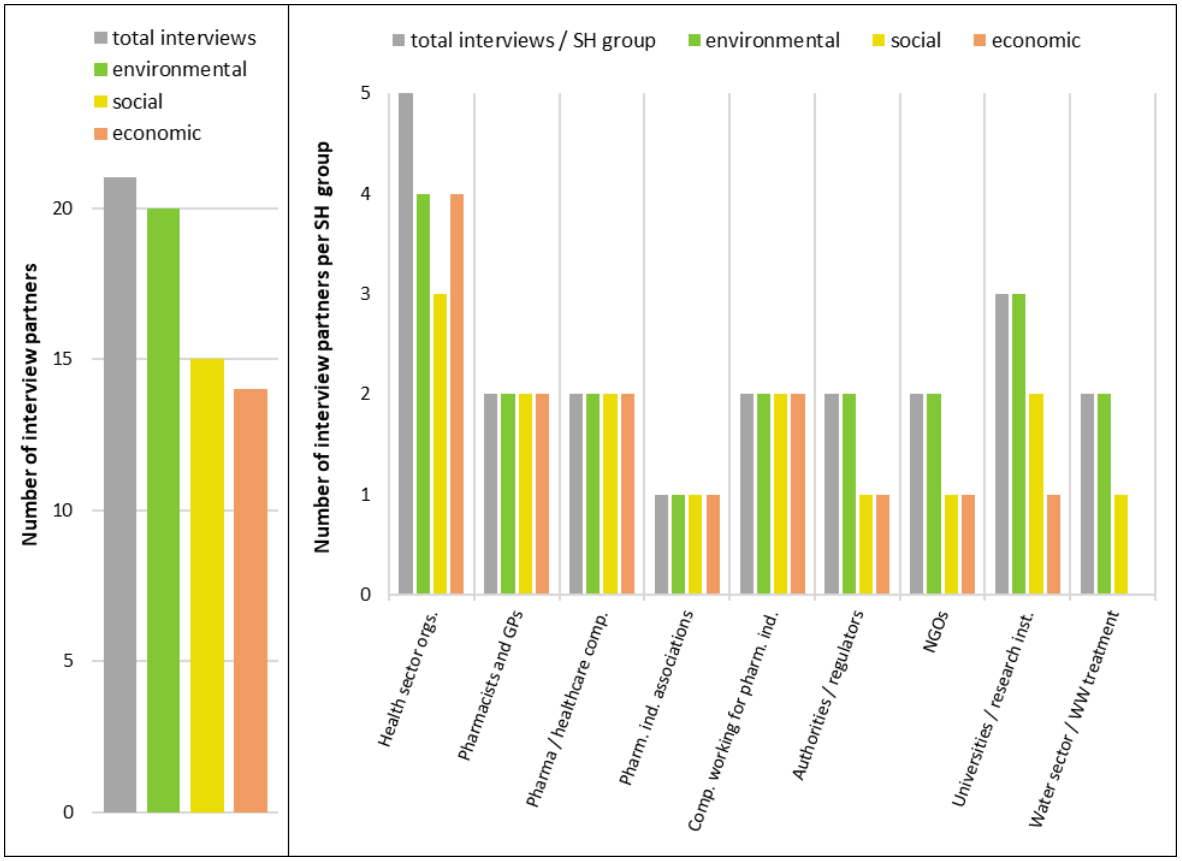


Figure 4: Overview of responses to Q1a, overall (left) and per stakeholder group (right).
Q1a: "Which of the following three dimensions of sustainability play a role in your organisation's work on sustainability of pharmaceuticals? a) environmental; b) social; c) economic.

Every organization interviewed currently working on the sustainability of pharmaceuticals (20 of 21) includes the environmental dimension in its work. The social dimension of sustainability plays a role in 15 of 20 and the economic dimension in 14 of 20 organisations. Among health sector

actors (health sector orgs + Pharmacists and GPs; first two groups in Figure 4, right) and actors involved in pharmaceutical production (pharma companies + industry association + companies working for the pharmaceutical industry; groups 3 to 5 in Figure 4, right), the social and economic dimensions have practically the same number of mentions as the environmental dimension.

The social and economic dimension play less of a role in the work of the interviewed authorities, NGOs, research institutions and water sector organisations, as shown by the tapering off of the yellow and orange-coloured columns towards the right of Figure 4 (last four stakeholder groups in Figure 4, right). This could be an indication of a difference in the approaches to sustainability of healthcare actors and actors involved in pharmaceutical production, compared to that of other stakeholder groups. However, the limited number of interviews does not allow for a conclusion in this regard.

Summing up, responses to Q1a highlight clearly the fundamental role of the environmental dimension in interviewees' organisations' work on sustainability, as well as showing that for most interviewed stakeholders, social and economic criteria also play a role in this work. However, the role of these two latter dimensions was typically caveated in the interviews, by being often described as less or much less prominent than the environmental dimension in their work. Numerous interview partners had responses similar in character to that of Interview 14 (university / research institution), who summarized their response to Q1a as *"Mostly a), partly b) and touching on c)"*.

Question 2 asked participants to provide an evaluation of the importance of the three sustainability dimensions when assessing the sustainability of pharmaceuticals. The options provided were "*very important*", *"somewhat important"*, and *"of low importance"*. The results are presented per dimension in Figure 5, both as average over all interviewed stakeholders as per stakeholder group.

Figure 5: Overview of responses to Q2, overall (left) and per stakeholder group (right).
Q2: "Which of the following three dimensions of sustainability do you consider "very important", "somewhat important", or "of low importance" when assessing the sustainability of pharmaceuticals? a) environmental, b) social, c) economic."

Assigning values of 3, 2 and 1 respectively to the options *"very important"*, *"somewhat important"* and *"of low importance"*, interviewees give the environmental dimension the maximum possible score (average score: 3), with all interview partners considering this aspect *"very important"*. The social and economic dimension both obtained average scores close to 2.5 (average score: 2.57 and 2.43, respectively), i.e. halfway between *"very important"* and *"somewhat important"*. No clear pattern emerges from the analysis of responses per stakeholder group.

Just as for Q1a, the results for the social and economic dimensions in Q2 should be caveated somewhat. Interview transcripts show that respondents often took this question as referring to how important the three dimensions are for the sustainability of pharmaceuticals or that of their production, rather than the importance for an assessment system addressing their sustainability. For instance, responses often highlighted the importance of economic sustainability for the sector, rather than the need for assessing economic aspects as part of a sustainability assessment. An example is given in Interview 21 (water sector): *"They [the three dimensions] go together. You cannot have one without the other. In my opinion, we cannot have a viable [pharmaceutical] industry without profits. You can discuss about profit margins, but that's what it is."* This is not comparable to believing the economic dimension should be assessed.

The following section provides more granularity on stakeholders' organisations' data requirements concerning a system that assesses the sustainability of pharmaceuticals.

3.2.2 Stakeholder input regarding impact categories

Question 11 presented stakeholders with the TransPharm draft impact categories (cf. Figure 3), while asking them to provide an evaluation of their relevance (high, middle, low) for their organisations' work and to identify any in their opinion missing categories. Figure 6 provides an overview of the responses regarding relevance (all stakeholder groups).

The figure shows that ICs 1 to 8 score significantly higher than ICs 9 to 13. For all of the former, over 50% of stakeholders consider them *"very relevant"* scores, and with the exception of IC2 – Land use, the share of stakeholders considering them very relevant is higher than 65%. *IC6 – AMR environment* and *IC8 – AMR people* have comparable ratings and show the highest scores, with over 90% of stakeholders considering them *"very relevant"*. The conceptually related categories *IC5 – Ecotoxicological impact* and *IC7 – Human toxicological impact* also show comparably high scores to each other.

These higher scoring ICs are all part of the environmental dimension, with IC1 intersecting with the economic dimension and ICs 7 and 8 with the social dimension (cf. Figure 3). The one IC part of the environmental dimension that does not score as highly is *IC10 – Patient and wider society's health and well-being*, which is also part of the economic and social dimensions.

Scores for ICs that are not part of the environmental dimension are significantly lower, with no category reaching more than 33% of *"very relevant"* scores. Categories that are part of the social

dimension (ICs 9, 10 and 11) score higher than the categories purely located in the economic dimension, ICs 12 and 13, on current and future prosperity. These two categories have comparably low scores, with 10% of *"very relevant"* responses, while *IC12 – Impact on current prosperity* scores slightly higher in the *"middle relevance"* response.

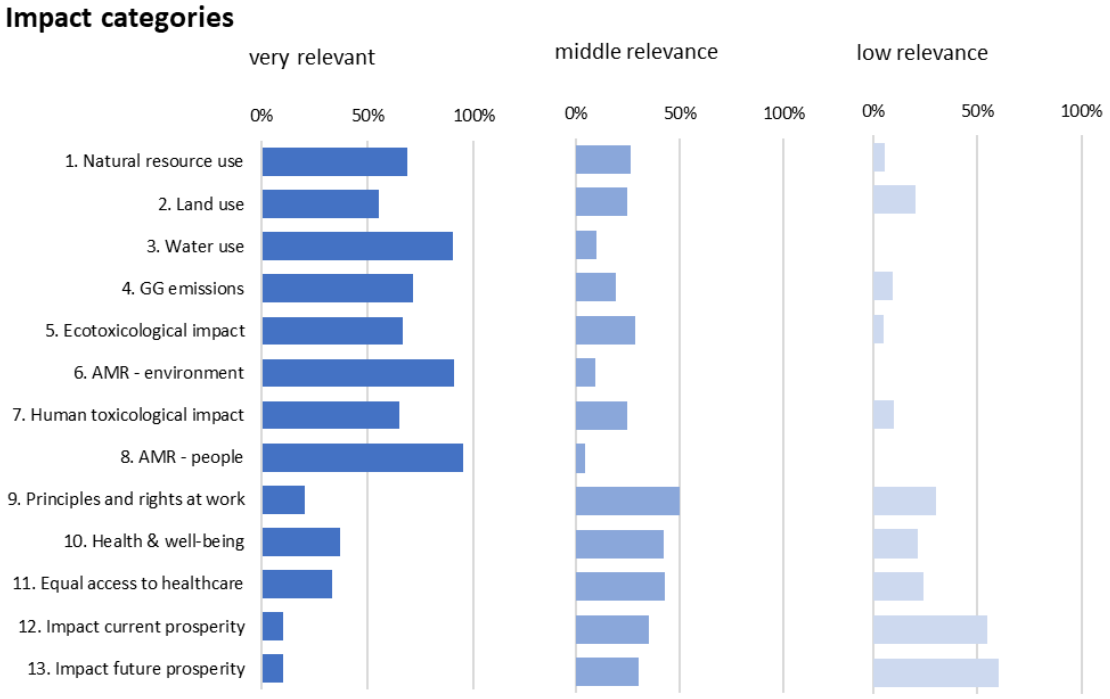


Figure 6: Stakeholder responses on the relevance of the TransPharm draft impact categories for their work, as percentage of all responses.

Figure 7 provides an overview of the stakeholder responses regarding the relevance of the draft impact categories, grouped by stakeholders.

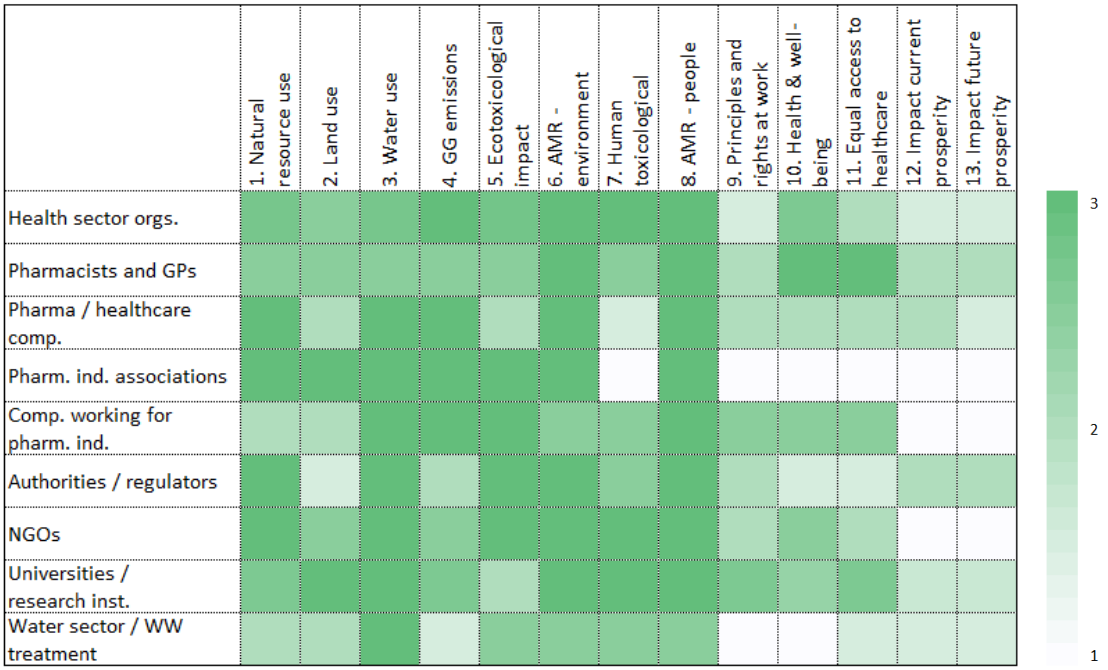


Figure 7: Heat map of average stakeholder responses re. relevance of Impact Categories, per stakeholder group. 3 = very relevant, 2 = middle relevance, 1 = low relevance

This figure again shows the clear difference in stakeholders' assessment of the relevance of ICs 1-8 vs. that of ICs 9-13. This difference holds in general terms across all stakeholder groups, thus seeming to indicate that the relevance of the environmental ICs for stakeholder organisations is higher across the board for all stakeholders. As already mentioned, these observations should not be overinterpreted due to the limited number of interviews performed (n=21).

3.2.2.1 Suggestions for additional impact categories

A limited number of additional impact categories were suggested by stakeholders in the interviews:

- Inclusion of an IC *"Workers' safety"* in the social dimension, as a distinct category to IC9 - Fundamental principles and rights at work.
- Inclusion of an IC in the social dimension addressing a company's ethics, transparency around reporting, and bribery.
- Inclusion of an IC around companies' human capital as a social objective.
- Inclusion of categories 'missing' in the TransPharm impact categories compared to the 16 environmental impact categories of the EU Commission's Product Environmental Footprint Method (e.g. particulate matter, ionising radiation, eutrophication, ozone formation).

A few stakeholders argued for including biodiversity as a distinct impact category. (In the draft ICs biodiversity is not a distinct category but is mentioned explicitly in ICs 1 and 2, and also has links with other ICs.).

3.2.2.2 Methodological issues identified by stakeholders

In the discussions regarding the TransPharm draft impact categories, stakeholders identified several methodological issues that could affect the TransPharm assessment system. These are summarised in the following.

- Scepticism regarding the possibility of evaluating certain ICs in the near future: Numerous interview partners pointed out that several proposed criteria are desirable in theory, but difficult if not impossible to implement in practice today. Different rationales for the difficulty were provided:

  a. *Availability of data:* Many stakeholders reported currently working on sustainability criteria for pharmaceuticals. They would be focusing their efforts on a few criteria where data availability would enable their being evaluated. Data often considered accessible was data on AMR (ICs 6 and 8), ecotoxicity (IC5), water use (IC3) and greenhouse gas emissions (IC4). The remaining parameters, although considered desirable, were considered as only realistic in a rather distant future.

  b. *Scientific knowledge/studies lacking on topic:* Two interview partners were sceptical of including *IC7 – Human toxicological impact*, due to lack of scientific knowledge on topics such as the impacts of micropollutants on human health, cocktail effects, etc.

  c. *Lack of clarity regarding methodology:* Very significant challenges for implementation were identified for *IC2 – Land use*.

  d. *Complexity of measuring some ICs across the whole supply chain:* The number of companies and thus the effort involved in evaluating some of the ICs was seen by some participants as too high to justify the effort. (This objection was typically mentioned for ICs that are only in the social and economic dimensions.)

  e. *Complexity of the impact category:* Some interviewees highlighted that ICs of the social dimension would include too many details to be viable in practice. (In addition, some of the social ICs were seen as at least partly addressed by the use of minimum standards in contracts.)

- Overlaps between impact categories: Several interviewees highlighted the potential for overlaps between proposed categories, thus potentially leading to double counting. They specifically identified potential for overlap between IC1 – Primary and secondary natural resource use, IC3 – Water use and IC4 – Greenhouse gas emissions.

- ICs 6 and 8 addressing antimicrobial resistance (AMR): The two-fold inclusion of antimicrobial resistance caused confusion for approximately half the stakeholders and required clarifying discussions. A few stakeholders argued for the two ICs to be merged into one IC addressing AMR. One interviewee was in favour of the current approach of two ICs for AMR.
- Duplication of ICs with already existing, widely implemented initiatives: Some ICs in the social dimension were seen as already being addressed, either in legislative criteria, in contract practice or via initiatives such as the Global Compact. This was mentioned particularly often for IC9 – Fundamental principles and rights at work and for IC11 – Equal access to healthcare.

In general, whereas most stakeholders were strongly supportive of an assessment system encompassing many and varied ICs of all three dimensions, they highlighted again and again the very significant challenges in implementation. Stakeholders often emphasised that efforts should be focused on those ICs where it is possible to have 'proper' indicators with robust data, to *"build on what we have"*, and to not focus on those proposed ICs they saw as requiring years or decades of effort to become reality. This should not be a rationale for leaving indicators outside of an assessment system, though, but rather to take them up at an adequate moment in time.

3.3 Aim and application

3.3.1 Aim and application of an environmental sustainability assessment

A key aspect with impact on practically every feature of an assessment system is the aim(s) for which it will be used. For example, if the aim is to identify options for reducing environmental impacts along the life cycle of a pharmaceutical product, the questions that need to be answered by the assessment will be different than if the central question is which APIs should be preferred over other APIs with an equivalent health benefit.

The interviews addressed this topic in two questions. Question 4 was about the concrete decision-making processes that stakeholders would like an evaluation system to support, whereas Question 5 was about the overarching objectives for which they would use such an evaluation system.

3.3.1.1 Decision-making processes to be supported by an environmental sustainability assessment

Question 4 presented interviewees with a set of decision-making processes as a multiple-choice list, and included the option for them to suggest additional processes. The multiple-choice responses were selected from the most mentioned foci in literature and were as follows.

- **a.** Facilitating choices between different types of treatments (including non-pharmaceutical treatment and no treatment)?
- **b.** Facilitating choices between different APIs?
- **c.** Facilitating choices between different products with the same API?
- **d.** Facilitating choices between different pharmaceuticals processes (for the production of the same API)?
- **e.** To identify hotspots of environmental impacts within the lifecycle of the pharmaceutical product, for targeted mitigation efforts?
- **f.** For other aspects in the decision-making? If yes, which ones?

In case the interviewees' organization already uses an environmental sustainability assessment, they were asked to indicate which decision-making processes make use of its results. Figure 8 summarises interview responses.

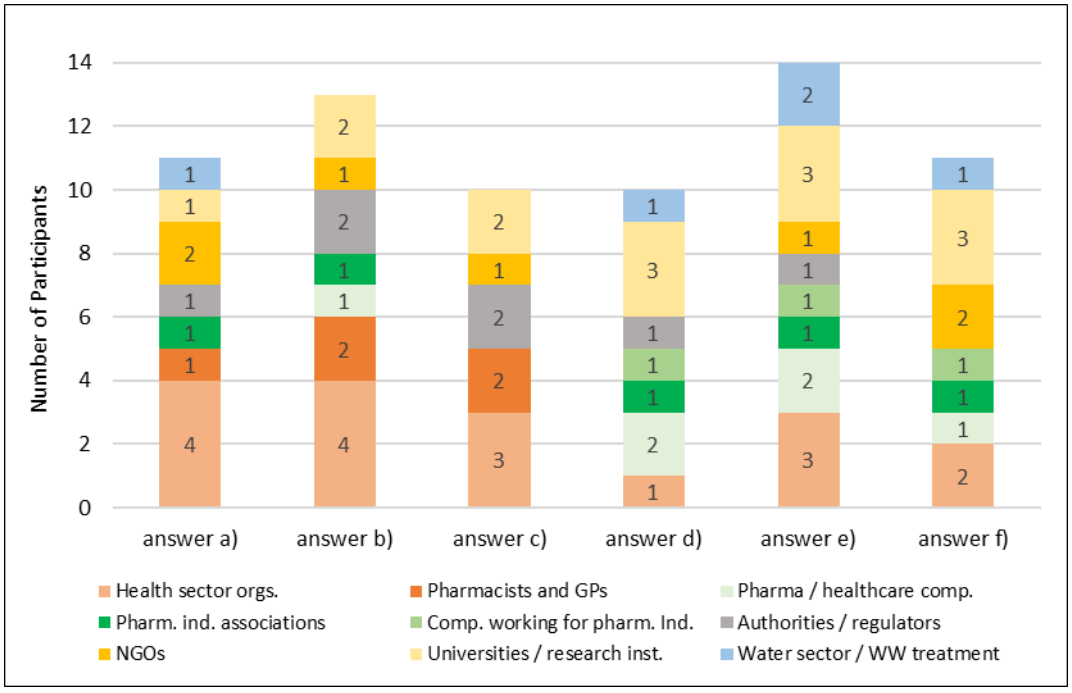


Figure 8: Stakeholder view´s on decision-making processes that should be supported through an environmental sustainability assessment.
Q4: In which specific decision-making processes would your organisation want to use an environmental sustainability assessments of pharmaceuticals? (multiple answers possible): a) Facilitating choices between

different types of treatments; b) Facilitating choices between different APIs; c) Facilitating choices between different products with the same API; d) Facilitating choices between different pharmaceutical production processes; e) To identify hotspots of environmental impacts within the lifecycle of the pharmaceutical product, for targeted mitigation efforts; f) For other aspects in the decision-making? If yes, which ones?
Respondents usually gave more than one answer as their organizations either use or would want to use such assessments to answer different questions.

The answer selected most often and across nearly all stakeholder groups interviewed is e, *"identify hotspots of environmental impacts within the lifecycle"*. This answer is closely followed by b, *"Facilitating choices between different APIs"*. Least interesting to the interviewees were option c, *"Facilitating choices between different products with the same API"* and d, *"Facilitating choices between different pharmaceuticals processes"*.

A preliminary conclusion is that all decision-making processes listed are relevant for stakeholders, who would use a sustainability assessment system for pharmaceuticals to support them in these processes. Looking at the distribution, there seems to be a tendency for organisations that are more concerned with procurement and the patient (the healthcare sector plus pharmacists and GPs) to use assessment to choose between treatments, active ingredients, or products. Representatives of manufacturing stakeholders were proportionally more interested in optimising processes and identifying environmental hotspots. However, with 21 respondents and a difference of only four votes between the most and least popular answer, the rating is not representative and can only give a first impression.

A representative of the healthcare organisations stakeholder group explained that the emphasis can change depending on the class of pharmaceutical. For example, facilitating choice between different types of treatment (option a) has recently been applied to procurement for asthma therapy. Gases used to treat asthma (with a high carbon footprint equivalent) may be excluded from purchasing agreements in favour of other types of treatment. The metered-dose inhalers for asthma have a high environmental impact in the use phase. Providing information to patients can already have a significant mitigating effect. However, impacts in the impact in the production and development phase are not accounted for but can be addressed through exclusions in purchasing agreements.

An additional implementation scenario (option f) could be to identify the most harmful pharmaceuticals and remove them from the list of options. This could motivate industry to consider environmental aspects in the development of pharmaceutical products. Conversely, environmental criteria could also be used as minimum standards for the selection of new pharmaceuticals.

For institutions that may have this freedom, it was considered an interesting option to choose between pharmaceutical products with the same active ingredient (option c), for example in the case of mass-produced generics. However, one respondent pointed out that only insurance companies can decide which pharmaceutical product is to be given preference.

Respondents from pharmaceutical companies stated that the optimisation of pharmaceutical production processes is of great importance, with an assessment system possibly enabling

decisions between different production methods. At the same time, the identification of environmental hotspots throughout the lifecycle is important for a number of reasons, including cost reduction and the potential for green business ventures. Sustainability is also a business opportunity that links seamlessly with key procurement considerations.

Having a tool to better understand the different environmental impacts, including the carbon footprint, along the supply chain is seen as very helpful for decision making.

Interview outcomes show a growing demand for sustainability in procurement, as evidenced by the increasing number of requests to pharmaceutical companies for environmental information from relevant organisations in various EU Member States. In particular, the discussion around certification in antibiotic production has emerged. Here, a point-based incentive for certified processes may be on the horizon. Another route being discussed would be to award moderate points for compliance with the standards set by the AMR Industry Alliance[2], and no points for lack of production standards.

Facilitating choices between different types of treatments or products are not central to the respondents from pharmaceutical companies. However, it was highlighted that many aspects relevant to environmental sustainability are considered early in the development phase. Thus, the identification of environmental hotspots is an interesting field of application for an assessment framework. Such an assessment facilitates important choices about production methods and how or which point clean chemistry principles need to be considered. A respondent said that already optimization processes not only cover the design of the active ingredient but also the manufacturing process with a spectrum of variables including materials, production volumes, process streamlining and yield improvement. This approach fits well with the options d, *"Facilitating choices between different pharmaceuticals processes"*, and e, *"identify hotspots of environmental impacts"*.

Views within the stakeholder group *"EU, national and regional authorities / regulators"* are divided regarding the relevance of certain options. While one representative opines that option a and option b, centred around facilitating choices between different types of treatments or active pharmaceutical ingredients (APIs), do not hold significance for this stakeholder group, another respondent from the same group holds a nuanced perspective. This second respondent suggests that option a could be pertinent when considering choices between formats like tablets or liquid medications versus external applications such as creams or patches. They perceive an overlap in the context of non-pharmaceutical treatments and the absence of treatment altogether.

[2] *The Antimicrobial Resistance Alliance unites more than a hundred member companies along the supply chain https://www.amrindustryalliance.org/, last accessed 09.08.2023*

Both respondents concur on the scope of their work encompassing the facilitation of choices between products that share the same API (option c). One respondent revealed ongoing efforts in determining the optimal criteria for such facilitation.

While recognizing the potential relevance of identifying hotspots of environmental impact within the pharmaceutical product life cycle (option e), most hotspots are located outside Europe and are therefore considered to be outside regulators' scope of action. Consequently, this aspect is not considered a primary focus of efforts.

Stakeholders from the water sector concurred that most aspects are not within the scope of their work but that they are primarily interested in identifying the amount and the persistence of pharmaceuticals in waste water. Nonetheless, they expressed general interest to support any actions that may provide information on or reduce the sources of water contamination – be it in the production or use phase.

From the perspectives of pharmacists, the choice between different treatment options (option a) is the most important, including non-pharmaceutical alternatives and no treatment. Furthermore, currently, information is lacking on how green production of pharmaceuticals is, despite customer demand for such knowledge. Some countries provide guidelines and standard operating procedures (SOPs) for pharmacists to advise patients, particularly on over-the-counter (OTC) medicines with lower environmental impact. While this practice isn't universal, some members of the profession incorporate these assessments into their patient counselling and advice roles.

The group of pharmacists and general practitioners also considered central to provide advice on different ingredients or products (options b and c) to patients. Choosing between different active ingredients, is particularly useful in scenarios where certain options are not in short supply, enabling pharmacists to suggest environmentally conscious alternatives.

Suppliers to industry may focus on option d, which involves facilitating the choice between different pharmaceutical processes, thus aiming to use such an assessment system for conducting comprehensive environmental assessments across their processes. For example, in cases where multiple processes are involved in the manufacture of an API, the environmental impact of each process is relevant; when changes are made to a process, it is useful to understand how this change will result in an improvement, deterioration or neutral impact on the environment. Over time, process changes to improve production efficiency and yield may require careful consideration of their environmental impact. However, this is a complex and challenging task. The widely used Process Mass Intensity (PMI) metric, which measures the amount of material required to make a product, was criticised as not capturing the full range of environmental considerations. PMI would overlook the use of hazardous chemicals as well as the energy-intensive aspects of production. It would also ignore factors such as manufacturing methods. Thus, a holistic environmental assessment that provides a comprehensive picture would still be missing. In option e, addressing life cycle hotspots is seen as a key focus for

suppliers. At least in some cases, companies are already trying to stay ahead by re-evaluating established APIs using modern chemistry, technology and equipment, often leading to more sustainable synthesis routes.

An additional option f identified was the integration of environmental sustainability assessments into companies' capital expenditure (capex) processes. This involves assessing the environmental impact of potential equipment purchases or the construction of new facilities and enabling the choice of the least environmentally damaging option with equivalent functionality.

Among NGO representatives there were conflicting opinions on option b, 'Choice between different APIs', which was considered too specific by one respondent and highly relevant by the other. However, there was agreement on the relevance of option a, 'Facilitating choice between different types of treatment'. To illustrate this point, an interviewee highlighted the choice of contraceptive methods. Individuals face a choice between hormonal and non-hormonal contraceptives, or even non-pharmaceutical alternatives. Similarly, the choice of painkillers involves weighing environmental sustainability considerations. Knowledge of the environmental impact can support the patient's decision by highlighting the importance of this option. In addition, facilitating the choice between products with the same active ingredient (option c) is considered to be in line with the commitment of NGOs to promote environmentally friendly practices. It should be noted here that one NGO representative emphasized that they cannot carry out sustainability assessments themselves but that they would like to see assessments to the specified purposes being carried out by other stakeholder groups.

Considering the feedback from interviewees from academia, they may work in different decision-making processes, depending on the project and the partners. However, there was agreement as to environmental sustainability assessments of pharmaceuticals being a relevant aspect in a wide variety of decision-making processes. The layout of the assessments, however, depends on the application. Thus, the application needs to be defined first and the assessment set-up accordingly.

3.3.1.2 Overarching objectives to be supported by an environmental sustainability assessment

Question 5 aimed to identify the overarching objectives that would guide an organization's utilization of an environmental sustainability assessment for pharmaceuticals, i.e. it seeks to understand the key priorities and goals that the organization would thus seek to achieve. The options provided in the multiple-choice options represent potential strategic objectives that the organization might pursue. These objectives encompass (a) developing greener pharmaceuticals, (b) making processes in the production of pharmaceuticals greener, (c) prescribing greener pharmaceuticals, (d) ensuring the procurement of greener pharmaceuticals, (e) making the public and/or other stakeholders aware of the environmental impacts of pharmaceuticals, and finally option (f) enabling the public and/or other stakeholders to factor in environmental impacts

when making decisions on the purchase or prescription of pharmaceuticals. The question also acknowledges the potential for organizations to have additional objectives beyond the provided options, as indicated by option (g). Results are shown in Figure 9.

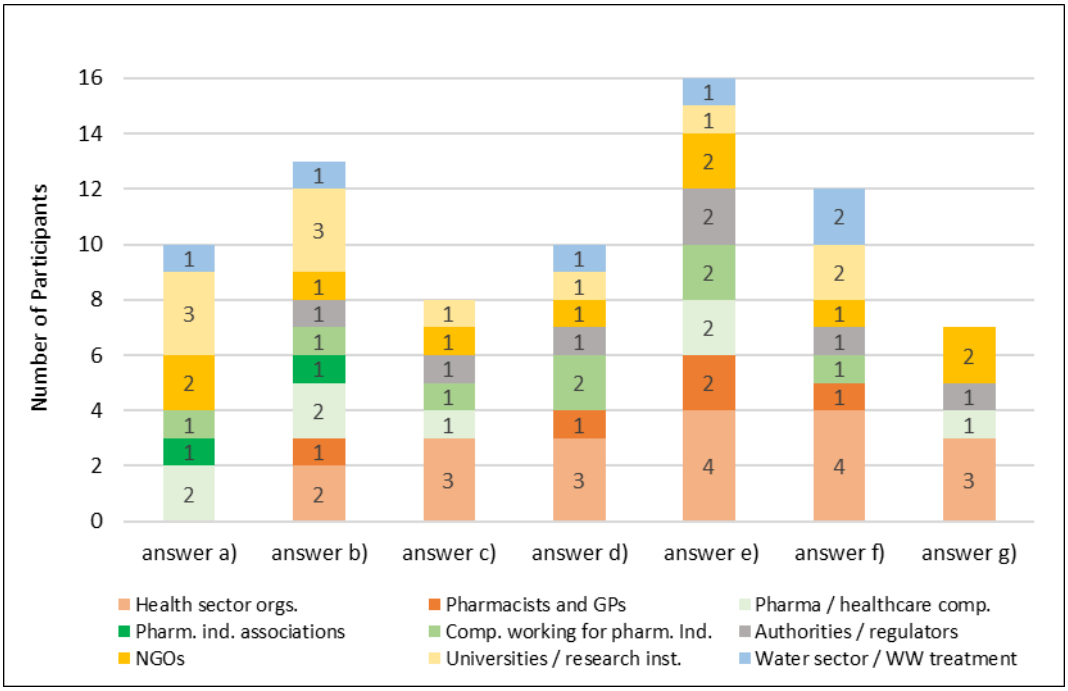


Figure 9: Distribution of responses regarding the overarching objective of an environmental sustainability assessment.
Q5: Which are/would be your organisation's overarching objectives when making use of such an environmental sustainability assessment? (multiple answers possible): a) Develop greener pharmaceuticals; b) Make processes in the production of pharmaceuticals greener; c) Prescribe greener pharmaceuticals; d) Ensure the procurement of greener pharmaceuticals; e) Make the public and/or other stakeholders aware of the environmental impacts of pharmaceuticals; f) Enable the public and/or other stakeholders to factor in environmental impacts when making decisions on the purchase or prescription of pharmaceuticals; g) Other? If yes, which ones?

An issue brought up when discussion option (a) developing greener pharmaceuticals was that the term 'green' or 'greener' pharmaceuticals lacks clarity. In the context of the water sector, as one interviewee mentioned, it could refer to substances that readily degrade. Having compounds that can be filtered out of wastewater streams but that persist in sewage sludge was not seen by these actors as a satisfactory outcome, while in other contexts this may differ. Another interviewee working for a Contract Development Manufacturing Organization (CDMO) pointed out, that this task is quite challenging, it will require significant time and effort to transform the development and production of pharmaceuticals, including making changes to the current portfolio. As manufacturers, they noted that the development of greener pharmaceuticals is usually not within their direct control, while option (b) making production processes more environmentally friendly is very much their objective. Nevertheless, several persons with an industry or production background emphasized the importance of options (a) and (b) from their

point of view. In the context of greener production reference was made to the Antibiotic Manufacturing Standard which was published by the AMR industry alliance in 2022 as well as to the associated certification scheme developed by British Standards Institution (BSI), a United Kingdom standards body.

Another key aspect was option (e) raising awareness and education regarding the environmental impact of pharmaceuticals. A large proportion of the interviewees highlighted the significance of informing the public and healthcare professionals about these effects. For instance, one interviewee expressed the goal of educating General Practitioners and patients about sustainable choices. Others also stressed the need to disseminate information to enable informed decisions and responsible usage. Someone from the water sector, for example, explained that they, as the last barrier, would try to ensure through educational work that the lowest possible concentration of harmful substances arrives at the sewage treatment plants in the first place.

Option f, enabling the public and stakeholders to factor in environmental impacts when making decisions about pharmaceutical purchase and prescription, emerged as a significant objective as well. This resonated with the desire from several stakeholders for a *"green label"* for pharmaceuticals to facilitate informed decision-making. This idea was not only put forward by interviewees working in the field of procurement, prescription, pharmacies or GPs but also from within the water sector and industry. As an example, reference was made to a label developed by the Swedish pharmacy association for OTC medicines. One interviewee associated with the pharmaceutical industry remarked that, while this not being their main focus, they acknowledge their role in providing information to enable public and other stakeholders to factor in environmental aspects (option f) and in raising awareness and communicating with stakeholders (option e).

In relation to option c, the interviewees underscored the crucial role of educating and informing General Practitioners about the environmental implications of pharmaceuticals. They also highlight the growing patient interest in sustainable choices, leading to a suggested *"information duty"*. Drawing inspiration from a concept in Sweden, some interviewees referenced the idea of a 'Wise list' as a potential strategy for prescribing more environmentally friendly pharmaceuticals.

Moreover, the procurement of greener pharmaceuticals (option d) was underscored as an essential objective by several interviewees. Primarily but not exclusively, interviewees from the procurement sector saw themselves in this role. However, they acknowledged the need for a mature market with greener pharmaceutical options for effective and greener procurement and emphasized that both pushing for greener options and having suitable products available are necessary for progress.

A person working in reimbursement made the observation that his organization aims to choose greener pharmaceutical products within the constraints of social health insurance (e.g. mandate of cost efficiency). They are considering rewarding companies with higher sustainability scores

through discounts, preferred dispensing pharmacies, and tendering procurement practices. However, before this system can be implemented, they need to be legally mandated to do so.

Interestingly, two interviewees with an industry background also mentioned the relevance for their organisations' procurement processes. Their role does not entail directly procuring green pharmaceuticals. Instead, they focus on a more upstream approach, specifically exploring ways to procure environmentally friendly starting materials. Therefore, they acknowledge the value of an environmental assessment in facilitating communication with suppliers.

Further overarching objectives mentioned (option g) covered enhancing waste management (e. g. the recycling of single-use syringes) and improving cooperation and communication with other actors and partners along the pharmaceutical life cycle.

The overarching objectives of interviewees in research or university settings exhibited significant diversity, shaped by their distinct research domains and projects. They either selected options pertinent to their specific focus or often embraced all available choices. Similarly, individuals affiliated with NGOs typically favoured multiple selections, reflecting their comprehensive viewpoint.

Discussions on options different to options a and b often circled back to these two options. Options c to f were often described as mediating the actual goals of a) greener pharmaceuticals and b) greener processes. These objectives were seen as foundational, indirectly impacting other purposes. For example, as one interviewee indicated, while their main mandate is ensuring the procurement of (greener) pharmaceuticals, this goal is closely related to the effort to make production processes greener; their aim in the uptake of environmental criteria in procurement processes is to *"develop, not divest of producers"*. This indirect link can be seen in the integration of production standards into procurement requirements or vice versa in the necessity for greener pharmaceuticals to be accessible for procurement purposes. From the perspective of pharmacists and GPs, this means developing an incentive for the pharmaceutical industry to become more greener by e.g. having a sustainability label and greener purchasing decisions. At the same time, pharmaceutical companies, for example, can only influence prescription guidelines to a very limited extent and pharmacies have only limited influence on the development of greener medicines. This shows the interconnections and interdependencies within the pharmaceutical life cycle. On the one hand, actors have the possibility to indirectly influence other areas. On the other hand, there is a core area that can be influenced more or less directly.

3.3.2 Aim and scope of an overall sustainability assessment

3.3.2.1 Purposes of stakeholders for using an overall sustainability assessment

Question 6 broadened the focus by moving from an environmental sustainability assessment to an assessment of overall sustainability (i.e. including the social and economic dimensions). Interviewees were asked for which purposes they now or would like to in future use such an assessment. The proposed options included (a) educating stakeholders on how to perform a full holistic assessment, (b) comparing benefits (e.g. for human health and wellbeing, including social & economic aspects) with negative (predominantly environmental) impacts, (c) identifying and highlighting trade-offs between different types of treatments, and (d) other purposes.

Most interviewees stated that their organization is currently not using an overall sustainability assessment, among other things due to the lack of a robust framework and complete data. At the same, they declared themselves in favour of the development and use of such an assessment system. Responses are summarised in Figure 10.

One objective prevalent amongst stakeholder groups was the use of such a system for education and awareness regarding holistic assessments (**option a**). One interviewee however, found this approach less relevant due to perceived challenges in comprehensive stakeholder education. They underscored the relevance of education about risks but doubted the practicality of imparting detailed environmental assessment specifics.

The purpose of comparing benefits and negative impacts (**option b**) stood out as the most voted for option in the overall view.

A pharmaceutical industry representative emphasized the significance of evaluating both benefits and drawbacks of specific chemicals, using Trifluoroacetic acid (TFA) in peptide manufacturing as an example. A comparison of benefits and negative impacts could provide arguments against the banning of compounds that are hard or impossible to replace in the production of important medication.

Similarly, a representative of an industry association highlighted challenges in comparing benefits and drawbacks. They cautioned against solely relying on environmental impact for decisions, pointing out the potential for conflicting priorities. The interviewee emphasized the need for evidence-based and validated methodologies to navigate the dilemma of recommending products with varying medical and environmental impacts.

This view was also expressed by an NGO representative, who underscored the importance of preventing barriers to necessary treatments through environmental assessments and ensure access to essential medications. On the other hand, they emphasized the necessity of factoring in environmental risks, particularly when viable alternative treatment methods are available. This need for a method that can deal with complex trade-offs was also identified by a person working

for a health sector organization, exemplified by their organisation's shift from propellant-based inhalers (which emitted harmful greenhouse gases) to dry powder inhalers (which entail increased plastic usage).

Option c received significantly less support overall compared to options a and b. Interestingly, besides the already mentioned pharmacists and GPs (consumers), the stakeholder groups pharma companies / healthcare companies, companies working for pharma industry, industry associations and EU, national and regional authorities / regulators found this option less relevant.

Nonetheless, people from the groups of health sector organisations and NGOs were particularly in favour of this option. One interviewee for example stated that their current emphasis lies on treatment costs, accessibility, and clinical efficacy. However, they highlighted the potential value of incorporating a sustainability perspective when faced with various treatments that possess equivalent costs and clinical effectiveness. This could provide valuable insights into the contrasting sustainability aspects between the options.

Interestingly, opinions within the groups with a public procurement and pharmacies background diverged. While one representative of a public procurement organization clearly advocated for option b, another one explained that b and c might not be feasible for them due to their limited control over treatment choices and the decision-making process of the decision-making body. However, if the decision-making body were to incorporate the assessment's findings, they held this could influence their procurement decisions and impact the entire supply chain.

Also, one individual from a pharmacy association outlined the difficulties they face concerning options b and c, underscoring that their responsibilities primarily entail dispensing medications based on healthcare provider recommendations. This limitation hinders their direct comparison of treatment benefits or selection. Despite recognizing the importance of such assessments, they grapple with the practical implementation within their current role. Conversely, another interviewee with a background in pharmacy expressed a preference for options a and b. They advocated for the education of stakeholders on the comprehensive holistic assessment and the comparison of treatment benefits, deeming these aspects most pertinent from their perspective. In relation to option c, which involves the identification and highlighting of trade-offs between varying treatment types, the interviewee acknowledged its relevance but indicated it might hold less significance within the pharmacist's purview.

In addition to the previously discussed options, interviewees mentioned as additional purposes related to an overall sustainability assessment **(option d)** the utilization of the assessment to pinpoint areas of concern within their organization and to create benchmarks that can be shared through Corporate Social Responsibility (CSR) reporting or data-driven Sustainability Indexes.

Moreover, an interviewee mentioned they are already engaged in options b and c to create guidelines for general practitioners, even without a comprehensive holistic assessment. These guidelines incorporate social and economic dimensions, and they have recently begun exploring

the inclusion of environmental aspects. However, there is **uncertainty regarding the utility and necessity of a complete holistic assessment in such applications**, as it remains uncertain whether it might be too complex and comprehensive.

Significantly, one interviewee pointed out that all **options presented in question 5 could as well be applied for question 6**, but with a broader focus on sustainability rather than just environmental aspects (see Chapter 3.3.1.1).

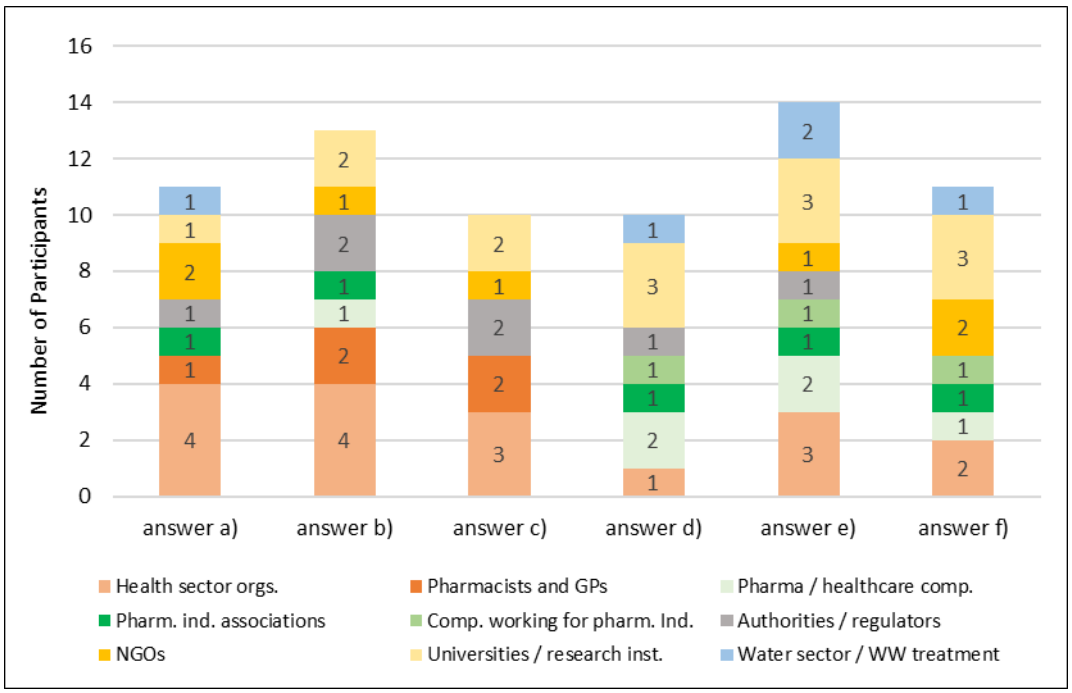


Figure 10: Distribution of responses regarding purpose of an overall sustainability assessment
Q6: Considering an overall sustainability assessment (i.e. including the social and economic dimensions): for which purposes are you using now, or would you like to use in the future, such an assessment? a) To educate stakeholders on how to perform a full holistic assessment; b) To compare benefits (e.g. for human health and wellbeing, including social & economic aspects) with negative (predominantly environmental) impacts; c) To identify and highlight trade-offs between different types of treatments; d) Other?

In terms of question 6a, which addresses whether interviewees that are already using such assessments find anything lacking in their approach, a person working for a pharmacy association discussed their current focus on OTC products and the implementation of a sustainability label for OTC medications. They highlighted the inclusion of six criteria, such as sustainability reporting and human rights requirements, while expressing the need for more comprehensive transparency and climate-related criteria for further enhancement. It was mentioned that their label focuses on the production phase; the importance of addressing sustainability across the entire lifecycle of pharmaceuticals was highlighted.

A representative of an industry association raised the topic of how in healthcare decision-making financial considerations are considered in conjunction with medical effectiveness. They

highlighted the need for an approach that considers both health and environmental aspects, and pointed out that it can get inspiration from the above-mentioned comparison approaches. Analogously to existing methodologies in health technology assessments, these methodologies could allow decision makers to determine the best option from a combined health and environmental perspective. They strongly highlighted the absence of a well-defined process to defend decisions that prioritize environmental sustainability while also considering medical efficacy.

3.3.2.2 Scope (system boundaries) of an overall sustainability assessment

The definition of an adequate scope and system boundaries is related to the appropriateness of the assessment results to the uses they will be given. For this reason, interviewees were asked which scope of an overall sustainability assessment (system boundaries) would be most suited to their needs. The options presented to interviewees were

a) production of pharmaceuticals (from production of precursors to finished products before they leave the factory) (*"cradle to gate"*),

b) full pharma life cycle (including distribution, consumption and disposal (*"cradle to grave"*),

c) full pharma life cycle + healthcare system pathway (including general practitioner visits, hospitalization, etc.),

d) full pharma life cycle + healthcare system pathway + full societal pathway (including job creation, informal caregiving, etc.), and

e) other scopes.

Option a (*"cradle to gate"*), according to one interviewee working in standardization, is an approach that tends to be favoured by manufacturers, as it covers that part of the product lifecycle they have control of: up to the point a product leaves the factory. Option a would offer a relatively manageable scope and is seen as suitable for certain industry needs. Another interviewee working in the water sector with close ties with the pharmaceutical industry also sees this approach as sufficient for industry purposes. However, the interviewee pointed out that other scopes would be necessary for other purposes, for example when considering take-back schemes. Another interviewee, working in the field of health insurance and reimbursement of pharmaceuticals, also identifies option a as sufficient under the presupposed purpose of facilitating choices between products with the same API. In this scope, products would be evaluated between supply chain A and B, or production route A and B. For the part of the lifecycle option a does not cover, from gate to grave, products with the same API would show a rather identical life cycle, which could therefore be neglected.

Option b (*"cradle to grave"*) garners the most support from interviewees (see Figure 11), as it encompasses the entire product lifecycle, including distribution, consumption, and disposal.

Many interviewees express support for this option, considering it both practical and sufficient for their purposes.

Some interviewees working in pharma industry argue for option b, as their companies would not yet be mature enough to go beyond this scope. Others even argued that in contrast to option a as the more usual industry option, option b is primarily adopted by those manufacturers that have greater maturity in the field. An interviewee from the stakeholder group *"Pharmacists and GPs"* mentioned their dependency from the pharmaceutical industry. They control only a very small part of the lifecycle, hence option b is adequate to their purpose. Interviewees from the water sector expressed very similar views: for them, it is initially sufficient if the end-of-life is included. Representatives of procurement organisations mentioned that currently, their focus is on evaluating the cradle-to-grave lifecycle of pharmaceuticals due to resource limitations, while further scopes like options c or d are seen as a theoretically ideal, but in practice rather distant scenario due to the lack of adequate methods, data and resources.

Other actors currently apply neither a nor b. From their point of view, either a or b would be desirable and already a big step forward. Options c and d would also be interesting, but currently not within reach.

Many interviewees expressed similar views. They would generally be in favour of more comprehensiveness, provided that sufficient reliable data is available. Regarding options c and d, they highlighted the challenges of quantifying broader societal impacts like job creation and informal caregiving. Arguments mentioned were higher complexity, greater effort, potential uncertainties, and less accuracy. Numerous interviewees emphasized the need to manage uncertainty and avoid incorporating elements with high levels of uncertainty in the assessment. Thus, the balance between ambition and practicality plays a role in determining the scope of the assessment. Some stated that drawing boundaries is necessary when the effort involved in collecting additional data starts to outweigh the benefits gained.

Option c (*"full pharma life cycle + healthcare system pathway"*), according to some interviewees, strikes a balance between comprehensiveness and practicality. It involves assessing the full pharmaceutical lifecycle and incorporating the healthcare system pathway, which includes factors like general practitioner visits and hospitalization. One interviewee mentioned that in particular health systems are interested in this option in order to calculate impacts along the care pathway.

On the other hand, option d (*"full pharma life cycle + healthcare system pathway + full societal pathway"*) was often deemed an ideal scenario, encompassing the entire lifecycle, healthcare system, and broader societal impacts like job creation. While some participants found this option suitable, others acknowledged it has advantages in theory, but voiced strong concerns about its intricate nature and the difficulties associated with quantification and practicality.

Numerous interviewees highlighted the benefits of having customisable system boundaries, emphasizing the need of actors to adapt the boundaries to the specific goals, context, and situation of the assessment. Having this flexibility acknowledges that different purposes may require different scopes. In the industrial context, a cradle-to-gate or cradle-to-grave approach may often prove most advantageous, particularly since companies have limited influence over the broader operations of the healthcare system. When the intention is to compare specific production routes or enhance the efficiency of a particular pharmaceutical's production, a cradle-to-gate assessment could be the most feasible option, especially in terms of resource allocation. However, in other scenarios, considering the entire life cycle, encompassing the healthcare system and even the complete societal pathway, might be both beneficial and fitting. One interviewee highlighted the sequential nature of options a, b, c, and d, suggesting that understanding the full lifecycle precedes delving into broader societal impacts.

Overall, an actor's understanding of the most adequate scope for a particular assessment tends to depend on their role in the lifecycle and where they exert control – which relate to the intended use of the assessment. While option b (*"cradle to grave"*) was the most voted option and option a (*"cradle to gate"*) also had several proponents, numerous interviewees expressed an interest in more comprehensive assessments that consider both the entire product lifecycle and its societal implications. However, interviewees also highlighted major issues of practicability, feasibility, and data availability for the options which more expansive system boundaries.

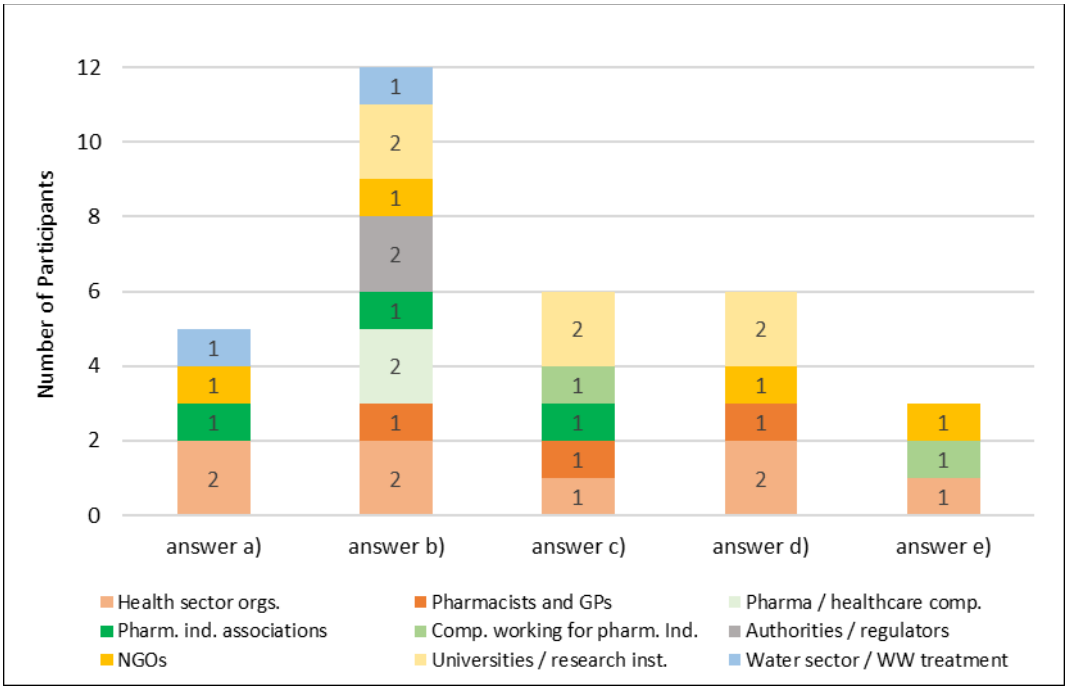


Figure 11: Distribution of responses regarding scope of an overall sustainability assessment
Q7: Which scope of an overall sustainability assessment (system boundaries) would be most suited to your needs?
a) production of pharmaceuticals (from production of precursors to finished products before they leave the factory)

("cradle to gate"); b) full pharma life cycle (including distribution, consumption and disposal ("cradle to grave"); c) full pharma life cycle + healthcare system pathway (including general practitioner visits, hospitalization, etc.); d) full pharma life cycle + healthcare system pathway + full societal pathway (including job creation, informal caregiving, etc.); e) other scopes?

3.4 Methodological aspects

3.4.1 Geographical level(s)

Environmental footprints can vary strongly depending on factors that can be local- or region-specific (e.g. wastewater treatment technology). This can lead to different results for an assessment of the same product, depending on the geographical scale chosen for the assessment. Based on this, interviewees were asked the question of which geographical level(s) would be the most appropriate for an environmental sustainability assessment valid for their organization. Interviewees could choose between options (a) local, (b) regional, (c) national, (d) multi-national (e.g. EU) and (e) global. In the course of the interviews, various points and arguments emerged.

There were two different strands of understanding regarding this question. On the one hand some interviewees considered the geographical level at which an assessment methodology should be harmonized or implemented, on the other hand other interviewees focused on the level of detail that the assessment data should have. In the following discussion, we will address these two aspects separately to the extent possible.

Regarding the first strand there was the tendency to view the assessment more in terms of a standard, a regulation or a general requirement. They all argued for a global or at least multinational agreement in order to have the biggest impact due to the global nature of the supply chain. In addition, there was a strong call for a global level playing field.

The other strand preferred a more differentiated approach and emphasized that there is no one-solution-fits-all approach. Accordingly, the geographical level(s) considered are dependent on the specific requirements and general conditions of the assessment, i.e., the intended application, outcome and use of it. For example, the assessment could be used for internal purposes, to identify hotspots within a closed supply chain of a product, it could be used for public communication and to compare different products, or it could be used for legally regulated approval procedures and regulatory tasks. An example of this is an interviewee working in national procurement of pharmaceuticals, who emphasized their focus on national concerns and circumstances.

Additionally, different impact categories might need different geographical levels applied as well. One interviewee mentioned that wastewater, for example, might need a more local or regional scope as there are very specific and impactful differences on that level. On the other hand,

greenhouse gas emissions tend to be more homogenous on a national level and their impact is even global. Therefore, another interviewee suggested to apply the scope or geographical level that is relevant to the impact category that one looks at.

Another key issue related to the geographical level was data availability and quality. For a certain level of detail (e.g. local or regional) there might be no data or no good-quality data available. Yet again, this may hold true for some impact categories, but not for others. The question then is if the burden and effort of collecting missing data points outweighs the benefits. As another interviewee put it: One could theoretically have all the local data and have thousands of pages of assessment, each covering every single area, but that would rather not be a particularly efficient use of anyone's resources. In summary, there is also a need for the chosen approaches to be practical.

Some interviewees stressed the problem of having to use estimated values if there is no data available or needing to work with averages. This was seen as possibly leading to a reduction in informative value, providing results that are too generic. For that reason, these interviewees suggested that the geographical level(s) applied should be as precise as possible while still being manageable and accurate. However, as one interviewee remarked, it would undoubtedly be necessary to work with average values at one point or another.

Moreover, various interview partners forwarded different propositions on this point. One argued for a methodology set at global level, while the data that is used could be regional or local. Others expressed very similar views and spoke in favour of a global minimum guideline which could then be improved in the national, local and regional level based on the specific circumstances in the area. This would enable authorities with national or regional mandates (e.g. procurement agencies) to improve the assessments with relevant data (e.g. wastewater treatment approaches) from their national or regional level. The level mentioned as the most realistic one for providing relevant data was the national level, as it is already quite homogenous due to regulations and standards in place; multinational blocks like the EU might already show huge variations and be quite heterogenous.

Whereas another participant suggested the application of a *"generic approach"*. This approach involves making certain assumptions that lean towards worst-case scenarios for environmental conditions, especially where there is a risk of negative impact. Such an approach would be commonly used in risk assessments, not only in the environmental domain but also in various other fields. The interviewee acknowledged that variations can occur at the local or regional level, leading to different conditions in specific instances. However, they emphasized that these unique situations cannot be effectively assessed using a uniform, all-encompassing instrument. Instead, for local or regional matters, and similarly to the approach mentioned in the previous paragraph, the respective authorities may need to be involved in assessing specific aspects relevant to their jurisdiction by using data of their jurisdiction level.

As a bottom line, many of the interviewees mentioned transparency regarding the geographical level(s) chosen in both the method and the data as an important prerequisite for a successful assessment framework. The interviewees presented diverse perspectives on the appropriate geographical level(s) for environmental sustainability assessments. Viewpoints ranged from a global perspective advocating for uniform regulations to practical considerations emphasizing regional or EU-level assessments. The importance of data precision, local context, regional differences, and efficient resource utilization were recurring themes. Ultimately, the choice of geographical level should consider the intended use, data availability, and the need for harmonization or specificity in assessing environmental sustainability.

3.4.1.1 Functional unit(s)

In addition, interviewees were asked about their thoughts concerning the type of functional unit[3] suitable for that geographic scope.

Only a small number of interviewees felt in a position to respond to the question: answers were provided in only 8 of 21 interviews. The depth of content and degree of detail of the answers varied greatly. However, some interesting aspects and arguments were presented.

A few interviewees noted that the functional unit and the information included can vary depending on factors such as availability of information, purpose and intended outcome of the assessment or actors supposed to work with the results. For example, as one interviewee noted, the functional unit only plays a particularly important role when comparing different options as a common reference value, whereas it is less relevant when identifying hotspots in a particular life cycle. Therefore, different functional units may be needed for different groups or application cases.

Most interviewees agreed that the inclusion of more information would be quite useful e. g. to better understand pharmaceutical usage patterns, as different products have very different administration pathways and different frequencies of medication use. However, several interviewees stressed that the necessary information was not currently available.

One interviewee with expertise in Life Cycle Assessment proposed the use of a reference value as a starting point in assessments. If there is variation within the data, conducting a sensitivity analysis or utilizing a weighted average approach could enhance specificity and accuracy in the assessment.

One interviewee linked the geographical level to the functional unit and stated that if the assessment is conducted at the national level, it should include mass-based prescribing data and

[3] *In the context of LCA, a functional unit is a quantifiable reference parameter that defines the functional performance of a product or system being assessed. It serves as a basis for comparing different products or systems in terms of their environmental impact throughout their life cycle.*

demographic information such as age-specific data. Additionally, they highlighted the need for caution when considering geographic differences, demography, and healthcare system structures in conducting assessments beyond the national level due to increasing complexity.

Another person referred to the upcoming legislative proposal on the European Health Data Space which could bear the potential of having and using information on individual patient level.

Nevertheless, all interviewees agreed on the need for standardization and practicality. One interviewee working for an industry association mentioned the need for a standardized approach and suggested using mass-based functional units. They noted that while the inclusion of further information may be useful in the future, the focus should be on establishing a standardized method using dose-based functional units. In a similar sense, one of the interviewees from the stakeholder group *"health sector organizations"* stressed the importance of accessing comprehensive and accurate data for meaningful assessments. At the moment, they would use defined daily dosage as default. They propose expanding the functional unit to incorporate additional information, such as disease type, age groups, or administration pathways, if the necessary data is available. Another one recognized that incorporating a range of patients and doses into assessments adds complexity, therefore information needs to be reduced to a manageable level.

In summary, the interviewees presented different arguments and perspectives regarding functional units and the inclusion of additional information in environmental sustainability assessments. The viewpoints ranged from the importance of data availability and standardization to the consideration of specific factors such as product administration, patient characteristics, and regional differences. Ultimately, the choice of functional unit and information inclusion depends on the availability of data, the intended purpose of the assessment, and the need for accuracy and practicality in the evaluation process.

3.4.2 Integration and harmonization of the sustainability assessment

Question 12 in the interviews asked whether the to-be-developed TransPharm sustainability assessment should be a stand-alone approach, or if it should be capable of integrating / working in conjunction with other assessment results. In addition to providing their opinion on this question, various interviewees provided insightful perspectives related to their response. At the same time, some interview partners lacked knowledge of the topic or were uncertain. For instance, one interviewee initially supported integration but later suggested considering a stand-alone approach. Another interviewee admitted their lack of awareness regarding the existence of any assessment for medicinal products in their country. As a result, they considered the TransPharm sustainability assessment to potentially be the first approach of its kind and, consequently, viewed it as a stand-alone approach. Three interviewees expressed not to have an opinion on this matter.

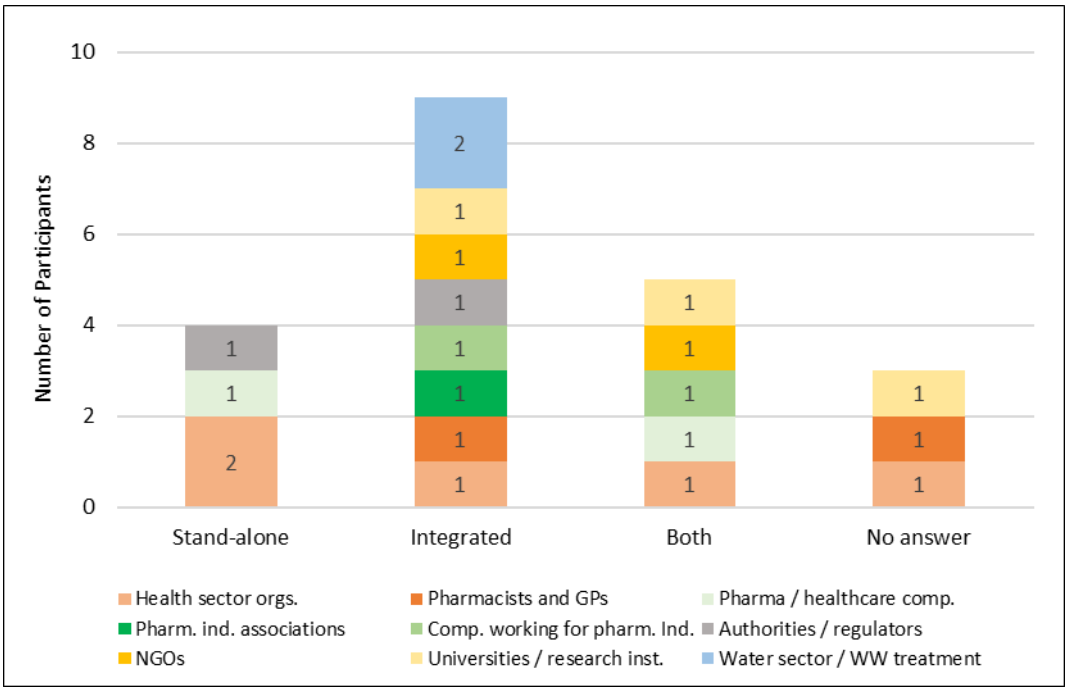


Figure 12: Distribution of responses regarding degree of integration of the sustainability assessment.
Q12: Would your organization like the TransPharm sustainability assessment to be a stand-alone approach? Or do you think it should be capable of integrating / working in conjunction with other assessment results? If yes, with the results of which assessments?

As shown in Figure 12, only four interviewees favoured a stand-alone approach. Proponents of a stand-alone approach highlighted that it could enhance ease of use by reducing complexity, difficulty, and effort associated with integrating with other assessments by streamlining procedures. Nonetheless, although they advocated a stand-alone approach, most of them still raised the issue of integration and harmonization.

Five interviewees directly underlined the importance of an assessment system covering both aspects: being a stand-alone approach and being capable of integrating and working in conjunction with other assessments and its results. Some interviewees argued that while an assessment or document can function as a standalone approach, it should also capitalize on what is already existing and be linked and aligned with other similar efforts, such as standardization initiatives advanced by the Pharmaceutical Supply Chain Initiative (PSCI) or with international indexes like the Sustainable Procurement Index for Health.

Half of the interviewees that answered this question (9 of 18) spoke out clearly in favour of developing an assessment capable of integration and harmonization with existing assessments, regulations, and initiatives to create a comprehensive and efficient sustainability assessment within the pharmaceutical industry. Considering interviewees that answered *"Both"*, this means that 14 of 18 interviewees argue for integration and harmonisation with other frameworks.

One of the most often cited justifications for such capability was to avoid redundant data collection efforts. Interviewees highlighted the importance of using data that organizations already collect due to regulatory requirements, such as Environmental Risk Assessments or their CSR reporting, to streamline the assessment process. This approach would ensure that efforts are not duplicated, and relevant data is utilized efficiently to build a comprehensive picture of a product's sustainability.

It was also emphasized that certain aspects of the sustainability assessment need not be developed separately as established frameworks, such as environmental product declarations, already exist. Instead, the focus should be on pharmaceutical-specific issues and harmonizing methodologies with existing standards. They suggested aligning with existing initiatives like the Sustainable Markets Initiative (SMI) Health Systems Task Force, which is reportedly launching a project in summer 2023 to develop Product Category Rules for pharmaceutical products for a common methodology framework to perform LCA at product level. The consortium consists of eight global pharmaceutical companies.

Another aspect mentioned was that the sustainability assessment should be context-specific, based on the stage of development. If conducted early on, it could be integrated with the authorisation evaluation, while a later assessment might be combined with evaluations of environmental and social conditions. This approach might ensure that the sustainability assessment aligns with existing processes and structures, tailoring it to specific needs and requirements.

At the same time, it was highlighted that frameworks under development such the Joint Research Centre's Safe and Sustainable by Design framework may be too extensive for a practical sustainability assessment. Instead, interviewees emphasized the need to manage complexity while building upon existing frameworks. Standardization emerged as a key factor, as without it, the results may lack usefulness. One suggestion was to start with a lean approach and gradually expand, prioritizing framework elements that are more mature and that can be standardized, to ensure comparability and effectiveness.

In summary, the majority of interviewees consistently advocated for the integration of the TransPharm sustainability assessment with other existing assessments, regulatory obligations, and initiatives. Harmonization of methodologies and collaboration among stakeholders were seen as key factors to ensure the effectiveness, feasibility, and acceptance of the assessment approach. By leveraging existing frameworks, aligning with established initiatives, and considering the specific context, the TransPharm sustainability assessment could build a more comprehensive and standardized approach to environmental sustainability assessment within the pharmaceutical industry.

3.4.2.1 Harmonisation of LCA methodologies addressing the environmental sustainability of pharmaceuticals

Question 12a, an optional question for interviewees with more in-depth knowledge of the topic, addressed the variety in the methodological foundation of Life Cycle Assessments used for assessing some aspects of environmental sustainability of pharmaceuticals, and which can hamper the comparability of the assessment results. Interviewees were asked what they thought would be necessary to enable the harmonization of methodologies and how this could be achieved.

In response to question 12a, the interviewees acknowledged the above-mentioned lack of harmonization in the methodological foundation of LCAs. The importance of harmonization in methodologies to enable comparability across different assessments was highlighted multiple times. They stressed the need for an independent body to convene and drive the process, which would need to foster consensus among all stakeholders including inter alia industry, regulators, users, and academic researchers. This harmonization would ensure that the pharmaceutical sector follows a unified approach, making it easier for procurement organizations to rely on provided LCAs when making decisions. However, assuming the existence of a standard, interviewees highlighted that it cannot be assumed that it will be universally adopted by all parties. The challenge therefore lies in ensuring widespread application of the standard throughout all stakeholder groups along the pharmaceutical life cycle.

Similarly, one interviewee expressed the importance of industry acceptance for the sustainability assessment. They emphasized that a standardized and global, or at least European, approach, developed through collaboration and consensus building with pharma companies, could ensure feasibility and comparability. Initiatives like the SMI project and involvement of independent bodies, like the BSI, could drive this harmonization process.

From a methodological perspective, interviewees emphasized the significance of defining and reaching a consensus on product category rules and emission factors. This approach would pave the way for a standardized and comparable assessment process. One example cited by some interviewees was the Product Environmental Footprint (PEF) method, along with its associated Product Environmental Footprint Category Rules, which aims to achieve this standardization. Developing category rules specifically for pharmaceutical products could prove beneficial in attaining harmonized and comparable assessment results.

It was acknowledged that the SMI project, mentioned earlier, holds potential for this endeavour. However, it was also noted that the practical application of the PEF framework has been limited so far, primarily due to its quite comprehensive and thus demanding nature. Additionally, the consensus-building procedure to develop category rules was identified as a burdensome process, constituting a potential bottleneck. These challenges should be taken into account while progressing towards harmonization in the pharmaceutical sustainability assessment domain.

According to one interviewee, regulations could ultimately serve as a potent means to promote and achieve the widespread adoption of harmonized methods and standards.

3.4.3 Weighting of assessment results

Question 13 of the interviews focused on the need to give weights to the different elements of the environmental sustainability assessment, and stakeholders' views regarding a generic weighting scheme versus the ability to adapt the weights to their organisation's needs.

Several interviewees, particularly from the stakeholder group pharmacists and GPs, argued in favour of a generic weighting scheme developed by experts, indicating a willingness to rely on experts' knowledge and expertise. Others highlighted the importance of comparability and consistency across assessments, suggesting that predetermined weights based on expert consensus would help avoid subjective biases. Transparency and standardization were seen as crucial factors in achieving results that have explanatory power.

One interviewee pointed out that weighting in itself means a transition from a scientific approach to a policy or value-based choice. The development of a weighting scheme could be done, for example, through a consultation process that should involve experts and other stakeholders as well as the wider public. Another interviewee emphasized the need for collaborative consensus-building to validate the approach and create wider acceptance.

On the other hand, several interviewees advocated for the flexibility to adapt the weights according to organizational needs. This argument was often heard from industry side or from interviewees working in health sector organisations, for example in the field of reimbursement or procurement. They favoured weighing the results themselves, enabling them to align the assessment with their organization's specific requirements, its objectives, as well as possible national legal requirements. However, other interviewees from the same sector mentioned it would be a smart and efficient use of resources to have a generic weighting scheme as a baseline, which can also be adapted to an organisation's specific needs.

This position was put forward by several other interviewees. They suggested a combination of a generic weighting scheme, based on some form of stakeholder consensus, with the ability to adapt the weights based on organizational priorities. They acknowledged the usefulness of a more widely used scheme, but also highlighted the importance of customization based on the organization's objectives. One interviewee emphasized adaptability, considering different perspectives and needs, while ensuring transparency and communication of the assessment criteria. Another version of this position argued for a modular approach, as not all the necessary information might be available to perform a complete assessment for all impact categories. This approach would also allow to select certain modules from the assessment, as not all questions may be applicable to every product.

Some interviewees forwarding this idea suggested that internal weighting schemes can vary but advocated for a harmonized weighting scheme when communicating externally, provided transparency is maintained. The purpose of an assessment (e.g. internal process optimisation vs. communication with procurement agencies) would therefore play a role in determining the type of weighting to be applied.

General challenges and difficulties in determining weights were raised by several interviewees. They highlighted the subjective nature of weighing different elements and the potential for biases and discrepancies. They stressed the need for transparency, understanding of the assessment factors, and consideration of specific organizational priorities and local circumstances.

Also, some of the interviewees noted that they had limited experience with weighting and that it was difficult to discuss this question at such a high level of abstraction with the specific assessment not yet available.

In summary, interviewees suggested diverse approaches on how to assign weights to the different elements of the environmental sustainability assessment. While some preferred a more generic weighting scheme for comparability and transparency, others emphasized the need for flexibility to adapt the weights according to organizational needs. Yet others argued for an assessment system that enables both options, highlighting that the options are not mutually exclusive, and that the different assessment purposes call for different uses of assessment data. Transparency, understanding of the criteria, adapting to the intended use and harmonization were recurring themes in the discussions.

3.4.4 Assessment outcome

3.4.4.1 Aggregation level

Question 14 aimed to understand which outcome the interviewees considered most desirable when assessing the sustainability of pharmaceuticals. Their responses provided insights into whether they preferred (a) a total sustainability score for the product, (b) scores per dimension of sustainability, (c) scores per impact category, (d) scores per individual impact category criterion, or (e) other outcomes.

Responses to this question varied strongly among the interviewees and stakeholder groups. Some interviewees expressed scepticism about a single total score (option a), citing challenges in weighting and the potential loss of meaningful information. They emphasized the need for transparency and clear communication of the components contributing to the total score. However, interviewees affiliated to the stakeholder group pharmacists and GPs tended to prefer option a. Some interviewees mentioned that a single total sustainability score provides a concise and easy-to-understand measure of the overall sustainability performance of a product. It allows

stakeholders, such as patients or GPs, to quickly assess and compare the sustainability of different products without getting lost in detailed information.

On the other hand, scores per dimension of sustainability (option b) were favoured by numerous interviewees. They argued that this approach provides a clear understanding of the performance in specific sustainability dimensions, such as environmental, social, and economic aspects. However, concerns were raised about the difficulty of balancing or trading off between different dimensions of sustainability and the potential dilution of specific impacts when aggregating scores across dimensions.

Scores per impact category (option c) received widespread support as a pragmatic and informative approach. Many interviewees highlighted the importance of a focused assessment that captures specific environmental, social, and economic impacts. They emphasized the relevance of different impact categories and the ability to prioritize areas of concern based on stakeholders' interests and context.

Scores per individual impact category criterion (option d) were mentioned by only three of 21 interviewed organisations, all belonging to the stakeholder group *"universities and research institutions"*. Interestingly, these interview partners all selected all the options (from a to d) as desirable, while at the same time emphasizing the importance of not solely focusing on the scores but being transparent and communicating the overall outcomes as well as their interconnection.

The idea of combining multiple options was also taken up by several other interviewees, recognizing that different stakeholders may have varying interests and priorities. They emphasized the need for flexibility in the assessment approach to cater to diverse needs and the possibility to dive into the details if needed. This is reflected in Figure 13 insofar as the number of options selected does not match the number of interviews. Some stakeholder groups named several options as their preference, while others did not choose any at all.

Interviewees also often suggested that different levels of aggregation are better suited to different stakeholder groups. It was often mentioned that patients and consumers would need more aggregation, and should not be expected to make sense of all the details. Also pharmacists and GPs would be a group that would profit from aggregated results. Other groups, however, would require more detailed information, sometimes limited to certain aspects. For instance the water sector actors would not focus on aspects such as energy expenditure in the production process, but rather on data related to what is released and how much of it ends up in the water cycle.

However, one interviewee argued strongly against any aggregation of results to a level higher than option c). They sustained that the use of lifecycle analysis is a tool for identifying weaknesses and documenting improvements in one's own processes and systems, rather than a communication tool or a means to compare between products. The interviewee highlighted the significant inherent uncertainties in lifecycle assessments (e.g. due to the use of averages for

non-available data) and suggested that it is not desirable to have statements such as companies suggesting their product is 5% better than that of a competitor, as this would not be upheld by any evidence.

Throughout the responses, several common themes emerged. Transparency was deemed crucial, with interviewees stressing the importance of clearly communicating the assessment methodology, weights, and scores to build trust and facilitate decision-making. The complexity of the assessment needed to be balanced with the need for comprehensible and easily communicable outcomes. Contextual relevance was also highlighted, acknowledging that different dimensions, impact categories, and criteria hold varying importance based on stakeholders' interests, local circumstances, and sector-specific considerations. The challenge of weighing different dimensions, impact categories, and criteria to derive an overall score was recognized, with an emphasis on the careful consideration of trade-offs.

In conclusion, responses showed strongly differing opinions among the interviewees and stakeholder groups. A preference for options b and c emerged as a practical approach to capture specific impacts while ensuring transparency and tailored communication. Many stakeholders expressed interest in outcomes being available at more than one level of aggregation. It seems recommendable to develop an assessment system that provides outcomes at different levels of aggregation, thus facilitating uptake by various stakeholder groups for differing purposes. Such an approach would dovetail nicely with the transparency requirements of stakeholders (see also Chapter 3.6).

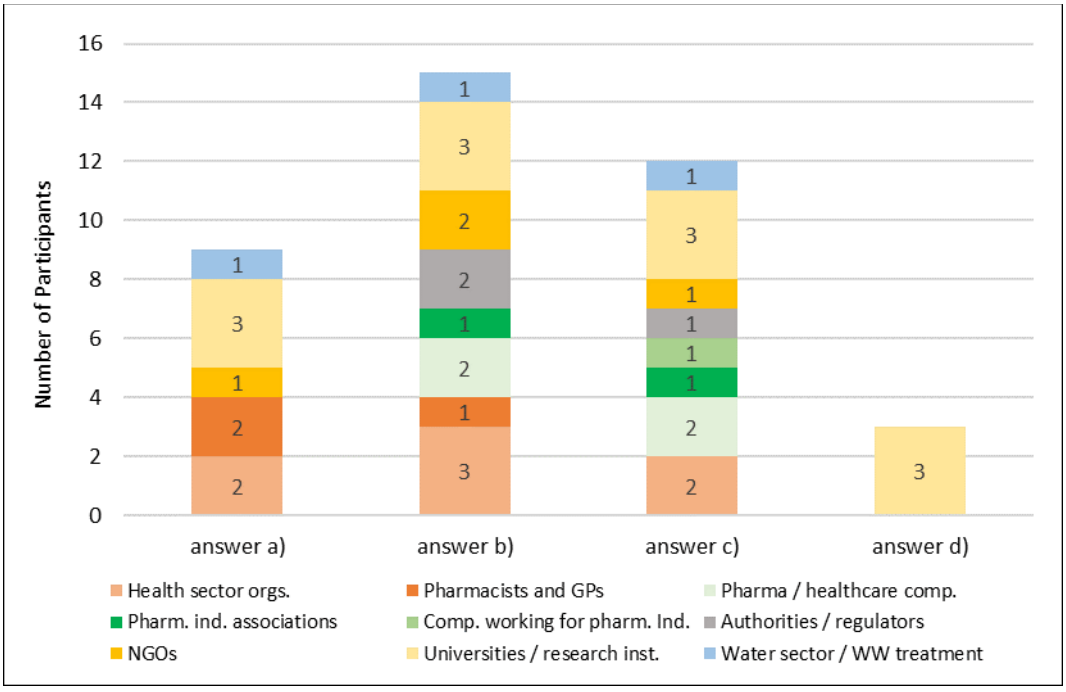


Figure 13: Distribution of responses regarding assessment outcome.

Q14: Would you want the assessment to have as outcome: a) a total sustainability score for the product; b) scores per dimension of sustainability (environmental, social, economic); c) scores per impact category; d) scores per individual impact category criterion; e) more than one of the above options? (answers to e) are included under a) to d).

3.4.4.2 Monetization of assessment results

In **Question 15** interviewees were asked their views about monetization (e.g., expressing the result in Euros) for aggregating the results (impacts and benefits) of an assessment. Most of them seemed not to have a lot of experience and expertise regarding this topic. Therefore, the answers were rather short, tended to be superficial and there was a lack of arguments backing their response. No pattern was evident with regard to the stakeholder groups.

Some interviewees expressed support for monetization as a way to aggregate assessment results and assign a monetary value to impacts and benefits. They saw potential benefits in terms of comparison, decision-making, and influencing behaviour. Monetization was seen as a tool for assessing environmental issues, incorporating economic and social impacts, and justifying higher prices. It could provide a tangible understanding and facilitate easy comparison between products. Proponents believed that monetization could be useful for public procurers and users, allowing them to make informed choices based on costs and benefits.

On the other hand, several interviewees expressed scepticism about monetization and questioned its value in aggregating assessment results. They highlighted various concerns, including the complexities of assigning monetary values, the limitations of expressing impacts solely in Euros, and the potential controversies and commercialization associated with monetization. Interview partners that were sceptical argued that sustainability assessments should not be solely focused on monetary values and emphasized the need for a comprehensive understanding of costs, impacts, and other metrics. They raised questions about the reliability of monetization, the difficulties of calculating costs in different contexts, and the diverse healthcare systems across Europe.

Besides that, several interviewees expressed uncertainty or a neutral stance on the topic. They acknowledged the potential usefulness of monetization but also raised questions and reservations. They mentioned the lack of experience or knowledge in working with monetization, the need for more details or further exploration, and the challenges associated with assigning monetary values to diverse categories and impacts.

3.5 Stakeholders' buy-in and roles

The interviewees were asked two questions addressing the various stakeholders' interest in using an assessment system and the roles they could play in performing these assessments.

- *"According to your experience, which stakeholder groups would have interest in using environmental sustainability assessments for pharmaceuticals?"* (**Question 8**), *and*
- *"Do you have an opinion on which role different stakeholder groups should have in performing the sustainability assessment, e. g., the role of industry, regulators (e. g., European Medicines Agency) or scientists?"* (**Question 9**).

The responses to both questions showed that respondents often combined answers about who is interested in using a sustainability assessment and what role they think the different stakeholders should play. Responses to both questions were therefore analysed jointly to provide a comprehensive picture of roles, as well as possible drivers of interest and decisions.

The interviewees agreed that **regulators / authorities** would have to play a key role in environmental sustainability assessments for pharmaceuticals. Regulators are expected to develop the guidelines and rules for environmental / sustainability assessments of pharmaceuticals. Several stakeholders suggested that regulators could include the requirement for a sustainability assessment to be part of applications for market authorization, and monitor environmental sustainability of API's across their lifecycle. They also make relevant information accessible to all stakeholders and inform healthcare professionals and patients alike. Some interview partners also highlighted the role that regulators can play in ensuring well-designed approaches to green procurement.

A key role would need to be played by the institutions in charge of market authorization, with European Medicines Agency (**EMA**) being a central player in this set-up for many interviewees. Several interviewees called for EMA to broaden their perspective to include sustainability issues. In addition, EMA should coordinate these future efforts with the European Commission (EC), the European Chemicals Agency (ECHA), and with the European Food Safety Authority (EFSA), to eliminate conflicting approaches and set coherent targets and standards. According to one interviewee, these authorities have worked inconsistently in the past. Key aspects are a clear framework as well as transparent data and processes.

Stakeholders highlighted the benefit of the responsibility for such an assessment system to be located at a higher (e.g. EU or international) rather than lower (e.g. national) level. The higher the level at which decisions are taken, the more uniform the rules can be across Europe, avoiding a patchwork of rules by providing clear and stable orientation for national actors and the industry. Here, the interviewees see the EMA as having a long overdue duty. In this line of thought, also the potential role of multinational organizations such as the UN was raised.

A few interviewees specified the responsibility of **politicians** to ensure these issues are sufficiently high on the political agenda and create both an enabling environment and relevant legislation, that can then be translated into specific rules and enforced by regulators. The European Green Deal as the basis for future developments was mentioned along with the EU Transparency Act. Stakeholders highlighted that fundamental changes in industry practices can

be achieved if the corresponding legislation is in place. The European Ecodesign Directive, which has been in force for less than two years, was cited as an example of how quick and effective policy decisions can lead to industry rethinking and tangible results in more sustainable product design. Another idea mentioned was the integration of environmental sustainability assessments into court practices.

Next to regulators, the **industry** as a key participant in a scheme assessing the sustainability of pharmaceuticals was named by 19 out of 21 interviewees. This stakeholder group was considered a primary user of any environmental assessment system, who will use the results to enhance their processes and products or possibly in their applications for market access. Professions within the industry deemed especially relevant in the interviews include discovery and development chemists, site managers, site directors, as well as corporate sustainability teams. Application of an environmental sustainability assessment was considered most relevant at the design and production stages for pharmaceuticals. Thus, manufactures are considered the group within the industry who would most likely benefit from the use such an assessment. Key aspects are a clear framework as well as transparent data and processes.

Opinions differed as to whether the motivation of manufacturers but also of the industry in general is intrinsic. Some industry players may be interested but want binding rules from public authorities to create a level playing field, other industry players may be less inclined to carry out environmental sustainability assessments and will only act if procurement rules of their products force them to do so. The variety of opinions seemed to result from personal experience and likely shows two sides of the same medal. One respondent suggested that industry is likely to move forward independently, as has happened with AMR industry Alliance project, as the EMA at present does not cover the area of sustainability in pharmaceuticals sufficiently. It can be concluded that policy makers and regulators on the one hand, and industry players on the other, are seen as the key actors that will only develop a transformative power through interaction.

While most interviewees agreed that the any sustainability assessment would be carried out primarily by industry actors, it was a widespread opinion that validation and control of the assessment outcomes would need to be conducted independently – be it by authorities or third-party evaluators. Several interview partners suggested that production site inspections carried out in the framework of Good Manufacturing Practice (GMP)[4] controls could be expanded to incorporate controls of sustainability criteria.

While industry players are considered to have the most in-depth knowledge and data access, some stakeholders also consider industry to have a bias that could lead to issues in their reporting of sustainability assessments. Next to assessing industry sustainability assessments, scientists

[4] *For more information on Good Manufacturing Practice (GMP) visit the WHO homepage: https://www.who.int/teams/health-product-policy-and-standards/standards-and-specifications/gmp, last accessed 09.08.2023*

were also viewed as a stakeholder group that could carry out sustainability assessments with in-depth knowledge. In pursuit of academic discoveries, assessments, outcomes and reporting would not necessarily stick to a predefined structure that would allow other stakeholders (e.g., regulators) to make systematic use of them.. Furthermore, scientists would often lack the access to data that the industry has. The third party named as possibly in charge of conducting sustainability assessments was regulators, namely EMA. However, another of the interviewees cautioned that in general, and as in the case for scientists, representatives from regulatory bodies may lack in-depth knowledge and access to data in comparison to actors such as industry.

In addition, **procurers** (such as hospitals, health sector managers and insurance companies), **health sector organisations** in general (community pharmacists, medical practitioners, and nurses) and **consumers** (patients) are considered to have a strong interest in sustainability assessments of pharmaceuticals. Interviewees describe a slowly raising awareness in these stakeholder groups, especially among medical practitioners and pharmacists. These professionals, along with other health sector organizations, can influence the market through decision making in prescriptions and procurement.

It was pointed out that green procurement guidelines can only be effective if there are choices between different pharmaceuticals and APIs on the market. Currently, mandates of procurers are often limited to costs (after considering the medical parameters, e.g., efficacy). Interviewees often identified a need for clear signals from policy makers to include sustainability criteria in procurement and reimbursement decisions, especially to guide decision making for health insurers and other entities responsible for procurement and reimbursement of pharmaceuticals. Sweden´s approach was named as a model in this context. One respondent identified the fragmented structure of the reimbursement system in many EU countries as a significant barrier to the integration of sustainability criteria. Respondents stressed the need for a sound legal basis, including sustainability criteria, to ensure that decisions taken by procurement and reimbursement bodies are legally sound. .

A majority of the interviewees considered universities as important in spreading state-of-the-art knowledge and provide knowledge to future actors for their decision making in all relevant professions. Stakeholders called for greater integration of sustainability issues into various curricula at an early stage of higher education to raise awareness. A smaller but still significant number of seven interviewees emphasized that universities and research institutions also have a vital role in advancing sustainability assessments through research.

Interestingly, a few interviewees voiced the importance of two additional stakeholder groups: 1) investors such as banks and investment companies and 2) media. Banks and private investors are considered to hold a lot of power through the rules they set themselves for investing in different industries, including the pharmaceutical industry. The hope was voiced that similar rules for green pharmaceuticals as for biodiversity issues might be established in the future.

A stakeholder group seen to be less relevant in using environmental sustainability assessments for pharmaceuticals is the **(waste) water sector**. This group expressed more interest in the environmental risk assessments performed under the EU legislation, which would be better equipped to provide answers to the questions relevant for this sector. Actors of this group expect that their information needs would be significantly more technical and detailed (e.g. behaviour of a certain compound in different wastewater treatment approaches) than the information that would be taken up in a sustainability assessment.

Even though regulators and industry are considered the most relevant actors for environmental sustainability assessments, several voices emphasized that all stakeholders are affected in one way or the other and therefore have their role and relevance - even though not everybody is equipped to carry out the assessments themselves. This includes, for example, also the general public, NGOs and the media. The role of the media is seen as both corrective, citing the US OxyContin scandal[5], and educational.

Opinions about the role and involvement of **patients** deviated strongly. There was fear that some patients may not take medicine once they know it to have an environmental impact. This is why, for example, the German Federal Institute for Drugs and Medical Devices (BfArM) prohibits mentioning the potential environmental hazards of medicines. The most common view was that patients want to be treated first and foremost, and that environmental issues are secondary in this situation. Another interviewee, however, considered patients to have a vested interest in the medication they receive, and all effects such medication may have on them and on their surroundings. One interviewee (stakeholder group: NGO) said that patients seemed to have only limited interest in delving into the details of a sustainability assessment. It was not specified whether an aggregated result would meet with interest. However, it was pointed out several times in the interviews that the wider public could be overwhelmed with details of the assessments. One interviewee (stakeholder group: NGO) said that patients seemed to have only limited interest in delving into the details of a sustainability assessment. It was not specified whether an aggregated result would meet with interest.

3.6 Transparency and data availability

Section 4 of the interview questionnaire included a question on assessment transparency and one on how to increase data availability along the supply chain.

All responses to **Question 16,** on how transparent sustainability assessments should be, strongly advocated for high transparency. Responses either called for *"complete transparency"*, or for *"as much transparency as possible"*.

[5] https://www.nbcnews.com/news/us-news/oxycontin-drugmaker-purdue-pharma-pleads-guilty-federal-criminal-charges-n1244155, *last accessed 09.08.2023*

Most stakeholder responses called for complete transparency without caveats. Several respondents highlighted that transparency should not only cover outputs, but also methods, and called for reports to be disclosed. The assessment should make it possible to understand results, assumptions and decisions taken within the assessment.

The remaining responses similarly emphasised the importance of transparency, but acknowledged the possibility of transparency facing limitations, due to e.g. proprietary reasons. Several interviewees related to industry mentioned the existence of these limitations.

Some respondents provided rationales for their call for high transparency. One highlighted that any limitations to transparency would affect the credibility of an assessment system. Another respondent highlighted that for organisations such as procurement agencies to make use of an assessment system they would need high levels of transparency, for legal reasons; as they can be taken to court by companies, they have to be able to transparently justify their procurement decisions. Transparency would thus have knock-on impacts on the possible uses and the uptake of an assessment system.

Whereas the call for very high transparency was generalised, respondents did differ in their views on who should have access to the highly transparent assessments. Some respondents argued for full transparency and the ability for everyone to access the assessments. Some others, however, saw risks in full disclosure of the assessments and were in favour of differentiating according to the audience. Consumers, for instance, could misinterpret ecotox information (Interview 15, industry association). Differentiated access to the assessments was also posited as a way to increase transparency, thus achieving the desired aim of full transparency for those actors making choices on which drugs are for which patients (Interview 6, health sector organisation).

Two interviewees working for the same regulator highlighted that full transparency should be accompanied by clear and unambiguous definitions of the necessary data that needs to be provided, and a structure to capture or evaluate it which enables the navigation of the framework. It should not be possible to *"overwhelm people with data"* (Interview 17, Authorities / regulators), which would be a tactic they sometimes encounter.

Several interviewees highlighted that, historically speaking, industry's arguments against transparency have proven hollow. Whereas they strongly oppose publishing list of API suppliers, this has been possible, and unproblematic, in New Zealand, where they are required by regulation to do so.

Question 17 asked interviewees for their ideas on tools or incentives that could be suitable for increasing the availability of relevant data along the supply chain.

Several respondents, both from industry and outside of it, identified industry-internal reporting requirements as a means to convey reporting requirements to suppliers along the supply chain. There would be numerous examples of major industries, such as the automotive industry, successfully implementing such requirements.

One interviewee suggested that engaging with suppliers to understand the feasibility of their providing the information requested would be a good means to increase data availability. Currently it would be the case that *"multinationals create something and more or less expect everyone to just follow suit"* (Interview 19, Companies working for pharma industry). Understanding the possibilities and issues of suppliers when providing data could make data disclosure a more feasible endeavour for supply chain actors.

Information requirements in procurement processes were also mentioned by several stakeholders. These could either take the form of tender requirements for transparency, or incentives (in the form additional procurement points when data is made available) for those companies that disclose information. Stakeholders mentioned that this second type of schemes work quite well, and companies that cannot or will not provide the data still have the freedom of not providing it. The Nordic countries would have interesting systems in place, such as incentives to disclose information (e.g. where an API was produced) in the Swedish procurement system.

Legislation was also identified as a means to increase data availability. Regulatory demands for data have resulted in industry providing data, and often more than originally envisaged (Interview 8, Pharmacists and GPs). Occasionally industry has threatened to leave small markets due to this kind of requirements, but in practice they would not have followed up these threats anywhere yet. This notwithstanding, the interviewee considered that the requirements should ideally come from the EU level.

Some respondents suggested that addressing confidentiality issues could increase data availability. A good means to do this would be having third-party brokers managing data and hiding confidential information from the value chain.

Finally, a methodological suggestion was given for deriving theoretical data (overestimating) in an assessment and asking companies to validate or comment the data thus derived. This would create an incentive for companies to provide their own data for the assessment.

4 OVERVIEW OF FINDINGS

This chapter presents a succinct overview of the study's findings and their implications. It also aims to be a stand-alone means for understanding Chapter 5: Conclusions.

4.1 Sustainability dimensions and impact categories

4.1.1 Dimensions of a sustainability assessment

Of the three dimensions of sustainability (environmental, social, economic) underpinning the TransPharm holistic assessment framework, **the environmental dimension scores a clear first**

both in the role it plays in their organisations' work and in the importance assigned to it by stakeholders.

The social and economic dimensions tend to also play a role in most of the interviewed organisations' work on sustainability: for about 3/4 of the interviewed organisations these dimensions are part of their work on the topic of sustainability. **Interviewees responses, however, show that environment is very much at the forefront of their organisations' sustainability endeavours, and that the remaining two dimensions, while considered important, tend to play a clearly subordinate role.**

4.1.2 Impact categories for a sustainability assessment

Stakeholders' evaluation of impact categories follows the pattern described for the sustainability dimensions. Asked to score the importance of the 13 TransPharm draft impact categories, stakeholders' responses clearly show a higher importance of eight impact categories that are part of the environmental dimension (ICs 1 to 8), and significantly lower importance for the categories outside of this dimension. (One category located in the intersection of all three dimensions, *"Patient and wider society's health and well-being"*, also received low scores.)

This difference in importance holds across all stakeholder groups. However, the limited number of interviews means the validity of these results should not be overinterpreted.

Many stakeholders pointed out potential issues that could affect the implementation of some of the draft impact categories:

- Scepticism regarding the possibility of evaluating certain ICs in the foreseeable future, due to
  - **a.** Scientific knowledge/studies lacking on topic
  - **b.** Lack of clarity regarding methodology
  - **c.** No availability of data
  - **d.** Complexity of measuring some parameters across the whole supply chain
  - **e.** Complexity of a particular impact category
- Overlaps between impact categories (e.g. IC1 – Primary and secondary natural resource use, IC3 – Water use and IC4 – Greenhouse gas emissions).
- Two impact categories addressing antimicrobial resistance caused confusion for many stakeholders. (A few stakeholders argued for their merger, one stakeholder argued for their being kept separate.)
- Duplication of some impact categories with already existing, widely implemented initiatives, such as social standards on workers' rights as part of organisations' contractual obligations.

4.2 Aim and Application

4.2.1 Aim and application of an environmental sustainability assessment

Stakeholders identified **numerous concrete decision-making processes distributed over the entire pharmaceutical life cycle that could be supported by an environmental sustainability assessment**.

Stakeholders seem **more interested in decision making processes rather closely related to their work**. For pharmaceutical companies this includes e. g. choices between different pharmaceuticals processes or identifying environmental hotspots along the life cycle. In contrast, procurement organizations, pharmacists and GPs are more interested in understanding which types of treatment, APIs or products are the best choice from an environmental perspective. Academia, on the other hand is basically interested in all aspects, depending on research interests. Ultimately, there is an interdependency between the layout of the assessment and the specific application.

Interviews also showed a **wide range of overarching objectives** that could be supported by an environmental sustainability assessment. This is reflected in the range of interviewees, each of whom covers a distinct phase of the entire lifecycle within their sphere of control (cf. Figure 2). For instance, pharmaceutical companies hold the most significant influence and control over the development and production of pharmaceuticals, while actors engaged in procurement are more likely to be able to directly influence decisions in this specific area. However, there are also indirect opportunities for influence, such as the inclusion of environmental criteria and production standards in procurement requirements or prescription guidelines. But it is also important to point out that the **objectives of some actors, e. g. procurement agencies, health insurance organizations and GPs, are at least partly set through legislation**.

Interestingly, **communication objectives are pursued equally by all stakeholder groups** across all stages and points of the life cycle. This includes awareness raising of the environmental impacts of pharmaceuticals as well as the ability to incorporate this information into decision-making processes. However, the addressees of the communication may differ.

Consequently, **the TransPharm assessment framework should encompass these diverse objectives and viewpoints, adapting to varying needs through modularity and flexibility**.

4.2.2 Aim and scope of an overall sustainability assessment

Currently, organizations are not conducting an overall sustainability assessment, partially due to the lack of a strong framework and complete data. Nevertheless, they are **in favour of developing such an assessment and see numerous possible purposes**. The true utility for

these purposes will, however, only become evident as the framework is further developed and takes shape.

It is important that such an assessment framework and its **results be adaptable to different contexts, considering the variety of intended use cases and requirements**. Also, mandatory legal requirements or national specificities could prevent the application of a generic approach. This is again a rationale for an assessment framework that is designed in a modular fashion, allowing stakeholders to make use of individual elements within it.

Regarding the scope of a sustainability assessment for pharmaceuticals, the main requirements are **customization, standardization, and practicality**. System boundaries need to be **adaptable to the specific goals, context, and situation of the assessment**. This flexibility acknowledges that different purposes may require different scopes. In the industrial context, a cradle-to-gate approach may often prove most advantageous for comparing specific production routes or to enhance the efficiency of a particular pharmaceutical's production. However, in other scenarios, considering the entire life cycle, or also including the healthcare system and societal pathway in the assessment, might be more beneficial and fitting.

However, the different system boundaries need to be standardized, and there should be guidelines for selecting a certain scope based on the intended use case.

4.3 Methodological aspects

4.3.1 Geographical level(s)

There would seem to be no one-size-fits-all approach to geographical level(s). Accordingly, the **geographical level(s) considered are dependent on the specific requirements and general conditions of the assessment**, i.e., the intended application, outcome, and use of it. However, a harmonized standard for a consistent methodology should be established on the highest level possible and transparency should be ensured.

There was one strand of understanding the assessment more in terms of a standard, a regulation or a general requirement. In this case, the highest possible geographical level was advocated for to enable a level playing field.

4.3.1.1 Functional unit(s)

The functional unit and the information included can vary depending on factors like availability of information, purpose and intended outcome of the assessment or actors who are supposed to work with the results. Generally, functional units only play a particularly important role when comparing different options as a common reference value, whereas it is less relevant when

identifying hotspots in a particular life cycle. Therefore, **different functional units may be needed for different groups or application cases**.

At the moment, the **information needed to expand the functional unit tends not to be available**.

4.3.2 Integration and harmonization of the sustainability assessment

Stakeholders advocated for a sustainability assessment that can integrate with existing structures and context. A **certain degree of integrability was considered absolutely necessary**.

Existing frameworks like the environmental risk assessments (ERA) performed within the authorisation process, the Environmental Product Declaration (EPD) and Sustainable Procurement Index for Health (SPIH) should be leveraged, and alignment with initiatives like SMI and PSCI should be aimed for. Other kinds of processes like e. g. CSR reporting should also be given consideration.

To establish a comprehensive framework for making informed decisions, accounting for trade-offs and more, a certain degree of complexity may be essential. Hence, it might be necessary to develop the capability to manage this complexity effectively. The assessment could be structured in a manner that allows for the reduction of complexity for distinct purposes (potentially through modularity).

4.3.2.1 Harmonisation of LCA methodologies addressing the environmental sustainability of pharmaceuticals

A **harmonized approach within the pharmaceutical sector was considered by stakeholders as highly beneficial for its establishment and uptake, while also enabling comparability of assessments**. An approach that works worldwide was often considered best, if this were not possible the aim should at least harmonisation at the European level. Some interviewees advocated reaching harmonisation by involving various stakeholders through a process led by an independent third party, ensuring a consensus is reached.

Such a standard **needs to include product category rules for pharmaceutical products**. The Product Environmental Footprint method, along with its associated Product Environmental Footprint Category Rules, may be a good approach. However, the comprehensiveness of the framework and the associated consensus-building process have been identified as barriers for uptake.

4.3.3 Weighting of assessment results

Stakeholder responses showed that a significant number if not most stakeholders would want to **assign their own weights to the assessment components**, in line with their organisation's objectives or constraints (such as their legal mandates, or relevant national regulation addressing sustainability). However, they were simultaneously in favour of having **generic weighting schemes created by experts targeting specific purposes**, such as medicine choices in the health sector, or companies' CSR reporting.

Allowing for modularity, flexibility, and adaptability was again considered crucial, all while ensuring comparability and preventing arbitrariness. While internal weighting schemes may vary, **there should be a harmonized weighting scheme when communicating externally**, provided transparency is maintained.

4.3.4 Assessment outcome

4.3.4.1 Aggregation level

From the results it also becomes evident that diverse stakeholders have different needs related to result aggregation. The need to have **the option to delve into specifics when necessary** was often highlighted.

However, nothing speaks against a system that offers not one but several different levels of aggregation of results, according to stakeholders needs, with policy makers and patients using a total score per product or per sustainability dimension, while authorities and the industry supply chain using all the details of completely disaggregated data.

4.3.4.2 Monetization of assessment results

During the interviews, it became evident that most participants lacked in-depth expertise on the subject. While some interviewees recognized the advantages of monetization for comparison, decision-making, and influencing behaviour, others exhibited doubt regarding the reliability, intricacies, and potential downsides of such an approach.

No real preference or recommendation can be derived from the answers, except that the **appropriateness of using monetization should be examined carefully**. A study considered particularly relevant in this context and which should be consulted is Amadei et al. (2021).

4.4 Stakeholders' buy-in and roles

There is a broad landscape of stakeholder interest and potential roles in utilizing environmental sustainability assessments for pharmaceuticals. In particular, the **stakeholder groups interested in using an environmental sustainability assessment are very numerous** and cover the entire spectrum. Among these are the pharmaceutical industry, regulators and authorities, academic institutions, health sector organizations, procurement entities as well as GPs and pharmacists.

Regarding performing the sustainability assessment, regulators and industry are seen as primarily responsible. Regulators and authorities are seen as central figures in establishing guidelines and rules, while also ensuring adherence to those rules. Hence, there is a clear call for the European Medicines Agency (EMA) to take on a more central role and integrate sustainability in the focus of its work. Secondly, industry stakeholders, particularly manufacturers and professionals in discovery and development, are deemed fundamental in executing the assessments. This is because availability and access to data are crucial for conducting the assessments. Alongside this, the role of universities and research institutes is also important for developing and disseminating state-of-the-art knowledge, e. g. regarding methodological issues, as well as scientifically reviewing of assessments and their results.

4.5 Transparency and data availability

Most interviewed stakeholders called for **complete transparency without caveats**, highlighting that transparency should not only cover outputs, but also methods, assumptions and decisions taken within the assessment. The remaining responses similarly emphasised the importance of transparency, but acknowledged the possibility of its facing limitations, due to e.g. proprietary reasons. Differentiated access to the assessments was posited as a way to increase transparency, thus achieving the desired aim of full transparency for those actors that require it (e.g. authorities, procurement agencies, health sector organisations making choices on which drugs are for which patients).

Incentives for data availability could be:

- Developed by industry: Industry-internal reporting requirements were suggested as a means to convey reporting requirements to suppliers along the supply chain. Engaging with suppliers to understand the feasibility of their providing the information requested would help in this process.
- Created by legislation: Regulatory demands for data have always resulted in industry providing data, and often more than originally envisaged, with threats to leave small markets not followed up anywhere yet.

- Generated within a sustainability assessment system: Methodological suggestions were made for deriving theoretical data (overestimating) in an assessment and asking companies to validate or comment the data thus derived. This would create an incentive for companies to provide their own data for the assessment.

5 CONCLUSION

Stakeholder engagement activities show a very large range of uses of an assessment system for pharmaceuticals. Stakeholders' overarching objectives and purposes for using such an assessment, as well as the decision-making processes the assessments would influence, were shown to be incredibly varied.

This variability can even be observed within organisations of a same stakeholder group. For instance, interviewed health sector organisations implement sustainability strategies following mandates linked to their national legislation. These place different priorities and give different weights to different sustainability aspects, such as achieving net zero emissions vs. addressing the issue of pharmaceuticals in the environment. Similarly, interviewees reported pharmaceutical companies placing very different emphasis and priorities in their corporation's sustainability strategies.

We conclude that **the TransPharm sustainability assessment framework needs to be capable of accommodating these different realities and use cases for it to find successful uptake.** Developing a singular approach for assessing the sustainability of pharmaceuticals would restrict the use of the assessment framework to a limited realm (e.g. companies' CSR reporting), with other relevant uses (e.g. uptake in health procurement systems' decision-making) resorting to their own frameworks, currently very much ad-hoc. An assessment system should thus refrain from providing 'the one answer' to the sustainability of a pharmaceutical, but rather take into consideration from the very start that it will have a variety of different users, focusing on different number of parameters, for different objectives.

Developing an **approach that can be used in a modular fashion, which at the same time provides generic recommendations and use guidelines** for those stakeholders who do not have strongly individualised requirements, could be the way forward. The modular capability would allow users to take those assessment building blocks relevant for their objectives, weigh them according to their priorities and include these results in their decision-making processes. Generic guidelines can cater to users with less specific objectives (e.g. pharmacists and GPs) that are comfortable with using experts' opinions on weights and more aggregated results.

The **need for modularity covers not only the impact categories** playing a role in an assessment (e.g. if an assessment is limited to a few environmental criteria, to all environmental criteria, or also includes criteria from the social and economic dimension), **but also the system boundaries**

(e.g. industry actors tending to use cradle-to-gate or cradle-to-grave assessments, as these cover those aspects they have control over, while health sector actors are often interested in scopes including the healthcare system pathway, which is something they can exert influence over), **the level of aggregation** of results (pharmacists and GPs for instance were comfortable with a higher aggregation / overall scores, compared to procurement agencies' or healthcare sector actors' need for detailed outcomes), **and the geographical level of analysis** (several actors were interested in being able to replace e.g. EU averages in an assessment with their own national or regional data if this were available to them).

The good news is that the assessment elements typically build upon each other. For instance, a cradle-to-gate assessment is required for a cradle-to-grave assessment, which is required for a full pharma lifecycle + health system pathway assessment. Similarly, nothing speaks against a system that offers not one but several different levels of aggregation of results, according to stakeholders needs, with policy makers and patients using a total score per product or per sustainability dimension, while authorities and the industry supply chain using all the details of completely disaggregated data.

Stakeholders showed **widespread consensus on the need for full transparency (or as much transparency as possible)** in such an assessment framework. It should not only cover outputs, but also the methods, limitations, assumptions and decisions taken within the assessment process. This transparency is not just a 'nice-to-have', but actually impacts the possibility of stakeholders making use of the TransPharm sustainability assessment or discarding it for other tools. An example are as procurement agencies and health insurance companies, who need to be in a position to justify their procurement decisions if these are legally challenged. They require highly transparent assessments to be able to back up their decision-making processes in case they have to go to court.

Another point with widespread consensus was the potential for **harmonizing individual elements of the assessment framework with existing reporting approaches or requirements**, including regulatory ones. Data already being generated within the ERA of pharmaceuticals could play a role in assessing a product's ecotoxicological impact in a sustainability assessment, for instance. Other examples include the alignment of the AMR impact categories with current initiatives addressing AMR, and that of social impact categories with contractual and reporting requirements addressing these points. In general, there are a number of ongoing initiatives, such as the SMI, the PSCI, and a new project of the British Standards Institute, which show promise for alignment. The need for **developing harmonized standards for LCAs of pharmaceuticals** also found broad consensus.

Stakeholders highlighted the importance of having reliable numbers feeding into an assessment of managing uncertainty and of avoiding incorporating elements with high levels of uncertainty in the assessment (i.e. to avoid estimates as far as possible). In general, whereas more comprehensiveness in an assessment tended to be appreciated by stakeholders, there was

widespread uncertainty regarding the practicability of developing an assessment system within a four-year project that could cover all 13 impact categories in a satisfactory manner, as these were not seen as equally mature. Such a development was considered viable for the more mature impact categories for which widely accepted methods are already available; these would, however, still require complex consensus-finding process incorporating a wide range of actors. For those impact categories considered less mature, the process of deriving methods that produce reliable numbers, that are accepted by actors and then consensualising them was considered a task of numerous years, potentially even spanning one or several decades.

There was similar scepticism from some stakeholders on present-day assessments using the larger system boundaries (full pharma lifecycle + health system pathway; full pharma lifecycle + health system pathway + societal impact), which were seen by some as desirable but at present too far-fetched and complex to measure. The complexity involved in assessments following these wider scopes and the lack of reliable data could lead to estimates and thus *"fanciful numbers"* becoming part of assessments, which was seen as very problematic. However, once these methodological issues have been addressed, assessments using these scopes were seen as highly interesting.

We believe **a promising option for establishing a sustainability assessment for pharmaceuticals could be starting with a leaner approach, which incorporates those categories which are closer to maturity, and that is capable of gradual expansion over time** to address all relevant impact categories. (This is a similar approach to the slow development and expansion of procurement criteria in some EU Member States.)

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7 ANNEXES

Annex I: Questionnaire stakeholder interviews

Interview questionnaire – Stakeholder views and needs regarding a sustainability assessment of pharmaceuticals

What does TransPharm do?

Medicines are essential for human health, but also impact the environment. TransPharm supports a move towards a sustainable pharmaceutical sector by showing leadership in (i) technological innovation and (ii) the transition to sustainability. Among different actions, TransPharm will develop methodological innovations to improve the sustainability assessment over the entire pharmaceutical lifecycle, addressing specific challenges such as scarcity of lifecycle inventory (LCI) data and the lack of characterization factors for ecotoxicity.

What is this interview about?

This interview series is the first step in developing the methodological innovations mentioned above. It intends to gather stakeholder views regarding (a) the assessment of 'overall' sustainability (environmental, social and economic) of pharmaceuticals, and (b) of environmental sustainability of pharmaceuticals in particular. Interview results will feed into the development of a holistic sustainability assessment methodology that the Transpharm project will be developing in the coming years (referred to below as the "Transpharm sustainability assessment"). The purpose of this assessment will be to support its users in making better informed decisions with regards to pharmaceuticals.

We expect the interview to take around 90 minutes of your time. For further information on the background of the assessment and key terminology used, please refer to the technical brief (incl. glossary) attached.

Contents

Section 1: Context and life cycle

Q1: Is your organisation currently involved in the topic of sustainability of pharmaceuticals?

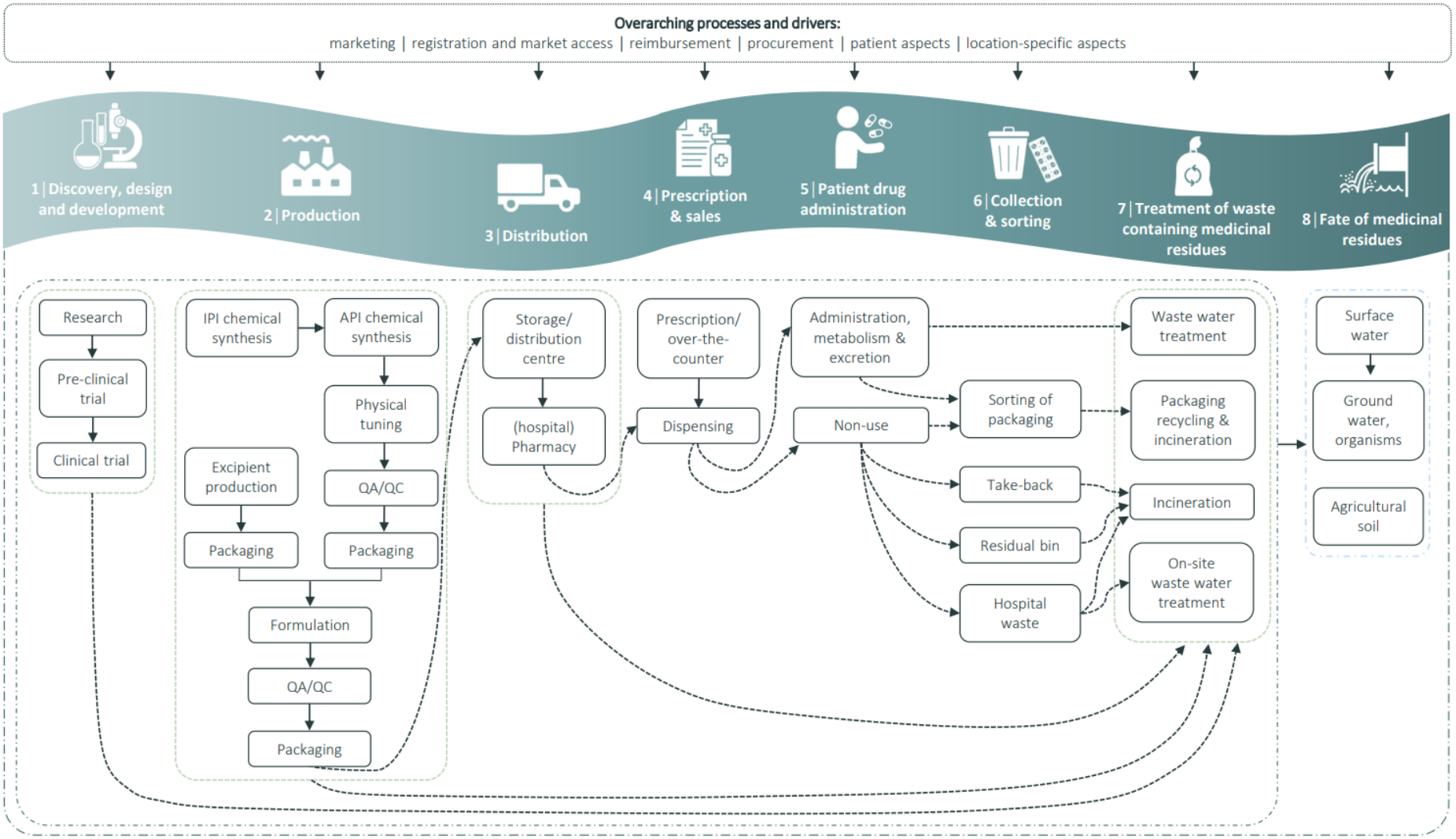
***[Q1a** – Optional, for organisation's already involved in topic: Which of the following three dimensions of sustainability play a role in your organisation's work on sustainability of pharmaceuticals?*

a) environmental
b) social
c) economic]

Q2: Which of the following three dimensions of sustainability do you consider "very important", "somewhat important", or "of low importance" when assessing the sustainability of pharmaceuticals?

a) environmental
b) social
c) economic

Q3: Do you see any gaps or ambiguities in the overview of the pharmaceutical life cycle shown in Figure 1? In which stage of the pharmaceutical/health care life cycle would you locate your organisation?



API: active pharmaceutical ingedient; IPI: intermediate pharmaceutical ingredient; QA/QC: quality assurance/quality control;

Figure 1: Overview of the pharmaceutical life cycle. (Sustainable Systems Engineering (STEN) research group, UGent, 2023)

Section 2: Aim and scope of a sustainability assessment for pharmaceuticals

Q4: In which specific decision-making processes would your organisation want to use an environmental sustainability assessments of pharmaceuticals? (If your organisation already uses one, please indicate which decision-making processes you are already addressing.) (multiple answers possible)

a) Facilitating choices between different types of treatments (including non-pharmaceutical treatment and no treatment)?
b) Facilitating choices between different active pharmaceutical ingredients (APIs)?
c) Facilitating choices between products with the same API?
d) Facilitating choices between different pharmaceuticals processes (for the production of the same API)?
e) To identify hotspots of environmental impacts within the lifecycle of the pharmaceutical product, for targeted mitigation efforts?
f) For other aspects in the decision-making? If yes, which ones?

Q5: Which are/would be your organisation's overarching objectives when making use of such an environmental sustainability assessment? (multiple answers possible)

a) Develop greener pharmaceuticals
b) Make processes in the production of pharmaceuticals greener
c) Prescribe greener pharmaceuticals
d) Ensure the procurement of greener pharmaceuticals
e) Make the public and/or other stakeholders aware of the environmental impacts of pharmaceuticals.
f) Enable the public and/or other stakeholders to factor in environmental impacts when making decisions on the purchase or prescription of pharmaceuticals
g) Other? If yes, which ones?

Q6: Now considering an overall sustainability assessment (i.e. including the social and economic dimensions): for which purposes are you using now, or would you like to use in the future, such an assessment?

a) To educate stakeholders on how to perform a full holistic assessment
b) To compare benefits (e.g. for human health and wellbeing, including social & economic aspects) with negative (predominantly environmental) impacts
c) To identify and highlight trade-offs between different types of treatments
d) Other? Which ones?

***[Q6a** – Optional, for interviewees already using such an assessment: Are you missing something in the approach you use, and if yes what?]*

Q7: Which scope of an overall sustainability assessment (system boundaries) would be most suited to your needs?

a) production of pharmaceuticals (from production of precursors to finished products before they leave the factory) ("cradle to gate")
b) full pharma life cycle (including distribution, consumption and disposal ("cradle to grave")
c) full pharma life cycle + healthcare system pathway (including general practitioner visits, hospitalization, etc.)

d) full pharma life cycle + healthcare system pathway + full societal pathway (including job creation, informal caregiving, etc.)
e) other scopes?

Q8: According to your experience, which stakeholder groups would have interest in using environmental sustainability assessments for pharmaceuticals?

Q9: Do you have an opinion on which role different stakeholder groups should have in performing the sustainability assessment, e.g. the role of industry, regulators (e.g. European Medicines Agency) or scientists?

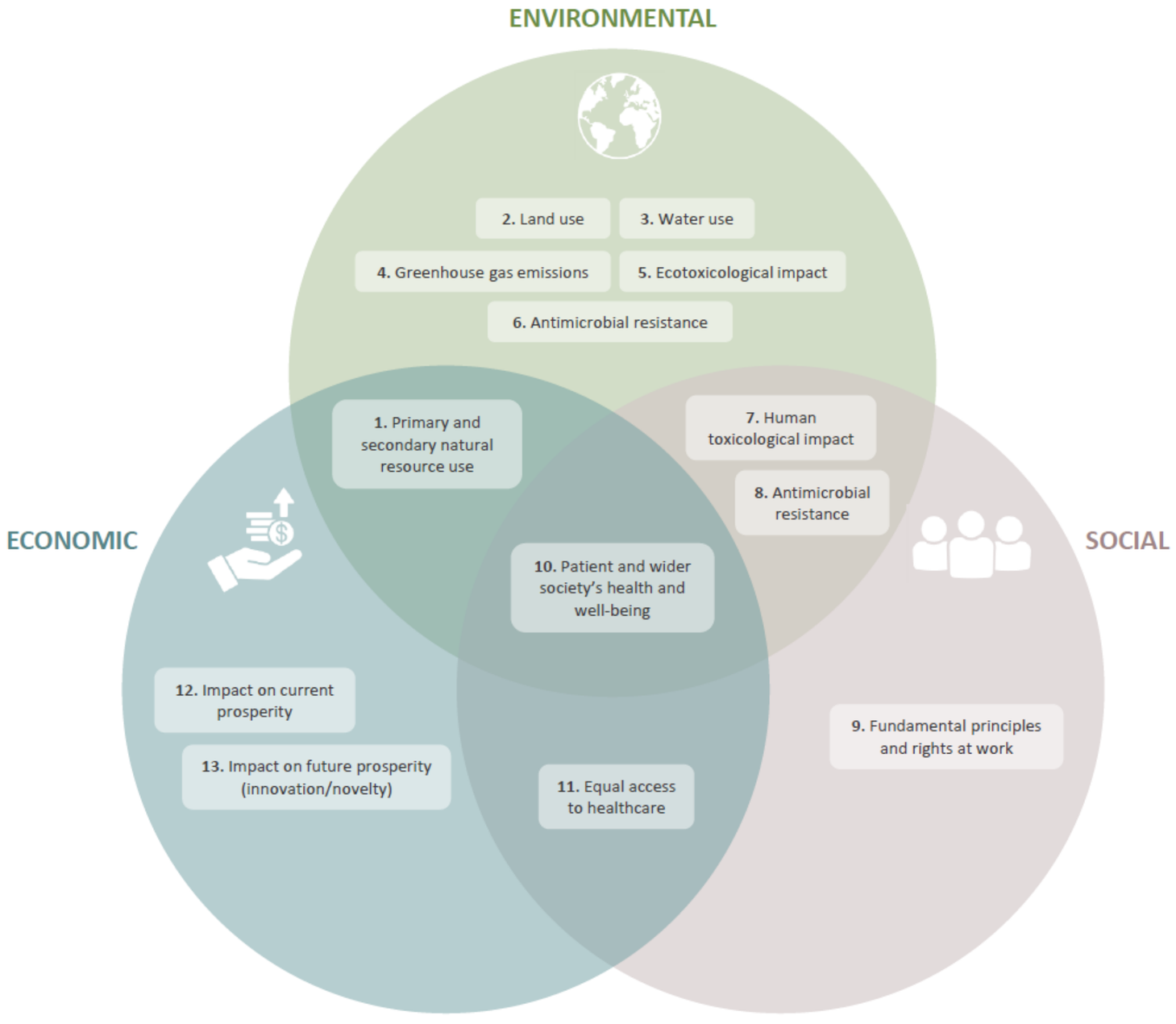
Q10: Environmental footprints can vary strongly depending on local- or region-specific factors (e.g. wastewater treatment technology). This can lead to different results for an assessment of the same product, depending on the geographical scale chosen for the assessment. Based on this, which geographical level(s) should be considered for an environmental sustainability assessment valid for your organisation and why?

a) Local
b) Regional
c) National
d) Multi-national (e.g. EU)
e) Global

[Q10a *- Optional, for interviewees with in-depth knowledge of topic: Which type of functional unit do you think would be best suitable for that geographic scope (mass based or one including further information e.g on patient's age, time of treatment and place)?]*

Section 3: Questions on assessment methodology

Q11: Which of the thirteen following Impact Categories should be included so that the approach Transpharm is developing covers your organisation's requirements of a sustainability assessment of pharmaceutical products? Which relevance (low, middle, high) would you assign them? Are there Impact Categories missing in your opinion, and if yes which?



1. Amount of primary natural resources (e.g. renewable resources, fossil fuels, nuclear energy, metal ores, minerals, atmospheric resources) used, including secondary natural resources (obtained from reuse and recycling practices). This is related to the degradation of resources such as soils, land and water, and air pollution with toxic substances, and thus closely related to climate change and biodiversity loss.
2. Damage to ecosystems due to the occupation of a certain area, its transformation or a combination of both impacts. Land use is a strong driver for biodiversity loss and land use competition.
3. Total water consumption, used to evaluate the impact of the extraction of water, which has a potential for damaging ecosystems.
4. Greenhouse gas emission are increasing the radiative forcing of the atmosphere, which leads to an increment of the global average temperature affecting ecosystems.
5. The toxicological potential of substances (e.g., active pharmaceutical ingredients, excipients, microplastics) emitted to air, soil and water to impact ecosystems.
6. Antimicrobial resistance can lead to a decreased ability to treat infections in the environment.
7. The toxicological potential of substances (e.g., active pharmaceutical ingredients, excipients, microplastics) emitted to air, soil and water, to impact humans.
8. Antimicrobial resistance can lead to a decreased ability to treat infections in people.
9. The "freedom of association and the effective recognition of the right to collective bargaining"; being free "of all forms of forced or compulsory labour"; "of child labour"; "of discrimination in respect of employment and occupation"; and "working in a safe and healthy environment".
10. The burdens (e.g., side-effects) and benefits (e.g., decrease in disability-adjusted life years) associated with the pharmaceutical, which are directly linked to the health and social/financial well-being (e.g., increased social connection, lower out-of-pocket costs) of the patient. This also refers to the impact on health and social/financial well-being (e.g., decreased productivity loss) of the wider society (e.g., health care providers, social network) as a result of the patient using the pharmaceutical.
11. Equal access of vulnerable groups (e.g., women, people with low socioeconomic status) to pharmaceuticals and healthcare (e.g., ability to see a doctor due to social and time restrictions, reading prescriptions).
12. Expenditures (e.g., capital, operational, and end-of-life expenditures) and revenues (e.g., sales of the pharmaceutical, incoming fees, jobs created) related to the lifecycle of the pharmaceutical.
13. Impact of the pharmaceutical on future prosperity (e.g., hindering research, development, innovation (R&D&I) in the pharmaceutical and/or healthcare sector due to patent protection).

Based on validated impact categories developed by international (European Union) and national (the Netherlands) projects:

- *Gaasbeek & Meijer (2013). PROSUITE. Handbook on a novel methodology for the sustainability impact assessment of new technologies.*
- *Harmens & Goedkoop (2021). ORIENTING. Critical evaluation of social approaches.*
- *Health Care Without Harm (2023). Procuring for greener pharma.*
- *van Wezel (2022). Exploration of an assessment framework for medicinal products based on sustainability. Internship report for RIVM.*
- *ILO Declaration on Fundamental Principles and Rights at Work. https://www.ilo.org/declaration/lang--en/index.htm*

Figure 2: Overview of proposed Impact Categories to be considered in the TransPharm sustainability assessment (Sustainable Systems Engineering (STEN) research group, UGent, 2023).

Q12: Would your organization like the TransPharm sustainability assessment to be a stand-alone approach? Or do you think it should be capable of integrating / working in conjunction with other assessment results? If yes, with the results of which assessments?

[Q12a – *Optional, for interviewees with in-depth knowledge of topic: The methodological foundation of Life Cycle Assessments (LCAs) used for assessing some aspects of environmental sustainability of pharmaceuticals currently varies greatly, which can hamper the comparability of the results of different assessments per API/product. What do you think would be necessary to enable the harmonization of methodologies and how?]*

Q13: Is it in your opinion necessary to give weights to the different elements of the environmental sustainability assessment? Would you want to be able to weigh the results of the assessment yourself (according to your organisation's needs), or do you see your organisation using a more generic weighting scheme? If the latter, how would you want to adapt the weights to your needs?

Q14: Would you want the assessment to have as outcome:

a) a total sustainability score for the product,
b) scores per dimension of sustainability (environmental, social, economic)
c) scores per impact category,
d) scores per individual impact category criterion,
e) more than one of the above options?

Q15: What are your thoughts about monetization (e.g., expressing the result in Euros) for aggregating the results (impacts and benefits) of an assessment?

Section 4: Data availability and transparency

Q16: How transparent should the sustainability assessment be?

Q17: Do you have ideas on how to increase the availability of relevant data along the supply chain? Which tools or incentives would be suitable for actors to share their data (e.g. positive evaluation for actors that make data transparent, use of worst-case estimates or red flags for process steps where data is not made available)?

Section 5: Barriers to take-up / opportunities

Q18: Regarding the possibility to have APIs or products on the market that are more environmentally sustainable, which barriers to take-up do you see?

Q19: How can these barriers be addressed?

Q20: Which opportunities are there, or could be created?

Last but not least…

We would be interested in getting your opinion once we have developed final drafts of the impact categories and their underlying criteria (Figure 2). **Could we contact you for participating in a brief online survey** on the criteria and associated indicators to be used to assess the impact categories (approx. late 2023/early 2024)?

Annex II: Workshop programme

Workshop 4-6 April 2023, Nijmegen, the Netherlands

The transition towards sustainable pharmaceuticals – assessing sustainability, from design & production to prescription & use

PREMIER
PRIORITISATION AND RISK EVALUATION OF MEDICINES IN THE ENVIRONMENT

TRANS PHARM

The meeting will be held at hotel Van der Valk Nijmegen-Lent.

Tuesday April 4, afternoon (day 1)

Chair: Ad Ragas (Radboud University)

Moving towards the design of active pharmaceutical ingredients (APIs) with less impact on the environment after use

12:00	**Registration and lunch**
13:00	***Plenary session (Room 3 Waalsprong)*** Ad Ragas (Radboud University, the Netherlands) – Welcome, Introduction to the PREMIER project, setup and goal of the meeting Gerd Maack (UBA, Germany) - Setting the scene: the need to design greener APIs Robert Sheppard (AstraZeneca, Sweden) Introduction - overview of the drug R&D process
14:00	**Interactive intermezzo**
14:20	***Plenary session (Room 3 Waalsprong)*** Neele Puhlmann (Leuphana University, Germany) - Outcomes of the interviews and workshop with R&D experts Irene Bramke (Astra Zeneca, UK) - Applying environmental hazard criteria in the R&D process: testing candidate substances. Tobias Pamminger (Bayer Crop Science, Germany) - The implementation of environmental criteria in crop protection product R&D
15:20	**Break**
15:50	***Interactive session in subgroups*** **Rooms 4 and 11**: What are the needs of R&D organisations to embrace the challenge to design greener APIs? **Rooms 3 and 5**: How can stakeholders from the healthcare sector implement use of greener APIs?
17:00	***Plenary feedback and discussion (Room 3 Waalsprong)***
17:45	**End of day 1**
19:00	**Dinner at Humphrey's, sponsored by GSK** (Mariënburg 59, 6511 PS Nijmegen) https://www.humphreys.nl/en/restaurants/humphreys-nijmegen

Wednesday April 5, morning (day 2)

Chair: Caroline Moermond (RIVM)

Environmental criteria for active pharmaceutical ingredients to reduce their impact after use

9:00	***Welcome (Room 3 Waalsprong)*** Caroline Moermond (RIVM, the Netherlands) - Welcome, introduction to today's meeting
9:10	***Plenary session (Room 3 Waalsprong)*** Caroline Moermond (RIVM, the Netherlands) - GREENER criteria for sustainable active ingredients; possibilities for risk mitigation Klaus Kümmerer (Leuphana University, Germany) - Reducing environmental persistence Bastiaan Venhuis (RIVM, the Netherlands) - PFAS pharmaceuticals Tiina Sikanen (University of Helsinki, Finland) – Bioaccumulation in aquatic species Irene Bramke (AstraZeneca, UK) - Mobility
10:30	**Break**
11:00	***Plenary session (Room 3 Waalsprong)*** Andreas Häner (Roche, Switzerland) - Ecotoxicity Jim Ryan (GSK, UK) - How criteria for environmental properties and criteria for efficacy and safety interact Ross Brown (University of Exeter, UK) - Tools and assays to predict environmental properties
11:50	***Discussion in subgroups*** **Rooms 3 and 4**: R&D **Rooms 5 and 6**: Health care Criteria to reduce environmental impact of APIs after use
12:40	**Lunch**

Wednesday April 5, afternoon (day 2)
PREMIER parallel session

Chair: Caroline Moermond (RIVM)

Implementation of environmental criteria in drug discovery and design of small molecules

13:30	***Interactive session (Room 6 de Warmoes)*** Implementation of environmental criteria in drug discovery and design of small molecules - Your view on sustainability in early small molecule R&D - Barriers for implementation of environmental criteria in the R&D process - What are windows of opportunity? What would be drivers? - What do R&D experts need from environmental experts?
15:00	***Plenary discussion (Room 6 de Warmoes)***
15:15	***Wrap-up, future work***
15:30	**End of PREMIER part; Drinks in Lola's bar**
18:30	**Dinner at De Hemel** (Franseplaats 1, 6511 VS Nijmegen) https://restaurantdehemel.nl/en/
21:00	***Serious Game on Safe and Sustainable by Design*** Restaurant De Hemel (Franseplaats 1, 6511 VS Nijmegen) https://restaurantdehemel.nl/en/ We will play a serious game on SSbD. Within the TransPharm project, we intend to change this game to focus on pharmaceuticals. All input appreciated!

Wednesday April 5, afternoon (day 2)
TransPharm parallel session
Chair: Ad Ragas (Radboud University)

Criteria for greener production of pharmaceutical products

12:30	**Registration and lunch**
13:40	***Plenary session (Room 3 Waalsprong)*** Ad Ragas (Radboud University, the Netherlands) – Welcome, introduction to this session Lowik Pieters (RIVM, the Netherlands) - First inventory of stakeholder views on criteria Rosalie van Zelm (Radboud University, the Netherlands) - Introduction on LCA aspects; differences between active ingredients, materials, products, etc.
14:30	**Interactive intermezzo**
14:50	***Plenary session (Room 3 Waalsprong)*** Lieselot Boone (Ghent University, Belgium) - Case study on LCA Wouter de Soete (Johnson and Johnson Ghent, Belgium) - Generating actionable insights through environmental impact assessment: challenges and opportunities Alex Mullen (AstraZeneca, UK) - Product Sustainability Index – Driving Innovation for Sustainable Medicines Production
15:50	**Break**
16:20	***Plenary discussion (Room 3 Waalsprong)***
16:50	***Plenary interactive session*** Is there a business case for Green pharmaceuticals?
17:30	***Plenary wrap-up***
17:45	**End of day 2**
18:30	**Dinner at De Hemel** (Franseplaats 1, 6511 VS Nijmegen) https://restaurantdehemel.nl/en/
21:00	***Serious Game on Safe and Sustainable by Design*** Restaurant De Hemel (Franseplaats 1, 6511 VS Nijmegen) https://restaurantdehemel.nl/en/ We will play a serious game on SSbD. Within the TransPharm project, we intend to change this game to focus on pharmaceuticals. All input appreciated!

Thursday April 6 (day 3)

Chair: Caroline Moermond (RIVM)

Sustainability assessment of pharmaceutical products

8:30	**Registration**
9:00	***Plenary session (Room 3 Waalsprong)*** Caroline Moermond (RIVM, the Netherlands) - Welcome, Introduction to the TransPharm project, setup and goal of the meeting Jen Hochmuth (HealthCare without Harm, Belgium) - Need for sustainability assessment; Sustainable public procurement of pharmaceuticals Ad Ragas (Radboud University, the Netherlands) - Re-cap of day 2: criteria for APIs after use and criteria for sustainable APIs/products Lisa van Wilder (Ghent University, Belgium) - Mapping of the value chain, introduction of handprint/footprint concept
10:10	**Break**
10:40	***Interactive session in subgroups*** **Rooms 3 and 5**: Topic A. Mapping the life cycle of pharmaceuticals and needs for an assessment system by stakeholders: Who, why? **Rooms 6 and 7**: Topic B. Aspects to consider when designing an assessment system for environmental sustainability of pharmaceuticals
12:10	**Lunch**
13:00	***Interactive session in subgroups*** **Rooms 3 and 5**: Topic A. Mapping the life cycle of pharmaceuticals and needs for an assessment system by stakeholders: Who, why? **Rooms 6 and 7**: Topic B. Aspects to consider when designing an assessment system for environmental sustainability of pharmaceuticals
14:30	**Short break**
14:45	***Interactive session in subgroups*** **Room 6**: Needs and opportunities for education and awareness raising in drug R&D **Room 3**: Education of healthcare professionals: needs, best practices, opportunities
15:45	***Plenary wrap-up (Room 3 Waalsprong)***
16:00	**End of day 3 – Drinks in the Foyer!**