> CHAPTER 12

Making use of STI mappings

Empowering stakeholders to select the relevant STI for SDGs

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OVERVIEW

- Existing mappings of publications and patents hide the diversity of ways that STI may lead to sustainable development.
- In contrast, the STRINGS approach provides a visualization of research landscapes, based on research areas, revealing a range of diverse research options related to one or more SDGs.
- These visualizations illuminate gaps, potential synergies, and current imbalances in STI investments.
- Our interactive visualization tool allows stakeholders to inspect research areas that are potentially related to a given SDG, and to develop their own mapping, according to their context and perspectives.
- Rather than a unique map of STIs for each SDG, there are a multiplicity of 'mappings' dependent on the choices made by stakeholders.
- The tool is based on the Web of Science, a mainstream publication database with uneven coverage. More comprehensive databases are needed to reflect research activities in different disciplines and in lower income countries.

Footnotes for this chapter are on page 130. A full list of references can be found on page 140.

Introduction: allowing for choice in the exploration of STI for the SDGs

One of the key insights of the STRINGS project is that a disparate range of science, technology and innovation (STI) activities may potentially contribute to a given sustainable development challenge, and that stakeholders hold diverse views about which STI directions should be pursued, according to their particular perspectives, values, needs or interests.

This diversity of options and perspectives presents a challenge for attempts to map STI activities to the Sustainable Development Goals (SDGs). While conventional mapping techniques work in scientific or technical fields, where differences in understandings are relatively small, they are problematic in the case of divergent understandings as when mapping STI activities to the SDGs. These differences in understanding are clear from the results of our Delphi study (chapter 7), as well as the range of STI pathways in the case studies (chapter 8).

It is clear that a consensus cannot be reached about the type of STI activity needed to achieve a given SDG or target. Neither should analysts aim to construct a consensus about the best or preferred STIs for achieving SDGs as this would fail to respect a key SDG value, namely cultural diversity and political autonomy, for example of indigenous people and ethnic minorities.[1] Instead, analysis should embrace the plurality of stakeholders' perspectives about the various research directions that may contribute to the SDGs.

In this chapter, therefore, we introduce our open, interactive visualization tool, together with a description of participatory processes. These tools and processes can empower stakeholders to explore and develop their own mappings of STI for SDGs, choosing those research areas which they perceive as appropriate for addressing SDGs according to their context, needs, values and aspirations.

A multiplicity of possible mappings of STI for SDGs

Previous attempts to map research efforts to the SDGs[2] take a dichotomous approach: some publications or projects are classified as contributing to an SDG, while others are classified as not contributing. These classifications are based on technical criteria, such as the presence of particular keywords associated with an SDG, or the similarity with a set of documents considered central to a specific SDG by experts.

In general, these maps or research landscapes are created by positioning publications on a two-dimensional visualization according to their similarity in citation patterns, disciplines or topics. The resulting maps and landscapes are thus contingent on inevitably subjective choices about the publication database used, the specific keywords selected, and the particular methods of grouping and positioning publications.

Choice of database

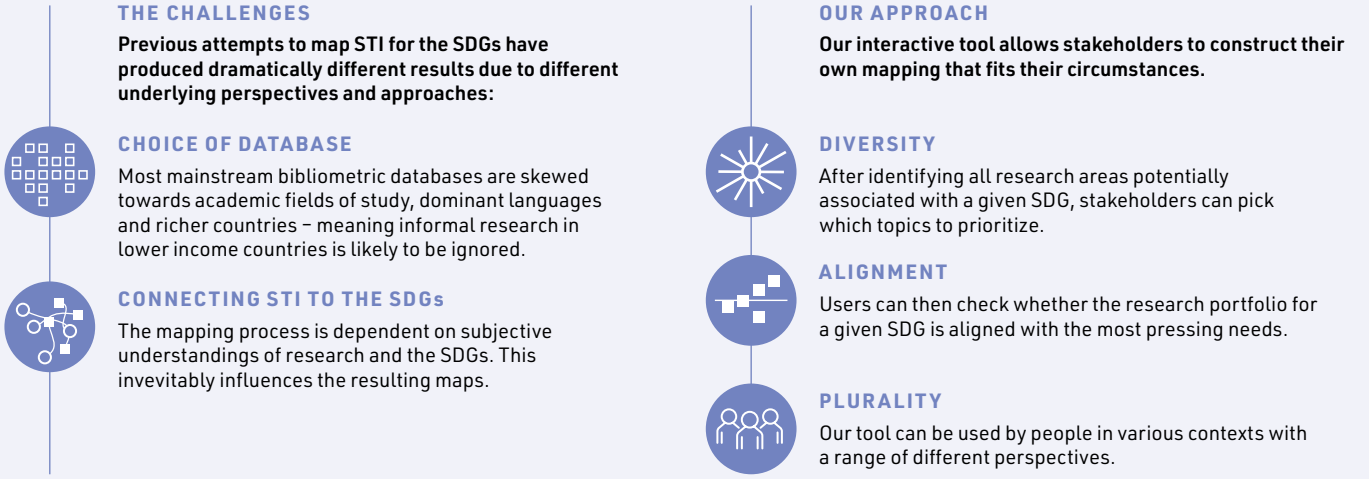
The first challenge is the comprehensiveness of the publication database that is used to map research. It is well known that mainstream bibliometric databases are skewed towards certain academic fields of study, dominant languages and richer countries.[3] As a result, social and applied sciences, along with research that is relevant to developing countries, are severely underrepresented.[4] Due to constraints in resources and time, the STRINGS project uses the Web of Science database. This is a major limitation of this study: future studies should aim to use more inclusive databases such as Lens.org or OpenAlex. To this end, we urge international bodies to support the creation of open information infrastructures that improve the coverage of research in middle- and low-income countries, in applied fields and in diverse languages.[5]

Procedures for connecting STI to the SDGs

A more intractable challenge is the reliance on particular procedures to characterize relations between the publications and the SDGs. In our case, the procedure is based on keywords associated with a given SDG. However, since SDGs are often not explicitly mentioned in scientific publications (perhaps because expert readers are expected to already know about, or not be concerned with, the potential applications of the research) the process of mapping projects or articles to the SDGs must be carried out through an interpretative process. Such a process is inevitably dependent on subjective understandings of research and the SDGs.

In some cases, there may be consensus about the value of research for achieving the SDGs. For example, most analysts would agree that research on malaria is important for achieving global health. However, in a number of SDG areas, such as SDG 2 (Zero hunger) or SDG 10 (Reduced inequalities), there are stark disagreements about the potential benefits of certain types of STI. Some stakeholders believe that genetically modified crops will help reduce hunger, for example, while others would argue that these approaches will impoverish small farmers.[6] Moreover, relatively little research explicitly mentions gender equality (SDG 5), despite the large amount of research into issues such as robotization, AI and transportation, whose application may have an impact on gender-based inequalities.

Figure 12.1 / Allowing for choice in the exploration of STI related to the SDGs



Disparities between mapping studies

These differences in underlying perspectives and databases have surfaced in dramatic statistical disagreements between the findings of mapping exercises.[7] When comparing the papers related to SDGs retrieved by a Bergen University team with those retrieved by Elsevier's study, the Bergen team found astonishingly little overlap. For most SDGs, they found only around 25% to 35% agreement, as illustrated in Figure 12.2.

A consortium of universities for SDGs (Aurora) also found striking disparities between different keyword searches. For example, between the 2020 and the 2021 versions of Elsevier's mapping of SDG-related publications, there is less than 33% agreement for all SDGs except SDG 3 and 7, as shown in Figure 12.3. The comparison between Aurora's and Elsevier's search strategies yields even lower overlaps: they only agree on one or two out of every 10 publications they label as SDG-related.[8] Comparisons between the Elsevier, SIRIS, and Dimensions approaches and our own STRINGS approach have confirmed extremely large differences.[9]

These findings confirm that mappings of STI to SDGs are contingent on specific contexts, perspectives and understandings. In other words, the inconsistencies between mappings are due not only to methodological differences, but to different interpretations, implicit in the retrieval methods, of what type of STIs will help to achieve SDGs.

In summary, there is a multiplicity of possible meaningful mappings of STI for SDGs and the difference between mappings is significant. Under these conditions, rather than searching for a single 'best' mapping, we aim to provide a comprehensive SDG-related research landscape, allowing stakeholders to make choices about which parts of the landscape are relevant according to their own perspectives and contexts.[10]

Our approach: helping stakeholders develop their own mappings of SDG-related research

To accommodate stakeholders' varied understandings about which STI is most relevant to a particular SDG, our approach to mapping consists of three stages:

- Demonstrating the *diversity of STI research directions* for a given SDG.
- Examining *misalignments* in the distribution of publications.
- Understanding the *plurality of views* on research directions.

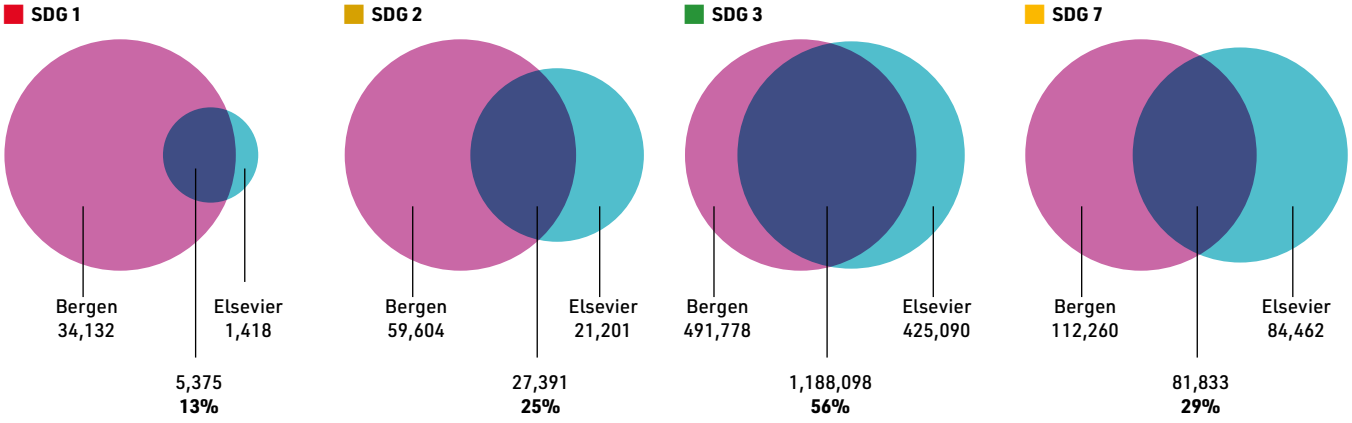
Diversity of research directions for a given SDG

In the first step, we aim to show the diversity of research options by identifying the research areas potentially associated with a given SDG (see Chapter 4). The research areas for a given SDG are visualized in a research landscape in which they are positioned according to their similarity, as illustrated in Figure 12.5.

The key innovation of our approach is to connect specific research areas (based on citation clusters), rather than individual publications, to SDGs. One advantage of this approach is that it assigns publications to an SDG not only based on the content of the publication, but also on the content of neighbouring publications. This aggregation makes the assignation statistically more robust.

A second advantage is that it provides a bird's eye view of the portfolio of topics potentially related to an SDG (in the same way as a farmer can look at the mix of crops in their property from a drone). This allows stakeholders to reflect on which of these topics should be prioritized and which are less relevant for them.

Figure 12.2 / Comparison between results of Bergen and Elsevier approaches to mapping SDG-related publications

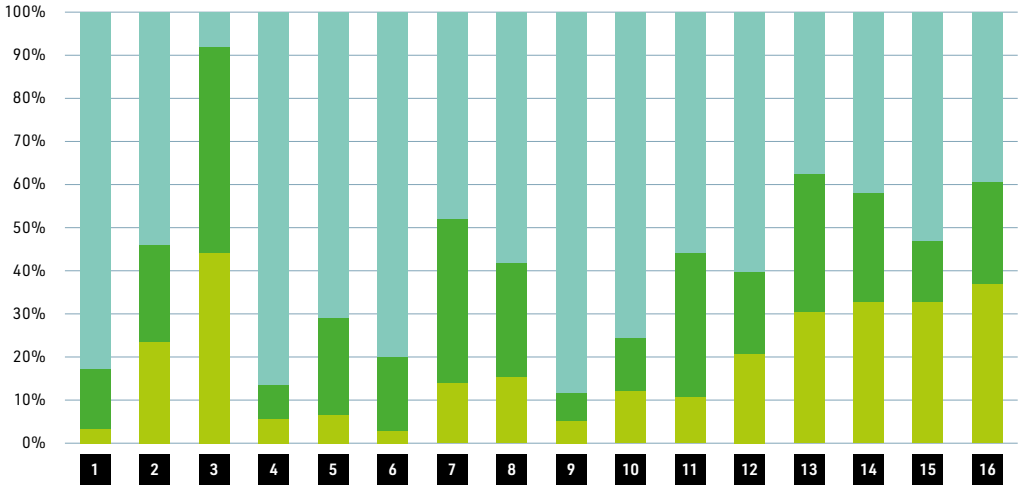


> KEY

- Bergen study (publications identified as being related to this SDG)
- Overlap (the number of publications included in both studies)
- Elsevier study (publications identified as being related to this SDG)

Based on the Web of Science Core collection, 2015-2018. Source: Armitage et al. (2020).

Figure 12.3 / Comparison between results of two different Elsevier approaches (in 2020 and 2021) to mapping SDG-related publications



The dark green area shows the percentage of agreement (overlap) between the methods used in 2020 and 2021.

Source: Schmidt and Vanderfeesten (2021).

> KEY

- Elsevier 2020
- Overlap
- Elsevier 2021
- SDG number

> KEY: **Sustainable Development Goals**

- **SDG 1** No poverty
- **SDG 2** Zero hunger
- **SDG 3** Good health and well-being
- **SDG 4** Quality education
- **SDG 5** Gender equality
- **SDG 6** Clean water and sanitation
- **SDG 7** Affordable and clean energy
- **SDG 8** Decent work and economic growth
- **SDG 9** Industry, innovation and infrastructure
- **SDG 10** Reducing inequality
- **SDG 11** Sustainable cities and communities
- **SDG 12** Responsible consumption and production
- **SDG 13** Climate action
- **SDG 14** Life below water
- **SDG 15** Life on land
- **SDG 16** Peace, justice, and strong institutions
- **SDG 17** Partnerships for the Goals

The disadvantage is that it is difficult to label the contents of the clusters with keywords that are easy to understand by non-experts, in contrast to traditional disciplinary classifications, which are less precise but more user friendly.

In short the proposed approach goes beyond counting whether a particular organization or country has more or less publications relating to a certain SDG. Instead, the visualization of a portfolio of research areas enables an analysis of how to target specific goals by focusing efforts towards particular directions in the research landscape.

Examining misalignments in the distribution of publications

In a second step, we examine misalignments in research directions within an SDG. This type of analysis is important to check whether the whole research portfolio for a given SDG is indeed aligned with the most pressing needs or aspirations of a given population for that SDG (see Chapter 6).

SDG 3 (Good health and well-being) is useful to illustrate this approach. SDG 3 is the goal with by far the most related research, in both high- and low-income countries (see Chapter 4). However, as shown in Figure 12.4, many more publications relate to cancer, which affects relatively more people in rich countries, than to diseases such as malaria or tuberculosis or cardiovascular diseases which affect poorer populations (see Chapter 4).

Provided with such information about the distribution of health research efforts in the SDG-research landscape, stakeholders may consider increasing their research into relatively understudied diseases that affect poor populations, and may choose to put less effort into fields such as some cancers, which are already highly funded in relation to their disease burden.

Similarly, the analysis of publication distributions may help stakeholders to consider which approaches (and therefore which solutions) to prioritize for a given problem.[11] For example, decisions about research for SDG 3 depend on the relative value accorded to prevention, care, treatment and diagnosis. The research areas relating to SDG 3 include three topics linked to Alzheimer's disease (which is relevant to target 4 of SDG 3: mental health). These topics comprise one large cluster on psychiatry and clinical neurology, one on the amyloid-beta proteins that cause Alzheimer's (basic biomedicine), and one smaller cluster focused on caregiving (gerontology).[12] While all three may be relevant to achieving the SDG, there are decisions to make: since there are no medium-term expectations of silver-bullet therapies for Alzheimer's, which of these three approaches deserves further support?

A plurality of views on research for the SDGs

To enable stakeholders to better prioritize among the diversity of research options related to SDGs, it is important to assess the potential benefits and harms to sustainable development of different types of research. For example, it is useful to compare the relative long-term benefits of therapeutic versus preventative approaches to mental health. This is not only technically difficult, but is also inevitably shaped by different perspectives on the value and impact of research.

Therefore, the STRINGS proposal is to be as transparent and flexible as possible about how topics (and associated research areas) are related to SDGs. We are developing visualization interfaces, such as the research landscape shown in Figure 12.5. These tools are designed to help stakeholders explore research areas and choose which ones they consider most relevant to each SDG, thus constructing their own mapping of STI for SDG – a mapping that fits their particular circumstances and preferences

As shown in Figure 12.5, the visualizations show research areas that are potentially relevant for each SDG. Currently, interactive functions allow users to explore the contents of each research area. We are making efforts to improve these platforms, but deeper expertise in visualization design and participatory methods is needed to further develop the interfaces and the contextual mapping processes. The research areas shown represent technical areas of expertise and may

Figure 12.4 / Percentage of disease burden in 2015 against percentage of disease publications in SDG3 in 2015-2019, for the world for the main disease groups.

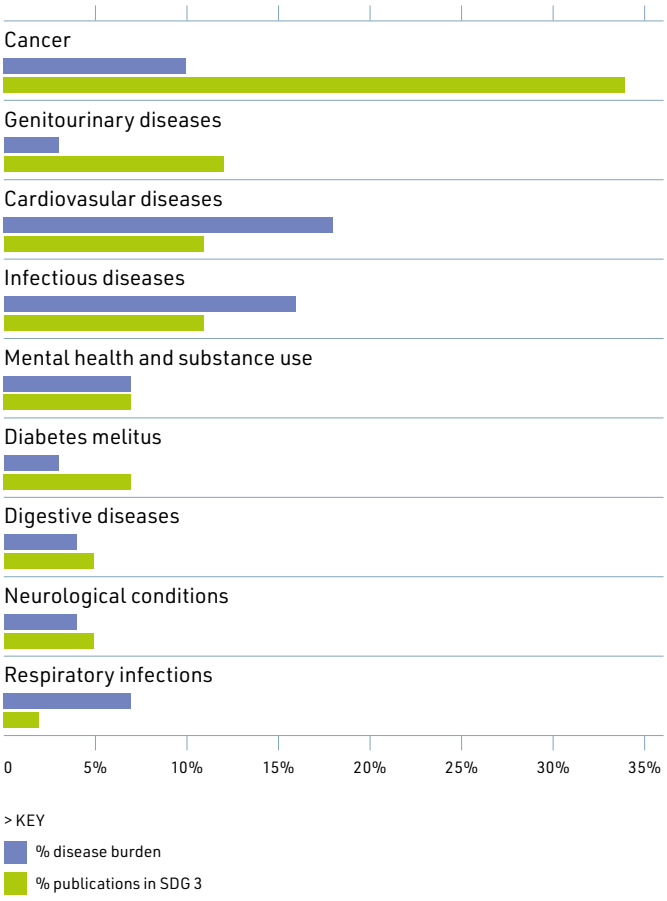
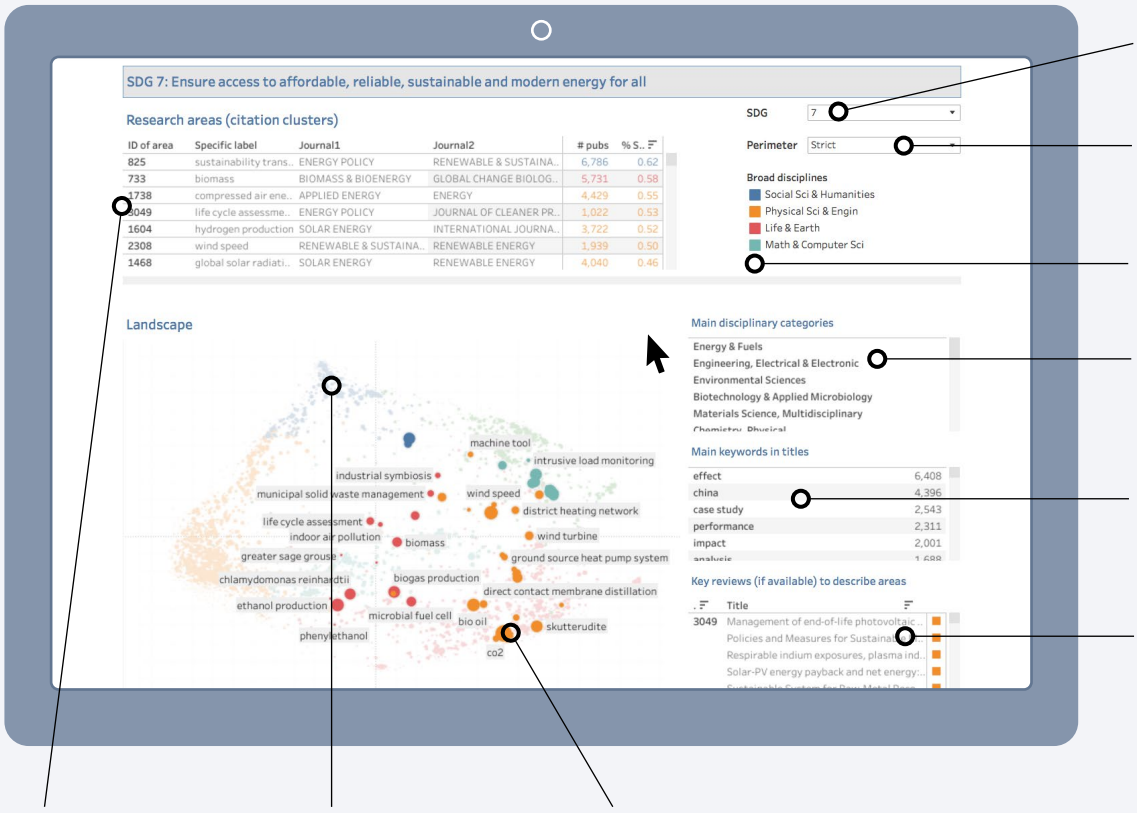


Figure 12.5 / Interactive visualization of the research landscape for SDG 7 (Affordable and clean energy)

The STRINGS interactive tool enables users to create their own mapping of scientific research to the SDGs. Users can adjust settings to identify research areas that are potentially relevant for each SDG.



Example of a research landscape for SDG 7

'Strict' perimeter indicates areas that we considered strongly related to the SDGs. 'Loose' indicates areas with a weaker relationship

The colours indicate the broad discipline of each research area

The disciplinary categories section shows the most common scientific fields in the selected research areas

The keywords section shows the most common keywords in the publications of the research areas

The key reviews section shows the titles of the most cited review publications (which review previously published research on a topic)

This section shows the research area labels along with the number (# pubs) and proportion (% SDG) of SDG-related publications in each area

The dots in the background show other research areas that are not related to a given SDG. Their positions reflect the structure of the global research landscape

The research areas related to this SDG are highlighted

An interactive version is available here.

www.cwts.nl/strings

be challenging to interpret for non-experts. More user-friendly analytical tools will be needed to illuminate the relations between the needs and demands of social groups and specific research areas or other aspects of STI.

Given these complexities, a variety of transdisciplinary appraisal methods, combining analytical and interpretative as well as qualitative and quantitative approaches and capabilities, will be needed to empower users to make choices. The development of quantitative analytical tools needs to be intertwined with the development of social research methodologies for the inclusive engagement of diverse stakeholders in the use of these tools.[13]

While the approach proposed in this chapter relies on specific interfaces that are shaped by particular methodological choices and need some further development, we believe it offers an important way of ensuring that STI contributes to a plural and democratic pursuit of the SDGs.

Notes

1. Virtanen et al., 2020.
2. Jayabalasingham et al., 2019; Wastl et al., 2020.
3. Mongeon and Paul-Hus, 2015; Chavarro et al., 2018.
4. Vessuri et al., 2014; Rafols et al., 2015.
5. Vessuri et al., 2014.
6. Ely et al. 2014; Ruttan, 2015.
7. Armitage et al., 2020; Schmidt and Vanderfeesten, 2021.
8. Schmidt and Vanderfeesten, 2021.
9. Purnell, P. J., 2022.
10. Rafols and Stirling, 2020.
11. Ciarli and Rafols, 2019.
12. Rafols, I., Yegros-Yegros, A., van de Klippe, W., and Willemse, T., 2022.
13. Rafols and Stirling, 2020.