Tightening the gap between knowledge production addressing SDGs and action for sustainable development

Student name: Mees Eringa

Student number: 0833843

Email: m.j.eringa@students.uu.nl

Utrecht University

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Supervisor: dr. Gaston Heimeriks

Abstract

In order to achieve the Sustainable Development Goals for 2030, it is important that the society overcomes the 'wicked' characteristics of the environmental and social challenges that are bound to the SDGs. Traditionally science focuses on disciplinary research, but this system is not applicable to the current problems society is facing. Focus should shift to trans- and interdisciplinary research. Rather than only producing knowledge, researchers are urged to apply knowledge together with other disciplines and relevant stakeholders from society. Though, the shift towards this type of research is harder than it seems.

This research aims to answer the question of what the institutional mechanisms that facilitate knowledge production addressing SDGs are and what the corresponding bottlenecks are that create a gap between knowledge and action. These were identified through the use of the credibility cycle focusing on the six areas of knowledge production, while the possibilities for changing this system are explored with the theory of Open Science. Whitley's framework is used in order to analyse how this could affect organisational structures. A case study including SDG3 and SDG13 was conducted, interviewing researchers linked to these SDGs as well as researchers experienced with Open Science at the Utrecht University.

The competitive nature of acquiring public grants resulted in a rat race for publications, in which funding agencies are trying to make a change. Lower pressure on publications could lead to more efforts for the application of knowledge. The findings on data sharing made clear that there has been an increase in sharing of data and open access, increasing the range of knowledge, which is one of the main characteristics of Open Science. The process of quality control is still done through journals and traditional peer review methods continue to being used, as alternative methods are still inadequate. Recognition and rewards for research are governed by universities and funding agencies, but are also shifting towards a system in which multiple factors like societal relevance become more important.

While it seems that most of these developments are countering these bottlenecks, it should be noted that is the case of the Utrecht University which already implements a lot of aspects of Open Science. It shows that some of these aspects work in opening up knowledge systems. Though, even at the UU it needs time to become the norm, not to mention other universities and institutes that form the system of knowledge production.

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Introduction

In 2015, the United Nations developed the Sustainable Development Goals for 2030 (SDGs), a global political agreement with 17 goals and 169 targets, was signed by 193 different countries with the ultimate goal to achieve sustainable development (United Nations, 2015). The goals and targets are intended to address and accomplish the biggest environmental and social challenges that our society faces, such as ending poverty, combating inequalities or to protect the ecosystems of Earth and to create conditions for a sustainable, inclusive and sustained economic growth together with shared prosperity and decent work for all, taking into account different levels of national development and capacities. The SDGs focus on the integration and balance of the three dimensions of sustainable development: the economic, the social and the environmental. The goals and targets described within the SDGs are meant to stimulate action for the next 15 years since it was introduced in 2015.

In order to stimulate action to reach the 17 goals and to be able to transform our world, developing new knowledge is necessary (Romero-Goyeneche et al., 2021). The production of knowledge has been important for the identification of the global problems of unsustainability (Cornell et al., 2013), on which the SDGs are based. There is a consensus that knowledge plays an important factor in responding to these problems by driving investments in research and scientific efforts globally. Though, old knowledge systems are still being used to counter the global social- and environmental challenges that are emerging. Knowledge systems are broader than science, and consist of the agents, practices and institutions that organise the production, transfer and use of knowledge. Knowledge systems have science as a fundamental role, but are influenced by the likes of actors, institutions and networks.

The procedures of production, transfer and use of knowledge that are part of knowledge systems has changed over time. It ultimately led to the distinction between two modes of knowledge production, referred to as Mode 1 and Mode 2 (Gibbons, 2003). The first mode is focused on a disciplinary structure, the traditional model of knowledge production used at most universities. Here, “problems of knowledge are set and solved in a context governed by academic interests of a specific community” (Tjeldvoll, 2010, p. 430). The context is here defined in terms of the cognitive and social norms that underlie basic research and academic science (Gibbons, 2003). While the disciplinary model focuses on a particular discipline, this model is not optimal for the “wicked problems” that drive the need for sustainable development. Wicked problems were defined by Rittel & Weber (1973) as “a complex issue that defies complete definition, for which there can be no final solution, since any resolution generates further issues, and where solutions are not true or false, or good or bad, but the best that can be done at the time”. This makes the domain of sustainability different from a lot of other domains in which the problems are clearly defined. Many of the problems described in the SDGs have wicked characteristics (Craps, 2018). The problems are globally interconnected with a lot of competing explanations and resolutions while the responsibilities of public and private actors are not clear. The answers, for example in the form of new knowledge, are not objective and therefore there is not one best solution to these problems. Knowledge is rather seen as biassed, uncertain and ambiguous (Edelenbos et al., 2004). It is often produced in separate networks and arenas, for example between institutes that produce knowledge and those who make use of the knowledge. Traditional knowledge systems that are focusing on Mode 1 are to a large extent still used for social and environmental challenges that come with climate change, challenges that are relatively new compared to these knowledge systems (Cornell et al., 2013). Though, the pressure for change towards the traditional model of knowledge systems is increasing.

This is where Mode 2 of knowledge production becomes interesting, which is more focused on the application of knowledge (Gibbons, 2003). This includes an interdisciplinary- and transdisciplinary approach, which are found to be a good reaction towards wicked problems as these ensure that the knowledge from all relevant disciplines and actors related to the problem is incorporated as well as the increase in legitimacy, ownership, and accountability through collaboration between researchers from different disciplines and non-academic stakeholders (Lang et al., 2012). Scientists are not only responsible for their share of the application of knowledge, but also other stakeholders such as civil society, industry and the polity (Cornell et al, 2013). This would evolve the relationship between research-based knowledge and action into arenas of shared responsibility between different stakeholders, within larger landscapes of power and knowledge that shift and change over time. Within the academic world, institutional barriers have been created over time and are deeply ingrained in the structure of universities and scientific journals, that reward disciplinary excellence and discourage transdisciplinary research (Craps, 2019). In this structure, academic careers advance through a quantitative credit system focused on short term output which is primarily evaluated at the individual level (Miedema, 2022).

Knowledge systems are often structured by institutional mechanisms, which are based on the definition of institutions: "systems of established and prevalent social rules that structure social interactions." (Hodgson, 2006, p. 2). Institutional mechanisms can therefore be described as different parts with particular functions such as rules, norms and tools that determine the structure and actions of institutes. Funding of research, for example, comes in different structures, has different procedures, stakeholders and norms involved, that are all influencing how the funding is allocated. This research will focus on identifying the strengths and weaknesses of these institutional mechanisms, which will be further explained in the theoretical section. This helps to understand how the current knowledge systems work and how knowledge can become more effectively transferred into action, referring to "open cooperation between different science communities and all others with relevant knowledge for contributing to solutions for the complex problems of sustainability" (Cornell et al., 2013, p.62). The theory of Open Science offers some relevant insights that could help counter the bottlenecks that hinder knowledge production for sustainable development. The theory focuses on connectivity and transparency by opening up the process of knowledge development, and therefore opening up knowledge systems (Cornell et al., 2013; Roche et al., 2021). This should result in more engagement with actors from other scientific disciplines and actors outside of the academic world, such as civil society, the industry and polity which in turn would result in scientific researches that are easier to understand and apply, and are trusted by a wider group of people.

The focus in this research is on the development of research addressing SDGs. The thesis is part of research that is done towards mapping SDGs at the Utrecht University (Romero-Goyeneche et al., 2021). The report analysed the growth and development of SDG research at Utrecht University for the period 2000-2019, in order to get a better systemic understanding of this type of research. For this research the SDGs that are used are SDG3 (Health Care and Wellbeing) and SDG13 (Climate Action), in which SDG3 is mainly focused on Mode 1 knowledge production, while SDG13 is more focused on Mode 2 knowledge production. The content and goals of the SDGs will be elaborated upon in the methodology.

The following research question was drafted in order get an understanding of the institutional mechanisms of knowledge systems and how to effectively manage them to tighten the gap between knowledge and action:

What are the institutional mechanisms that facilitate knowledge production addressing SDG's and what are the corresponding bottlenecks that create a gap between knowledge and action?

As described before, there seems to be a gap between knowledge and action, in which action can be seen as the assumption that scientists must share their responsibility for not only the creation of knowledge, but also the application of this knowledge, together with the relevant stakeholders in the form of civil society, the industry and polity (Cornell, 2013).

The research question will be divided into three sub-questions:

- *What are the current institutional mechanisms that facilitate knowledge production?*
- *What are the bottlenecks of the institutional mechanisms that are creating the gap between knowledge and action?*
- *What are potential solutions to minimise this gap between knowledge and action?*

The first two sub-questions relate to the current strengths and weaknesses of knowledge development that addresses the SDGs that will be used in this case. These will be identified using the credibility cycle which will be explained in the next chapter. The last sub-question refers to the theory of Open Science, a theory and phenomenon that is also being implemented at the University of Utrecht, which could help open up knowledge systems.

Theoretical Framework

The following chapter describes the different theories that will be used within the research. First, the institutional theory will be introduced, which helps us to understand how institutes are formed and how it forms the context for the organisational structures of, for example, universities. This theory will be followed by a section about the history of policies directed towards science and technology, explaining the historical trajectories of the system of knowledge production and how it became what it is today. These theories are important for the understanding of the institutional mechanisms that will be identified within the credibility cycle. The model will also help to elaborate upon the second sub-question, which focuses on finding the bottlenecks within the current system of knowledge production. The second part of this chapter is focused on opening up the current knowledge systems, which should have a positive effect on the goal to tighten the gap between knowledge and action.

2.1 Introduction to the Institutional Theory

In order to better understand the institutional mechanisms of the current knowledge systems, this section takes a closer look at institutional theory. The institutional theory pays attention to how the aspects of institutions were created and established within social structures over time, and how they are prone to decline which could make them irrelevant over time (Scott, 2004). It is necessary to describe the meanings of the terms "institutions" along with other terms in order to understand the development and current state of the institutional mechanisms within the system of knowledge production and the degree to which these mechanisms can change. Institutions were shortly introduced in the introduction but will be elaborated upon in this section. They can be referred to as "multifaceted, durable social structures, made up of symbolic elements, social activities and material resources" (Scott, 2001, p. 49). These elements come in different forms. Regulative refers to the form that involves enforcement, such as rules or laws (Scott, 2013). The normative form is enforced by shared ideas about how people should behave, such as norms. And the last form is cognitive, which could refer more to organisational routines and processes and actions that are taken for granted. These different forms result in behavioural guidelines for individuals on how to act (Scott, 2004). The term institutionalisation could therefore be referred to as the acceptance of an element that is part of the above mentioned forms and "to take on a rule like status in social thought and action" (Meyer & Rowan, 1977, p. 341).

The institutional theory is often used in the context of organisations. Generally speaking, organisations are understood as "systems of coordinated and controlled activities that arise when work is embedded in complex networks of technical relations and boundary-spanning exchanges" (Meyer & Rowan, 1977,

p. 340), such as universities. The structure of an organisation is important, as this determines how activities within organisations are directed in order to achieve its goals (Whitley, 1984). Meyer & Rowan (1977) state in their article that in modern societies, these formal organisations are formed in highly institutionalised contexts. While products and services might be created on their own rationalities, formal organisations are driven to form these products and services around professions, policies, programs that have been institutionalised within society, in order to increase their legitimacy and in turn its chance to survive. Therefore, many formal organisations adapt their structure while this might clash with efficiency around an organisation. Vice versa, formal organisations that want to work towards maximum efficiency tend to sacrifice its support and legitimacy. Institutional rules in that way have the potential to build gaps between the structure of an organisation and the activities it performs.

This idea of organisations seeking legitimacy by directing it towards comparability with environmental characteristics forms the concept of institutional isomorphism (DiMaggio & Powell, 1983). To further explain, institutional isomorphism is characterised by three mechanisms: coercive, mimetic and normative. Coercive isomorphism is the result of both formal- and informal pressures on organisations coming from other, often authoritative organisations upon which they are dependent. These pressures could come as forces or as invitations and often result in organisational changes. Mimetic isomorphism derives from uncertainty in which organisations deal with problems by modelling themselves on other organisations that are successful. This is often the result of organisations trying to enhance their legitimacy. The last mechanism is normative isomorphism, and this comes primarily from professionalisation. That is, if individuals have similar educational backgrounds or similar experiences within their industry, processes like problem solving and handling information tend to be executed similarly, resulting in homogeneity over time. Members of an occupation will therefore define conditions and methods that seem most appropriate to that occupation.

Institutional isomorphism will eventually lead to an organisational field, in which organisations “constitute a recognized area of institutional life” (DiMaggio & Powell, 1983, p. 148). And while goals of organisations might change or the possibility that new organisations enter the field, in the long run a homogeneity and institutional environment is built that limits the ability to change. This is important for this research since the system of knowledge production consists of multiple organisational fields that experience coercive, mimetic, and normative pressures.

2.2 The history of innovation policies

As described in the previous chapter, policies and laws influence the way institutional environments are formed. The three frames for innovation policy written by Schot & Steinmueller (2018) will help to understand the history of policies directed towards science and technology. The policies have been established through different *frames*, which are defined as "interpretations of experience, ordering of present circumstances and imaginations of future potentialities that create the foundations for policy analysis and action and shape expectations concerning potentials and opportunities" (p. 3). Frames have a big influence on society's worldview and their associated actions, having influence on what is seen as legitimate and therefore having an impact on institutional environments.

The first frame was right after World War II and focused on innovation for growth, meaning that the direction of science and technology was pointed towards mass production and consumption out of fear of rising unemployment rates and new economic crises. There was a consensus that the state should expand their role by conducting more research. Since then, science was contributing to the modernisation of industry and technological changes provoked the interests in science. It was also the beginning of universities taking up the role of doing basic research, which was the start of the transformation towards becoming the major player that they are today (Gibbons, 2020). The model behind innovation in the first frame was the commercialisation of scientific discoveries driven by investments.

The second frame came into play after the competition between nations increased during the oil crisis in 1970 and the economic recession in 1981 (Schot & Steinmueller, 2008). This showed the innovative and productive performances of nations as well, revealing the gap between higher and lower income countries. After re-examination of the innovation model, it became clear that scientific and technological knowledge could not be seen as a global public good. Much of the performances were dependent on "the capacity to innovate and focussed attention on the processes of learning and the relation between different organisations in a society" (p. 9). Knowledge is generated through the "interaction between actors which involve "interactive learning and the building of capabilities to absorb and adapt knowledge" (p. 11). These processes become effective when actors' objectives and capacities for interaction are aligned. Schot & Steinmueller (2008) state that the second frame is therefore linked to Mode 2 knowledge, as knowledge is produced in the context of application. Industry, government and universities started to collaborate more in this new frame creating an environment in which universities started to become more entrepreneurial by setting up spin-offs and developing new technologies through academic research. This period also led to the introduction of ranking universities, a system in which universities are ranked compared to a set of criteria which ultimately sets the academic quality of a university (Anafinova, 2020). It resulted in a lot of competition between universities, as the rankings offer benefits for universities that are listed high which eventually had a big influence on the organisational structures of universities (Sauder & Espeland, 2009).

The third frame and last frame developed after the emergence and recognition of environmental and social challenges like climate change, reduction of equality, poverty and pollution (Schot & Steinmueller, 2008). Many governments see the potential for science, technology and innovation policy to overcome these challenges. For example, it is expected that externalities, such as climate change, can be managed through regulation. Though, it is doubtable if clean technology and distributional measures are able to solve these externalities. Schot & Steinmueller (2018) propose that the current innovation frames are not capable of addressing and solving the current challenges we face. In order to meet the goals that are described within the SDGs, transformative change is needed. This refers to the transformation of socio-technical systems, a change in “skills, infrastructures, industry structures, products, regulations, user preferences and cultural predilections” (p. 1562). This goes beyond a change in production, and also applies to distribution and consumption and therefore involves all actors within society. This framing implies the construction of a new relationship between the state, the market and civil society. While the second frame introduced Mode 2 knowledge and transdisciplinarity, until this day higher education is still dominated by disciplinary research (Craps, 2019). To reach effective transformative innovation policies, a new knowledge base is needed that focuses on inter- and transdisciplinary studies (Schot & Steinmueller, 2018), and that focuses on opening up knowledge systems. Institutional environments which formed the traditional knowledge systems created organisational structures that hamper the creation of sustainable pathways. Elements of the organisational structures of universities will be identified in the next chapter.

2.3 The Credibility cycle

Within the academic system, the impact of institutional elements are significant (Meyer & Rowan, 1977). Organisations like universities are "structured by phenomena in their environment" (p. 346). For example, organisations that regulate the educational system can influence the training processes, or the issues with quality assurance by using policies that pressure higher education institutions. These institutions change their organisational structures because of these coercive forces, by aligning towards these policies. In this way, the coercive, mimetic and normative forces are responsible for "generating global models of society that define internationally the concept of university" and thus how universities operate (Cardona Mejía et al., 2020, p. 63).

In turn, universities or journals force actors such as students and researchers to fit within their structures and therefore organise along prescribed lines. Values, beliefs and rules at higher education institutes play a key role in the way knowledge is developed. Funding agencies play a role in accommodating the required money that are enabling scientists to do research. Quality assessments such as peer reviewing, which is "the practice of assessing or commenting on manuscripts prior to publication" (Horbach & Halffman, 2018), safeguard the quality of scientific outcomes. Eventually, these stakeholders determine the "credibility building process" of scientific researchers via rules, norms, values, and beliefs that are part of the institutional mechanisms (Leišytė, 2007). When new curricula or procedures are successfully validated as legitimate innovations, they could eventually become authoritatively required. Students and researchers therefore have to obey the environment of the university.

One of the most important roles in the organisation of scientific work is reputation (Hessels et al., 2009). This has led to a system in which it is important for scientists to get positive reputations from other scientists. It also influences what tasks are carried out, how it's done and how they are evaluated. The activities that scientists execute are mostly done in order to convince the importance and significance of the results and to eventually enhance their own reputation, as this will lead to new jobs and resources (Hessels et al., 2009). Most of the researchers are seeking for credibility, the ability 'actually to do science'. The credibility cycle is a concept that shows how researchers are steered by different forms of credibility, which are shown in figure 1 (Latour & Woolgar, 1986). The cycle is meant to showcase the mechanisms that legitimises and incentivizes scientists and their projects. In this cycle, 6 different, interrelated areas of knowledge production are included which form these mechanisms. Credibility can be seen as a resource in different forms, as it eventually allows the scientist to continue doing research. The conversions cannot be made by the scientists independently. Each point in the cycle, the researcher is confronted with specific institutions which facilitate or constrain the conversions that are being made. (Hessels et al., 2009). In the area of money, researchers are for example confronted with the organisational structure and rules of funding agencies that determine how researchers are getting funded, and what type of research is getting funded. For the researcher, “the institutional environment is instrumental in building credibility.” (p. 392).

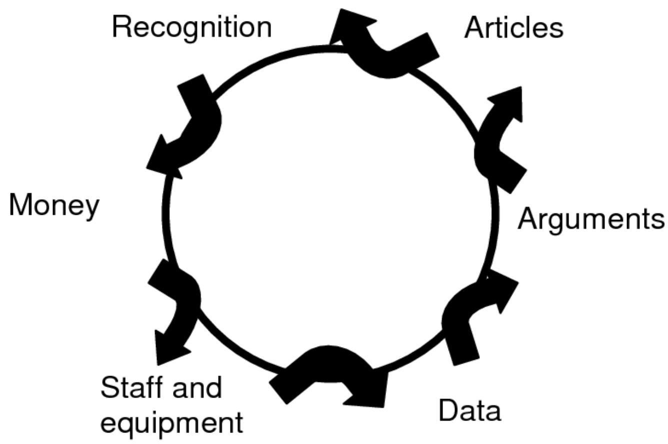

Figure 1. credibility cycle in regular science (Latour and Woolgar, 1986).

It should be stated that the credibility cycle can be tentative, and that it can be seen as a historical contingency. The selection and importance of the conversions that part of the cycle and what the guiding norms and values are, can change over time. This means that there are opportunities for transformative change. The institutes that are responsible for this system such as universities, funding agencies and quality assessments, should reconsider their values, beliefs and rules in order to make a real impact. As the above theory makes clear, there are a lot of mechanisms that play a role within the credibility cycle. By analysing the credibility cycle thoroughly, it will help to answer the first and second research questions about the institutional mechanisms that facilitate the development of scientific knowledge and the associated bottlenecks.

2.3.1 Money

After finishing and publishing a research project, most scientists will be looking for their next project. Without funding, research cannot be conducted. It takes time and materials in order to do research and money is therefore needed. The allocation of funding is often done through funding agencies, which have certain rules and norms when distributing its funds. New forms of funding created a system in which researchers are rewarded with an amount of money that is depending on the degree of the project's success.

Funding for sustainable development

Knowledge development that contributes to designing, implementing and monitoring sustainability for achieving the SDG targets for 2030 is only possible with proper funding. There are two types of funding; public funding and private funding. Public funding comes from publicly funded agencies such as governments while private funding usually comes through gifts and grants (Jones, 2018). Most of the funding is done through private funding, as more than 60% of global R&D spending is done by the private sector which is mainly focused on business interests (Messerli, 2019). The remaining share of funding which is done through public R&D funding seems to be focusing on multiple priorities with sustainable development being one of many.

When looking at Human Health and Wellbeing (SDG3), a report by Research America (2019) can give an example on the growing expenditures on medical and health R&D in the U.S. towards 2018. The total U.S. medical and health R&D spending was $194.2 billion in 2018. Expenditures ranges from the industry investing $129.5 billion in medical and health R&D, while academic and research institutions including colleges and universities, independent research institutes, and independent hospital medical research centres dedicated more than $15.7 billion of their own funds (8.1%). The medical and health R&D of the U.S. grew by 35.7% from 2013 to 2018, yet it still accounts for just 5 percent of the total U.S. health care spendings. Despite relatively low funding, it is expected that research productivity remains high in most academic faculty in the health sciences.

Elaborating on the investments in research for Climate Action (SDG13) is not as straightforward compared to SDG3, as the investments in climate action are subdivided into multiple sectors such as food, energy or water. However, Overland & Sovacool (2020) managed to identify funding related to climate change research. According to their estimates, natural and technical sciences received around 770% more fundings than social sciences in the period from 1990 to 2018. Besides, only a minor part of the social science fundings go to research for climate action. This was estimated at 5.21% of all funding for climate change research, or 0.12% of all research funding. Funding for climate research is based on the fact that it is expected that the problem of climate change can be helped through natural scientists who work out the causes and impacts to eventually come up with technological remedies. It shows that this assumption does not hold. Natural and technical sciences are not able to change attitudes, norms, incentives, and politics, while social sciences have the ability to do this.

The scarcity of funding means that only a minor part of funding goes to developing research that paves the way to sustainable development. In order for sustainability science to reveal its potentials, fundings have to rise. It has mainly to do with the fact that the organisations that dominate this space such as governments can only fulfil a small portion of the required funding for sustainable development. Fundings for sustainable development and climate action did actually grow over the years but calls for the extension of financing in this sector show that this growth is far from enough (Clark et al., 2018). There is a wide consensus that the public funding is insufficient for sustainable development, and it is therefore logical that the focus on the private sector is increasing. It is expected that the interviewed researchers heavily depend on public funding.

Hyper competition among individual scientists

Competitive research funding is a fund by the public sector based on competition, and was introduced in order to minimise failures in research systems (Kang & Motashi, 2020). In this form, funds are awarded to the best-performing researchers in order to create research efficiency and the best possible scientific outcomes. Young (2014) elaborates on how the Swedish government started allocated funding through the use of 2 indicators in 2008. The first indicator was the amount of funding a university had received and the second indicator was a point system for individual researchers. This point system counted the amount of publications on the Web of Science database (WoS) and then normalised it based on the year and the field of discipline. Like Sweden, this point awarded system was also part of the European agenda, as the Commission of the European Communities stated that “competitive funding should be based on institutional evaluation systems and on diversified performance indicators” (Commission, 2006). And this was proven to be true, by late 2010 14 nations had adopted such a system in which research funding was allocated through research performance. In many countries this was the result of the increasing accountability pressure of higher education due to questions about “the value of credentials, rising costs of providing a quality education, and rising student loan debt”, which can also be linked to coercive and mimetic isomorphism (Ortagus et al., 2020,). At least a portion of the available funding for universities is tied to students’ research outcomes, and this is expected to come forward in the interviews. Despite all these changes and the focus on a system that is driven by performance, research to date does not show evidence for the intended outcomes of the system while there is growing evidence that it could lead to some unintended outcomes. For example, students making strategic choices in which field they are going to do research and on what topic to do research based on the chance of building a resume that is worth credibility and esteem from other peers (Miedema, 2022). This is ultimately done to acquire grants for their next research.

2.3.2 Staff and Equipment

Funding is closely related to staff & equipment. For the hypercompetitive individual researchers, hiring staff is unnecessary as they work on their own. Though, for projects evaluating researchers is important for the hiring, promotion and tenure of staff. The selection of curriculum vitae (CVs) is often a time-consuming process in which institutions such as assessment committees have to make decisions with limited time and budget (Moher et al., 2018). Therefore, many assessments are done via more efficient methods, such as the number and amount of funded grants and the number of citations and published papers. Langfeldt et al., (2021) identified three types of publication-based indicators:

1. productivity/number of publications,
2. scientific impact/citations and
3. The impact factor of journals.

The first indicator is focused on the amount of knowledge that is produced by a researcher. The second indicator is commonly applied in order to identify the impact of a research, which is one of the essential parts of scientific quality. The H-index is a commonly used metric on the author-level. The third type of publication-based indicators refers to the Journal Impact Factor (JIF), which will be elaborated upon later in this chapter. It is regarded as one the most visible metrics and an indicator of the significance and prestige of a journal. Other metrics that are often used are the CiteScore, article influence factor, Eigenfactor (EF), source normalised impact per article (SNIP) and Scimago journal rank (SJR). The outcomes of the metrics are involved during faculty hiring and promotion informing, the distribution of grants and funds and when comparing the perceived productivity of researchers (Büttner et al., 2021). Langfeldt et al. (2021) complements this statement, as “a large majority of their research indicated metrics were important in the review of grant proposals and assessments of candidates for academic positions” (p. 112). A good score on these research metrics results in a higher chance of promotion or the acquisition of funding (Hessels & Van Lente, 2011). Therefore, it also influences the progress of science. Since research funding is scarce, the amount of funding received is an important factor to a researcher's reputation as well. It is expected that the researchers within the interviews are making use of the three types of publication-based indicators.

The Journal Impact Factor

A widely known method in order to evaluate the performance and productivity of researchers and their research is the Journal Impact Factor (JIF), which refers to the average number of citations of the papers published in a journal (Ali, 2022). It is a great example of the way quality of research is measured through quantitative terms. Academic recruitment, promotions and research funding all rely on the JIF and journal ranking. Multiple stakeholders are involved like the authors of research in choosing the journal for submission, by the journals as a measure of their performance index, by librarians that use it when putting together a scientific collection and by funding agencies and academia when picking new researchers. It can be said that a lot of an individual researcher's career depends on this method. The calculation on JIF is done through "the number of citations received in a given year by documents published in a journal during the two previous years, divided by the number of items published in that journal over the two previous years" (Lariviere & Sugimoto, 2019, p.4). Many criticisms point towards the imperfections of the indicators such as the skewness, false precision, absence of confidence intervals, and the asymmetry in the calculation. Besides, the current JIF dominated metric system also results in researchers shifting away from their field of interest in order to pursue a good resume that will help them get more grants (Miedema, 2022). Despite the critique it is receiving, the JIF will probably continue to be used within the performance assessment of research as long as journals remain the primary mechanism for diffusing new knowledge.

H-Index

The H-index reports on an author's performance by using the total numbers of publications and the total number of citations that belong to these works (Grech & Rizk, 2018). The index helps to evaluate an individual researcher as well as that of peers and provides an indication of the consistency of a researcher over time as well. The H-index is measured over the last 5 years and works as follows: when a researcher has at least five articles that have each been cited at least five times or equivalent, the researcher will have an H-index of five. Despite the success of the H-index, it also received a lot of criticism as it disadvantages early researchers with a low amount of indexed publications (Gasparyan, 2018). Besides, the H-index can be manipulated by self-citations. While the index works in independent fields, it is not applicable to make comparisons between researchers from different fields.

2.3.3 Data & Arguments

In order to develop a research project, data is essential for answering research questions, testing hypotheses, and coming up with a conclusion. These can be adapted from various sources such as databases or literature that are external, or through the creation of data that are received with the help of surveys, interviews or other methods. Data is essential to making arguments and without data, arguments would not substantiate. This section focuses on the process from data to arguments.

Data sharing

Data sharing is the facilitator in the progress of research and makes science stronger. Data internally created by researchers is easy to access, but external data could cause some complexity as data sharing is not always obvious. In some scientific disciplines, data sharing is more common compared to others (Krahe et al., 2020). Reasons for a researcher to participate in data sharing are increased citations of a research, a supportive data sharing culture or when a researcher has good experiences with sharing data. Reasons against data sharing could be the concern about privacy, fear of reputational damage or the misinterpretation of data, and the desire to have exclusive rights over the data.

Especially in health research, which is directly linked to Human Health and Wellbeing (SDG3), data can be highly sensitive or have security and privacy considerations. In order to protect the privacy and to respect the research's participants, data needs to be planned, collected and stored in a convenient way. For some research, it might even be impossible to share the data due to restrictions. This happens in 65-70% of the research that is conducted by scientists in health research. As this is the majority of research in the health sector, it is important that researchers start to plan and conduct their research in an alternative way that makes it possible for them to share the data. There are some situations in health research that show the potential possibilities when data is shared within health research (Lucas-Dominguez, 2021). In the past, during Ebola and Zika outbreaks, data has been shared by researchers, allowing more publications, accelerating investigations and eventually taking control of the infections. Though, during the Ebola and Zika outbreaks, these experiences with data storage have not always been clear as the infrastructure was not sufficient for proper management of data. The recent COVID-19 outbreak is different, as it has been marked as a pandemic. This means that the outbreak is worldwide, affecting the global human population. Considering such an outbreak, a publicly available dataset is invaluable and necessary. But unfortunately, patient-level COVID-19 data is not publicly available and even though the COVID-19 related studies grew during the outbreak, research shows that only 13,6% of these studies included supplementary material or data that was received through repositories (Cosgriff et al., 2020; Lucas-Domingquez, 2021).

Paywalls

Another problem for transferring proper data to arguments within scientific research are paywalls. This can be seen as an extension on the problem of data sharing, as data is less easy to access. Paywalls refer to the inability to access an article until a payment is made. It is estimated that only 28% of scholarly publications are open access, meaning that the remaining 72% requires a payment in order to be accessed (Day et al., 2020). Stakeholders such as research scientists, universities, and libraries encounter the most problems with the burden of expensive access to information. Without open access, the ability to obtain this information depends on the financial capacity of these institutions. Harvard University, for example, stated that the annual costs of 3,5 million dollars for access to data is financially unsustainable. Next to hindering access to information, paywalls also influence the spreading of publications. Paywalled articles receive fewer page views, citations and social media attention. Besides, paywalls increase the inequalities between the global north and global south when it comes to scientific resources. Paywalls are contributing to hindering the transfer of knowledge to and can be seen as a barrier between knowledge development and action.

2.2.4 Articles

When data is transferred into arguments, the research will eventually take form in scientific articles. Before scientific articles are published, quality assessments such as peer reviews will be executed to test the credibility of the research. This section will elaborate on the process of peer reviews in the current system and the bottlenecks that are identified during this process.

Peer reviews

Most scholars and researchers agree that peer reviews were invented in order to separate 'good' science from 'bad' science. It is seen as the best method to ensure the correctness when scientific literature is produced (Horbach & Halffman, 2018). The traditional method of peer reviewing is based on single-blind peer review, in which the author is identified and the reviewer anonymised, or double-blind peer review which makes the identity of both the peer reviewer and author unknown (da Silva, 2019). After the implementation of external reviewing between 1960 and 1970, peer reviewing grew at a fast pace. At this time, peer reviewing was used as a form of quality-guarantee (Horbach & Halffman, 2018). Over time the method of peer reviewing has developed in different forms, caused by the rapid growth of science, the increased specialisation in science and the "changing financial foundation and incentives in scientific publishing" (p. 2). This resulted in multiple systems of peer reviewing, and the intentions of peer reviewing changed as well. It went from quality-guarantee towards a system that is concerned about "inequality in science, the efficiency of the publication system and a perceived increase in scientific misconduct".

The objectivity, reliability and consistency of traditional peer reviewing seem to be in question (Ross-Hellauer, 2017). The decision whether a research is accepted or rejected seems to be inconsistent which results in peer reviews being unable and this makes it hard to keep errors and fraud outside of the scientific literature. This mainly has to do with the fact that reviewers are unable to detect methodological flaws. Besides, the traditional peer reviewing process also takes up a lot of time. The time it takes to go from submission to publication often exceeds one year, with peer reviewing taking up most of the time. The costs of peer reviewing increases with the selectivity of the journals (Ule, 2020). Springer Nature estimates the publication of a scientific research to cost between €10,000 and €30,000 as the research is evaluated by in-house, professional editors. Another point of criticism on traditional peer review is the lack of incentives, as the work of reviewers is mostly unpaid and whose effort in reviewing is anonymous and therefore not rewarded in recognition (Ross-Hellauer, 2017).

Single-blind peer reviewing and double-blind peer reviewing were introduced to combat the "bias" that was caused by an author's background or personal characteristics (Horbach & Haffman, 2018). These forms are nowadays criticised as well. Single-blinded peer reviewing makes it easy for reviewers to discriminate against authors based on their nationality and their native language, gender and the institution they did their research for (Haffar et al., 2019). For double-blind peer review this is harder, as the identity of the author is blinded as well. However, the digital era made it easy to identify authors of "blinded manuscripts", with reviewers taking time to uncover the identity of the author. When the identity of an author is discovered, double-blind peer review only leads to bigger workloads and higher costs for publishing.

Reproducibility

As mentioned before, the integrity of science has recently been damaged after it became clear that there is an "increase in cases of scientific fraud and irreproducible research" (Horbach & Halffman, 2018, p. 1). Motives for these retractions range from mistakes to image manipulation to outright fraud. For example, it is documented in a 2012 (Fang et al.) PNAS paper that two-thirds of the retractions are due to misconduct in the forms of plagiarism, data fabrication and image manipulation. These trends led to awareness which made the scientific community become more conscious about the possibility of an outbreak of corrupt or untrustworthy science. An article by Baker and Penny (2016) conducted an online survey among 1,576 researchers on the crisis of reproducibility in which 52% of the researchers identified a significant crisis and 38% identified a slight crisis. Only 3% of these researchers thought there was no crisis while 7% of the remaining researchers did not know. Though, it should be said that less than 31% of the same researchers thought that the failure of reproducibility automatically leads to a false result. When asked about the causes for the bad reproducibility, the majority of the researchers pointed towards pressure to publish and selective reporting among a couple of other factors. But these factors are strengthened by the overarching problems of intense competition and time pressure. Around 80% of the researchers thought that funders and publishers should do more to improve reproducibility.

2.2.5 Recognition

Once the scientific articles are finished, these will be published in order to spread information about the evidence-based practice. This will lead to a certain degree of recognition for researchers which is an important factor in order to continue future research. Universities have installed quantitative performance indicators to formalise the attribution of recognition. This section will elaborate especially on these mechanisms on how quality is decided through quantitative terms.

Quality in quantitative terms

There is a formal and informal component of recognition (Hessels & Van Lente, 2011). The formal component is decided by group evaluations and interviews of individual performance. Informal recognition comes in the form of assessments by colleagues, conferences, discussions and publications. This type of recognition also loops back to the score on formal performance evaluations. Since public grants have become scarce, acquiring funding is also contributing to the degree of recognition. Within someone's field, recognition can be earned through papers with innovative content and lectures. Beyond a researcher's field, recognition is based on quantitative indicators. As described within the section of Staff & Equipment, research metrics are used to evaluate the performance of research and researchers at different levels, including the journal and the author levels. Research outputs have many properties that influence the degree of recognition acquired (Van den Besselaar, 2019). It could be the number of publications, the number of highly cited research, the amount of citations, the size and quality of the co-author network, or the Journal Impact Factor and H-index which were described earlier. As with the processes of promotion and hiring, bibliometrics are important when it comes to recognition, or the ability to do science.

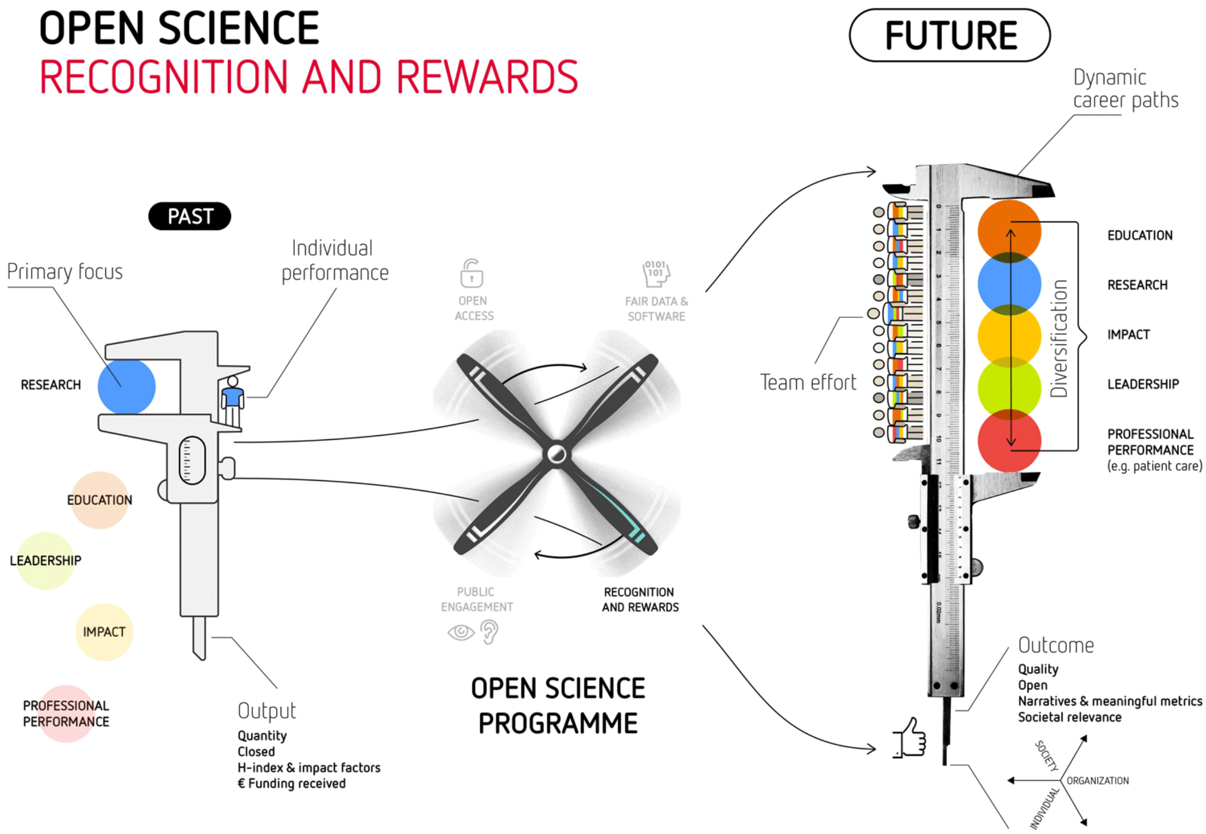

Figure 2. Infographic Recognition and rewards. University of Utrecht.

Research impact

It is said that the number of citations will evaluate the impact of research. Though, how is research impact defined? For the term impact, a distinction can be made between two types of impact. Academic impact focuses on the contribution of a researcher to one's field of study within academia. External socio-economic impact focuses on the impact that goes beyond academia (Penfield et al., 2014). However, these types of impact are often viewed as one, in order to give an overall evaluation and assessment of value and the changes that have been created through the research. The evaluation and assessment of research impact tends to be ruled by academic output, while these bibliometric techniques only give a partial image of the full impact. The understanding of the academic output of research quality often ignores non-academics' views and experiences of what is relevant to them, or how exactly academic output impacts society (Rau et al., 2018). While research might include nonpublication outputs, evaluation should be based on "scientific integrity, societal need, advancement of the field, and other potentialities that matter to the evaluators" (Myers & Kahn, 2021, p. 1710). Complex assessments of the impact of research outcomes within the wider society remain scarce (Rau et al., 2018). Qualitative aspects of impact are most of the time excluded from research assessments altogether, or they are performed but ranked below the traditional indicators of performance such as publications. However, efforts to capture less tangible outcomes of scientific research, and to reward those engaged in non-traditional activities like co-producing knowledge, outreach, policy advice or action research to help and involve communities that face major sustainability challenges, continue to be developed. An example is shown in fig. 4, which is the Open Science programme of the University of Utrecht (Utrecht University, 2022). This explains that the primary focus should not only be on research, but on a variation of factors such as impact or education. In turn, this will result in more open outcomes that are also focused on societal relevance and narratives and meaningful metrics.

It is becoming more common to use measurements that alter from counting the number and quality of publications, which is being welcomed by those who use non-traditional research outputs like factsheets, social media coverage or face-to-face interactions with actors from local communities (Rau et al., 2018). It is therefore also expected that the interviewed researchers also focus on other fields of impact, as the interviewees are mainly researchers from the University of Utrecht. Even though this system is still far from becoming the paradigm, making (societal) impact like this should become a part of the organisational structure of universities, resulting in a change in the academic reward system which in turn would influence the progress of science. For now, different approaches to impact have been the norm.

Bottlenecks of institutional mechanisms of the traditional academic system
Minimal fundings for the development of sustainable pathways
Hypercompetition among individual researchers for limited funds
Using bibliometric indicators to analyse the performance of researchers (e.g. journal impact factor)
Limited data sharing & paywalls
Costs and time of peer review
Recent developments of scientific fraud and irreproducible research
Research impact based on quantitative indicators (such as amount of citations) and not focused on socio-economic impact

Table 2. Identified bottlenecks of institutional mechanisms in the current academic system.

2.4 Organisational structures of scientific fields

While the credibility cycle mainly focuses on the general institutional mechanisms within the academic system, it is important to make distinctions between the two scientific fields of SDG3 and SDG13 and their organisational structure and how these are affected by organisational change. The institutional theory helps to understand how these organisational structures are formed and how organisational changes happen.

Whitley (2000) developed a framework in order to compare the outcomes of scientific research in different organisational structures, in this case scientific fields, and how the work is controlled and organised. Whitley uses the concepts of mutual dependence and task uncertainty for this framework. As these concepts determine the organisational structure of scientific fields, it is also likely that mutual dependence and task uncertainty change whenever the organisational structure changes (e.g. changes in the educational system caused by coercive, mimetic and normative forces).

Mutual dependence is defined as “the scientists’ dependence upon particular groups of colleagues to make competent contributions to collective intellectual goals and acquire prestigious reputations which lead to material rewards. Increasing the degree of mutual dependence implies that scientists become more reliant upon a particular group of colleagues for reputations and access to resources.” (Whitley 1984, p. 87-88). There are two aspects: the “degree of functional dependence” and the “degree of strategic dependence”, which are defined in table 1. When fields mature, the demand for mobilising resources increases in order to keep conducting research efficiently (Wiarda, 2019). This increased demand is likely to be managed by a centralised control who are able to “converge, create collective agendas and allocate resources more effectively” (p. 10).

The second dimension, *task uncertainty*, describes the degree to which “the outcomes are not repetitious and highly predictable. Research however is highly methodical and systematic so that results are stable and replicable. Tacit knowledge however is hard to learn and can cause ambiguity.” (1984, p. 119- 120). According to Whitley, there are two types of task uncertainty, which are also defined in table 1.

The centralised control that comes with the maturing of fields can also lower the task uncertainty, as these have the legitimate position to change elements of the institutional environment of scientific fields like the educational system, academic positions, research standards and associated intellectual perspectives (Wiarda, 2019).

Whitley emphasises that both aspects of the high degree of mutual dependence and the task uncertainty are unlikely to occur with a very low aspect of that dimension's other aspect (Wiarda, 2019, p. 9). Therefore, mutual dependence and task uncertainty can be best described as an increasing and decreasing continuum (Fry & Talja, 2007). Fields with high mutual dependence and low task uncertainty are characterised with stable research objects, effectively coordinated research efforts with standardised research methods. Audience variety is low and communication is specific and effective through, for example, graphs and formulae. Fields with low mutual dependence and high task uncertainty are characterised with research objectives being conceived in different ways in which researchers pursue separate interests with research techniques that are not standardised. Audience variety is high while communication is a lot more personal and variable in which researchers try to justify their interpretations. These characteristics are common with wicked problems.

Mutual dependence	
Functional Dependence	The extent to which scientific researchers need certain results, procedures or ideas from other fellow researchers.
Strategic Dependence	The extent to which scientific researchers have to convince the field of the relevance of their research in order to convince them of the legitimacy of research results.
Task uncertainty	
Technical Task Uncertainty	To which degree other researchers within a scientific field share their understandings about the research methods and the outcomes these produce.
Strategic Task Uncertainty	To which degree researchers have the same research priorities and to which degree common strategies are used within research to get to the final outcomes.

Table 1. Types of mutual dependence and task uncertainty. The intellectual and social organisation of the science. Whitley (1984)

Whitley's framework lays the foundation for comparisons across scientific fields. The framework will be used to make comparisons between the scientific fields that are linked to the SDGs. It is therefore interesting to compare a field with high mutual dependence and low task uncertainty to a field with low mutual dependence and high task uncertainty. Eventually, the findings will also be analysed and used for potential updates to the framework, since the framework originated from a time before interdisciplinary research was prominent and where the primary focus was on disciplinary research.

2.5 Opening up knowledge systems with Open science

The previous paragraphs describe the current system of scientific developments and policies, how research is rewarded and the way scientific fields are organised. There is a consensus that scientific knowledge should inform societal responses to these problems, but traditional frameworks that reward disciplinary excellence (or Mode 1) are still being used for knowledge development, making it hard to meet research investments and scientific efforts that are needed for these emerging environmental problems. This section describes one of the theories that could contribute to the transformative change within the organisational structure of universities. The proposed solutions are needed in order to answer the third research question: *What are potential solutions to minimise this gap between knowledge and action?*

As described in the introduction, minimising the gap between knowledge and action means that knowledge is not only created, but also applied within society. Knowledge systems therefore have to become more open. Open science is a globally emerging phenomenon that is focused on socio-cultural and technological change, based on the concepts of openness and connectivity (Vicente-Saez & Martinez-Fuentes, 2018). Open science is defined as "the transparent and accessible knowledge that is shared and developed through collaborative networks ", making it a form of opening up knowledge systems as it not only makes knowledge more accessible for other scientists, but also for other stakeholders outside the academic system. It gives another perspective on how research is "designed, performed, captured, and assessed" through using "open data tools, open access platforms, open peer review methods, alternative metrics and public engagement activities" (p. 1). The theory of Open Science and its benefits and challenges will be introduced and explored in order to see to what extent it could be useful for the problems that are faced during the development of knowledge. The theory of opening up knowledge systems strongly complements the idea of Open Science, which focuses on making knowledge more accessible for stakeholders outside of the academic world and to strengthen knowledge democracy. This should in return lead to wider trust in science, the integration of more stakeholders in knowledge development that integrates an interdisciplinary- , or transdisciplinary approach, and eventually the creation of more effective sustainability pathways.

It is important to state that the term Open Science evokes quite different understandings, leading to several oppositions on the actual meaning of the term (Fecher & Friesike, 2014). Some argue that it should lead to the democratic right to access publicly funded knowledge while others refer to the development of freely available tools for collaboration. The diversity of meanings in the discourse of Open Science is not strange, as a lot of different stakeholders from different fields are affected by this phenomenon. While these different interpretations exist, it appears that Open Science includes several predominant thought patterns. Fecher & Friesike (2014) identified five *schools of thought* that define Open science. This chapter will use this theory to elaborate upon the predominant thought patterns of Open Science and the benefits and challenges in Open Science. The authors of this article visualised the different thought patterns into a table, which is shown below. This offers an overview of the various areas of development.

School of thought	Central assumption	Involved groups	Central Aim	Tools & Methods
Democratic	The access to knowledge is unequally distributed.	Scientists, politicians, citizens	Making knowledge freely available for everyone.	Open Access, intellectual property rights, Open data, Open code
Pragmatic	Knowledge-creation could be more efficient if scientists worked together.	Scientists	Opening up the process of knowledge creation.	Wisdom of the crowds, network effects, Open Data, Open Code
Infrastructure	Efficient research depends on the available tools and applications.	Scientists & platform providers	Creating openly available platforms, tools and services for scientists.	Collaboration platforms and tools
Public	Science needs to be made accessible to the public.	Scientists & citizens	Making science accessible for citizens.	Citizen Science, Science PR, Science Blogging
Measurement	Scientific contributions today need alternative impact measurements.	Scientists & politicians	Developing an alternative metric system for scientific impact.	Altmetrics, peer review, citation, impact factors

Figure 3. Fecher & Friesike (2014). Five Open Science schools of thought.

2.5.1 Open access, Open data & Open code

The first two schools of thought introduced by Fecher & Friesike (2014) are closely related to each other as they introduce the basic idea of Open Science. The aim of Open Science is to open up the process of knowledge creation by making knowledge freely available for everyone. The tools & methods that are included in these schools of thought are similar, such as Open Access, Open Data and Open Code, which are common terms used in Open Science. There are multiple benefits linked to the first two schools of thought. One of the strongest arguments is the improvement in scientific efficiency, which is the result of two mechanisms (Arza & Fressoli, 2017). As knowledge resources become more widely available, research becomes cheaper and more likely to be successful through beneficial spillovers. Collaborations among heterogeneous knowledge boosts the collective creativity and intelligence among researchers. The involvement of a wider, diverse set of actors enables the idea of 'the wisdom of the crowds'.

Another benefit is improving the democratisation of scientific knowledge. Three complementing mechanisms are responsible for this. The first mechanism is improving access to scientific resources which can be referred to as open access, a movement that emerged as a reaction to the closing access to scientific knowledge because of paywalls. Open access works without paywalls, and broadens the pool of accessible knowledge for everybody, not just scientists. The second mechanism is "enabling the participation of a wider community in the research process" (p. 466), as open access results in a wider participation of society in the production of scientific knowledge resulting in an increase in trans- and interdisciplinarity. One example is citizen science projects, which will be elaborated in the section about the public school of thought. The third mechanism of the democratisation of scientific knowledge is making science better understandable for a wider population. The public understanding of scientific knowledge has been rising and this has been in the form of interactive techniques lately, such as games, videos or experiments. There are also other forms of promoting scientific knowledge, such as tutorials or massive online courses.

The last benefit described by Arza & Fresssoli (2017) is the improvement in the ability of research to respond to societal needs. Again, there are three mechanisms for realising this. The first is that wider access results in more visibility. Local problems tend to become more visible and better communicated, which could help powerless actors over the long run. Secondly, by promoting actors of communities in scientific practices and by involving them in the process, research agendas would have narratives that would guide them better towards solving problems affecting that group and community actors could even contribute to developing solutions by offering their own experiences, which also increases transand interdisciplinarity. Finally, the open availability of scientific resources works against the privatisation of these resources, which could lead to cheaper solutions for societal problems. This reacts against the concept of "tragedy of the anticommons", which occurs when there is "such an accumulation of patents on small fractions of knowledge that makes it cumbersome and highly costly to combine all of those separate elements to produce useful solutions" (p. 466). Therefore, Open Science practices are seen as the opposite.

There are some important reasons for the first two schools of thought on why Open Science should be implemented within the processes of knowledge development. Though, it does not come without challenges. The first challenge is time cost. It is sometimes stated that Open Science would result in saving time. Though, the practices of Open Science often consume more time (Allen & Mehler, 2019). This includes archiving, documenting, and quality controlling of code and data. Prior to data collection, researchers have to participate in preregistration and registered reporting (RR), which will be elaborated upon later in this chapter, to secure the reproducibility of research and to lend credibility to research findings, prolonging the time to develop a research. Data collection takes more time as it often has requirements from higher powers. This will result in the completion of a lower amount of research in a certain period for researchers that conduct open research. Especially for early career researchers, this is important to consider, given the fact that resources are limited within graduate programs and post-doctoral positions. Another challenge that was identified by Lakomý et al. (2019), had to do with the consequences that come with Open Science that could form potential risks for researchers, participants of the research and funders. Examples of these risks are losing authorship, misuse of data by other parties, privacy violation, and data usage for research that is unethical. These ethical issues are most common in disciplines that work with highly sensitive data. As described before, health research is an example of this and open data could lead to some risks for the stakeholders involved when privacy considerations are violated. Furthermore, ethical issues also occur when science is communicated. Ethics committees that have to approve research with ethically controversial topics are heavily influenced by rules and legislation towards data sharing, which could limit the possibilities for open data. Research with ethically controversial topics could also lead to a reduced willingness in research participation. Therefore, it is expected that the first two schools of thoughts will contribute towards scientific efficiency as more people can contribute to the process. Though it is expected that the process takes more time. Next to that, it is expected that ethically controversial topics are restricted when it comes to data sharing.

2.5.2 Open platforms

The available tools and applications for Open Science are necessary for Open Science to realise its full potential. The third school of thought focuses on the infrastructure of Open Science, and the need for collaboration platforms and tools. The goal is to foster collaboration by creating openly available platforms and tools for scientists (Mancini, 2020). At the moment, users of open public and private data are most of the times unable to exploit the potential of open data to the fullest. The current way of making research findings available through journals works against the aspirations of Open Science. Open platforms encourage the reuse of open data, which could lead to the desired outcome of advancing social and economic benefits arising from open data. The recent push of open data increases the need for transparency and open data platforms that can provide this transparency.

2.5.3 Citizen Science

Another assumption according to Fecher & Friesike (2014) is to make science accessible to the public. This refers to knowledge democracy (In ‘t Veld, 2010), in which knowledge systems open up for other significant stakeholders such as civil society or the industry. One of the most important concepts in this category is Citizen Science (CS), which can be described as “intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge” (Shirk et al., 2012). It can be classified into three main categories (Bedessem, 2020). Contributory CS refers to citizens being data-collectors supervised by scientists. This type of CS has a great contribution towards the massive collection of data, which is becoming more and more a key role in the development of research. Collaborative CS beyond collecting data. Under the surveillance of professional scientists, citizens are more involved in the complex tasks, such as the design of methods and research plans, or the interpretation of results. The third category is co-created CS, in which citizens come up with a research program aiming to solve a certain problem identified by themselves (Bedessem, 2020). In these cases, the group of citizens is heavily involved in all phases of the process, from the research design to the collection of data and the diffusion of results. The benefit lies here in the voluntary solutions that are brought to society that eventually contribute to the development of sustainable pathways. These assumptions match the idea of Mode 2 knowledge production in which knowledge from all relevant stakeholders and disciplines is included, in order to also get a better grip on wicked problems.

Despite the benefits from Citizen Science (CS), there are also some challenges. The first challenge identified was that the overall impact of citizen science activities has proven to be somewhat limited, as the projects are short, and are not fully integrated within traditional science approaches, making it harder to effectively inform decision-making (Lee, 2020). Another challenge for CS is that while it has global potential, it is proven that there is a strong spatial bias towards western developed countries where activities are high compared to the low activities in less developed countries. Aside from bias in participants, there is also a bias in recording or in the choice of sampling sites (Irwin, 2018). In combination with deviations from standard protocols this could result in major CS-data flaws. Understanding the participant's motivation is another challenge as it is a highly complex issue, but important in-order to recruit participants, ensure buy-in and retain involvement (Lee, 2020). The next challenge is the occurrence of exploitation among CS, as citizen scientists put in effort and time without any expectation of financial compensation. Data ownership and Intellectual Property Rights also face a challenge for CS, as they define who owns the data and who can use it. Some citizen scientists might want to take control over their contributed data, resulting in potential barriers for data sharing. Therefore, it is expected that CS can contribute to knowledge democracy to a certain level, but the challenges that CS face could result in a lack of real contribution towards sustainable pathways.

2.5.4 Altmetrics

The fifth and last school of thought within the overview is measurement. Developing an alternative metric system for measuring impact is important in order to complement the current impact factor which raises a number of concerns mentioned earlier in this research such as the peer review being time consuming or the impact factor being linked to a journal rather than being linked to an article (Bartling & Friesike, 2014). This resulted in the development of metrics for impact areas that are not covered by traditional bibliometrics or usage metrics. The umbrella term for this new metric system is altmetrics. It relies on a wider set of metrics, including tweets, blogs, discussions and bookmarks but also social reference managers like CiteULike, Mendeley, and Zotero. Altmetrics is meant to measure the broader societal impacts of scientific research (Wilsdon et al., 2017). The benefits of altmetrics can be divided into three categories. First, the formats of relevance. Altmetrics have the ability to identify new formats of scholarly products to measure, such as research data and software, which have not been considered in research assessments before. The second category is the forms of impact. The extended impact assessment of altmetrics results in the involvement of new audiences, who “interact with or react to scholarly products and scenarios related to that” (p. 11). The last category is targets and use which reflect on the purposes for using altmetrics, such as budget allocations or self-assessment.

Altmetrics also come with some challenges. Perhaps the most dominant challenge is the lack of robustness and the ease of gaming the metrics-based evaluation systems (Wildson, 2017). While altmetrics can measure the reach and impact of an article, it tells little to nothing to the scientific quality of that article. Poor quality research therefore has a chance of getting “attention online, laying the focus of research based on ‘news’ value and interest, rather than on academic qualities” (Regan & Henchion, 2019, p. 18). Good communicators would be rewarded in this way, while good researchers might lose rewards. Besides, impact assessment with grey literature can be difficult, time consuming and has to be done manually. It also requires expert knowledge of the scientific information landscape, especially when data is not available on open repositories but is hidden on less-referenced or personal pages. With the Dark Web, which is represented by a small part of the internet that uses encryption, makes it possible to game in the new altmetrics system (Strielkowski & Chigisheva, 2018) It allows people to carry out data transfers and transactions anonymously, which in turn could lead to one creating blogs and Twitter accounts to act like they are different people in different countries. These can be used to praise one’s research to show the importance of it for society and the general public, boosting his or her citation score in the online environment. It is expected that most researchers agree that altmetrics have the potential to complement current impact assessments, rather than replace them (Wilsdon et al., 2017).

2.5.5 Open Peer Review

Besides altmetrics, open peer review (OPR) is also an upcoming concept that falls under the measurement school of thought. OPR is defined in many different ways. Ross-Hellauer (2017) linked 7 traits to OPR: open identities, open reports, open participation, open interaction, open pre-review manuscripts, open final-version commenting and open platforms. The first three traits cover more than 99% of all the definitions of OPR. Open identities, or signed peer review, is characterised by transparency, since authors and reviewers are aware of each other's identity. Signed peer review differs from single- and double blind peer review as it enhances accountability, gives credit to the reviewers, and makes the system more fair. Reviewers will be more motivated knowing that their names will be linked to the review. Open reports refer to the ability to publish review reports alongside the reviewed report, making it possible to reuse “potentially useful scholarly information”. This in turn increases the transparency and accountability of peer reviews. Traditionally, once articles are published, peer reviews serve no further purpose, while there is a chance that these contain information that could be useful. For example, when an article is published, readers can take the criticisms into account for their own work when similar situations occur. Review quality can also increase as open reports could motivate reviewers to be more thorough, and could form examples for reviewers that are just starting. The last important trait of OPR is open interaction, which makes it possible for the wider community to contribute to peer review. Instead of only inviting peers, this method also allows the invitation of members within the scholarly community. The aim of this method is to solve the problems that come with the reviews done by peers like biases, closed-networks or elitism which increases the reliability of peer review. External reviewers can come from, for example, representatives from a certain industry with the intention to include all potentially interested reviewers.

Regarding open peer review, the new method does not necessarily lead to lower costs or faster publications. Due to the existence of various stages of checks, it can take longer in order to peer review a research through open peer review (Barroga, 2013), while the reviews are not proven to have higher quality (Ross-Hellauer, 2017). This also has to do with the fact that reviewers might back down their real opinions in order to prevent controversy, as their names are also attached to the reports. Criticisms regarding open participation are focused on the quality of self-appointed reviewers. It is not clear if these are qualified to properly evaluate findings. Nature once ran an experiment for open participation, but concluded that the experiment failed due to the small number of authors taking part, the small amount of comments on articles, and the insufficient quality of these comments (Fitzpatrick, 2011). While open participation has the potential to complement traditional peer review, it will not be adequate enough to replace it. It is expected that the integration of OPR in the academic system still needs more time to develop. Highly selective journals have high internal costs, and are not easy to be transformed into a fully open-access model (Ule, 2020). Besides, the journals would risk losing quality when cutting costs. Springer Nature states that selective journals need different approaches in order to realise the transition towards open-access publishing.

2.5.6 Preregistrations and Registered reports

Added to the overview of Fecher & Friesike is the aim of Open Science to make science more reliable (Allen & Mehler, 2019), which was also identified as a bottleneck of the current academic system. Preregistrations and registered reports (RR) are good examples of procedures that help to realise the development of more reliable knowledge. Preregistration provides an explicit timeline and guards researchers from bad practices as well as forcing the researcher to get a more complete understanding of the analyses. It includes the registration of a researcher’s motivation and hypotheses before the actual data collection is conducted (Yamada, 2018). This prevents researchers from forming and including hypotheses after the collection of data, and such unethical practices could lead to false positive findings. The procedure of RR is similar, as submissions will be peer reviewed prior to data collection (Chambers, 2013). When the research is finished, the article will be re-reviewed, and raw data will become available. This method prevents issues like publication bias, promoting false discoveries and false negatives. Every aspect of Open Science is there to make science more reliable (Allen & Mehler, 2019). Sharing of protocols and data leads to replication, which eventually leads to greater scrutiny. As described in the previous chapter, there seems to be a crisis around the reproducibility of scientific research. The above-mentioned procedures could contribute to the strengthening of the reproducibility of scientific research. Replication of findings is core to Open Science and predominant in increasing reliability, and it is expected that these procedures will be mentioned by the interviewees as proper solutions for the problem of reproducibility.

2.5.7 Transformative change and shifting the paradigm

Open science is not only a set of research- practices and methods, but can also be seen as a mindset. With Open Science comes the creation of a cultural and transformative change that brings important alterations in the way individuals think, do and know (Alhadad et al., 2019). These changes are also partly making their way into education, as seen in figure 4, in which the University of Utrecht implements these practices. Though it takes time to shift a paradigm. Open Science still needs time to develop and to become part of the mainstream (Allen & Mehler, 2019). Systems that reward practices of Open science such as the University of Utrecht are still rare, and the traditional standards continue to be used to assess researchers. Assessment structures such as the Research Excellence Framework (REF) in the United Kingdom and research evaluations within universities are still not fully embracing the practices of Open Science. Besides, some editors and reviewers at journals remain to be convinced of the necessity of the methods of Open Science. Some journals have begun to take measures against traditional research practices by signing guidelines to promote Open Science. Though, the implementation of Open Science practices vary highly. While many prestigious journals, institutions, and senior researchers support the ideas of Open Science, few have actually used it. The trade-off between quality and quantity seems to tip towards quantity, as it gives researchers an easier time to compete for jobs and funding. As long as the processes of Open Science are not formally recognized, researchers that work with Open Science processes, especially in an earlier stage of their career, are going to have a hard time competing with researchers that are continuing doing research the traditional way.

Methodology

3.1 Research design

In order to answer the research question described in the introduction, this research made use of qualitative methods in the form of a literature review and the use of interviews. Qualitative research can be seen as a research strategy that focuses on words rather than quantification in the collection and analysis of data (Bryman, 2016). This type of research emphasises an inductive approach, in which patterns are observed and theories are developed through the use of hypotheses. Qualitative research prefers to look at how individuals interpret the social world and "embodies a view of social reality as a constantly shifting emergent property of individuals' creation". A qualitative approach was chosen, as the assessment of cause is one of the keynotes for this research and the needs are associated with the generation of new theory, rather than testing it.

A research design is a "framework for the generation of evidence that is suited both to a certain set of criteria and to the research question in which the investigator is interested" (Bryman, 2016). For this research, a *comparative study* was chosen as research design. This approach embodies the logic of comparison by focusing on two or more cases, while using the same methods. This research is focusing on research communities in two Sustainable Development Goals, aiming to find similarities and differences within the strengths and weaknesses of the institutional mechanisms and to get a greater awareness and deeper understanding of the gap between knowledge and action.

3.2 Case Selection

The cases used in this research are the SDGs of Climate Action (SDG13), and Health Care and Wellbeing (SDG3).

Sustainable Development Goal 3 (Human Health and Wellbeing)

The third SDG refers to Human Health and Wellbeing, a goal that aims to "ensure healthy lives and promote well-being for all at all ages" (United Nations, 2021). Healthy lives are essential for sustainable development. At the moment, the world is facing a global health crisis because of COVID19. Before the pandemic, this goal was making good progress in improving the health of people. Though, more efforts are needed to get rid of a wide range of diseases. The goal of this SDG is to get this done through focusing on the provision of more efficient funding of health systems, improving sanitation and hygiene, and increasing the access to physicians which are able to help millions of people with mental health issues. Health Care and Wellbeing is chosen as it is linked to disciplines within Health Sciences, which exist out a lot of established scientific disciplines. The scientific fields are more mature and therefore the mutual dependence is expected to be high, while the task uncertainty is expected to be low. Next to that, it is a relevant case with the ongoing pandemic, a period in which the focus on this SDG is larger. It would be interesting to see if knowledge is developed faster in order to get to action, as with the vaccines that came as fast as possible.

Sustainable Development Goal 13 (Climate Action)

The thirteenth SDG refers to Climate Action, a goal that aims for "urgent action to combat climate change and the additional consequences" (United Nations, 2021). Since COVID19, greenhouse gas emissions have been dropping, but this improvement is only temporary. The emissions are expected to rise again once the global economy will recover from the pandemic. Therefore, the Paris Agreement made in 2015 included a section for climate action to respond to the threat of climate change. Examples of the goals included in this agreement are to strengthen resilience and adaptation towards climate-related hazards, integrating climate change measures into national policies, strategies and planning, and to jointly mobilise $100 billion annually that will be used in developing countries. Climate Action is chosen as a case as it revolves around adapting to the current challenges and integrating new policies and strategies, subjects that are in line with the transformative change that is described within the third framing of innovation policies and the current reward system that is not optimal to contribute to these changes. Climate action is linked to several disciplines that have to do with sustainability science. There are several disciplines that have been developed with the rise of knowledge about climate change. Therefore, a low degree of mutual dependence is expected, with a high degree of task uncertainty.

Both are prominent knowledge clusters within Dutch universities according to Romero-Goyeneche et al. (2021). Table 3 shows the expected differences between the two cases.

Characteristics	**Human Health and Wellbeing (SDG 3)**	**Climate Action (SDG 13)**
Focus	Socio-technical systems and application areas	Transversal directions
Scientific disciplines	Established scientific disciplines	Established & new scientific disciplines
Expected Mutual dependence	High	Low
Expected Task uncertainty	Low	High
Expected type of knowledge	Often Mode 1 (Disciplinary)	Often Mode 2 (Inter- and Transdisciplinary)

Table 3. Characteristics of the two cases.

3.3 Data collection

A literature review was conducted in order to absorb information from the area which results in the development of arguments that are needed to prove the significance of this research and where it leads (Bryman, 2016). The literature review in this research has the form of a *narrative review*, to create an overview of a field of study through "a reasonably comprehensive assessment and critical reading of the literature" (Bryman, 2016, p. 654). The theory of the credibility cycle shows that additional mechanisms are identified that influence the development of a research, like the involvement of external stakeholders. The literature review in this research focused on analysing these additional mechanisms, in order to construct an updated credibility cycle that is applicable to the current environmental and social challenges. Besides, the literature review also resulted in a better understanding of the fields that are connected to both SDGs which will enable the determination of the task uncertainty and mutual dependence of Whitley's framework. Literature review on the new proposed theories of open knowledge and Open Science helps to find potential solutions for the identified institutional barriers that were found in SDG3 and SDG13. The data of the literature review is collected through the use of *Google Scholar* with search terms that are shown in table 4 as an example, and by using the references within the bibliography of research.

SDG3 or SDG13	Transdisciplinary
Climate adaptation or mitigation	Task uncertainty
Human Health	Mutual dependence
Research knowledge or development	Open Science
Health sciences	(Open) Knowledge systems
Credibility or Credibility cycle	(Open) data sharing
Funding	Paywalls
Research agenda	Quality Assessment
Stakeholders	(Open) Peer Review
Wicked problems	Recognition
Reproducibility	Geosciences

Table 4. Example of keywords that were used (in combination) in the literature review.

To extend the validity of the research, interviews were conducted aside from the literature review. In particular, semi-structured interviews are used in order to collect further data of the two cases. When interviews are semi-structured, new concepts and theories can be adopted from the collected data as the interviewer keeps an open mind towards the interviewee (Bryman, 2016). For this research, purposive sampling was used as a sampling strategy. This type of sampling is essentially in line with the research question and the corresponding selection of units (scientific researchers, universities, etc.). The goal of the research also gives an indication on what units, or categories of people needed to be sampled. Purposive sampling was done to ensure access to a wide range of individuals with different perspectives and ranges of activity. There are two levels of sampling: sampling of context and sampling of individuals. Sampling of context in this case refers to the two SDGs, Climate Action and Health Care and Wellbeing. The sampling of individuals refers to the people that are active within the communities that are linked to both SDGs. The form of purposive sampling for this research will be theoretical sampling. 11 interviews were conducted across the two cases. The researchers were found through a list that was supplied by the individuals from the overarching research that focuses on mapping SDGs at the Utrecht University, of which this thesis is part of. The first part of interviewees included researchers and scientists that are addressing SDG3 and SDG13 within their research and are interviewed in order to capture their experiences during the development of knowledge. Questions relate to the different stages of the credibility cycle and can be found in Appendix A. The second part includes three researchers that are affiliated with Open Science in order to get insights about the application of this solution. The questionnaire for this can be found in Appendix B. Most of the interviewees are active at the University of Utrecht, with two exceptions. The list (table 5) of the interviewees and their roles are present in the findings section.

In order to protect the rights from the interviewees, an informed consent form was used, which can be found in Appendix C. This form confirmed that the data that was retrieved from the participant could be used within the analysis of this research. The participant has the right to withdraw this consent for using the collected data and is also able to research the report after its completion. The form was presented and handled before the start of the interview.

3.4 Data analysis

After conducting the interviews, transcriptions were made in order to analyse the data. This was done through a *thematic analysis* (Bryman, 2016), a process in which interviews are transcribed and examined for core themes that can be distinguished between or within interviews. This kind of analysis helps to reduce the amount of data that was collected within the interviews, making it easier to interpret the material. The analysis and the coding was done through NVivo, which is a Qualitative Data Analysis software package. After uploading the transcripts into NVivo, the data was analysed through open, axial and selective coding. The open coding process consisted of conceptualising and categorising the data which resulted in broad themes and concepts. After that, the axial coding process was done in order to categorise these themes based on the relationships between open codes. At the end, selective coding was done in order to select the core categories.

3.5 Reliability and validity

Two prominent criteria for the quality of the research are reliability and validity. Reliability is "concerned with the question of whether the results of a study are repeatable". It is commonly used to test whether the measures of use are consistent in results (Bryman, 2016). There are two types of reliability: internal- and external reliability, in which internal reliability refers to the degree to which members of the research team agree on the findings. External reliability refers to the degree to which a study can be replicated. Reliability will be ensured by keeping record of all activities within the research such as problem formulation, interview transcripts and data analysis which can be 'audited' by the supervisor.

Probably the most important criteria of social research is validity. It is concerned with the integrity of the outcomes that are created by the research (Bryman, 2016). Validity can also be subdivided into internal- and external validity. Internal validity focuses on whether the match between the researcher's findings and the theoretical ideas they develop is good, while external validity checks whether the findings of the research can be generalised into social settings. The use of both literature review and conducting interviews with different participants and applying it in two different cases creates triangulation, a strategy that is used to ensure the validity and reliability of a research by combining multiple methods.

Findings

This section lays out the results of the data analysis. First, the credibility cycle and the expectations that were found in the theory will be addressed. After that, the theory of Open Science will be addressed to see if the expectations of the theory will work as solutions for the identified bottlenecks in the credibility cycle.

Interviewees	Position of interviewee	Research department
Interviewee 1 (SDG3)	Dr. Associate Professor	Social and behavioral sciences (UU)
Interviewee 2 (SDG3)	Dr. Researcher	Population Health Department (UU)
Interviewee 3 (SDG3)	Full Professor	Molecular Cancer Research (UMC Utrecht)
Interviewee 4 (SDG13)	Professor Lecturer	Geosciences (UU)
Interviewee 5 (SDG13)	Dr. Assistant Professor	Geosciences (UU)
Interviewee 6 (SDG13)	Researcher	Geosciences (UU)
Interviewee 7 (SDG13)	Researcher	Geosciences (UU)
Interviewee 8 (SDG13)	Dr. Assistant Professor	Civil Engineering and Geosciences (TU Delft)
Interviewee 9 (Open Science)	Dr. Associate Professor	Geosciences (UU)
Interviewee 10 (Open Science)	Dr. ir. Assistant Professor	Geosciences (UU)
Interviewee 11 (Open Science)	Dr. Professor	Science (UU)

Table 5. List of interviewees

4.1 Credibility Cycle

The upcoming section focuses on the credibility cycle and on the data that was retrieved mainly from the researchers that were chosen according to the communities. These include researchers from SDG3 and SDG13. The researchers that were interviewed come from multiple sub-disciplines. Therefore, the researchers are categorised into main scientific fields with researchers linked to SDG3 falling under Health Sciences, and the researchers linked to SDG13 falling under Earth Sciences, or Geosciences.
The findings in this section will help us answer the first two research questions which were:
What are the current institutional mechanisms that facilitate knowledge? & *What are the bottlenecks of the institutional mechanisms that are creating the gap between knowledge and action?*
The expectations that were formulated in the theory section will be investigated to see whether they were right or wrong.

Money

According to the theory on the section of money in the credibility cycle, funding from the private sector is relatively low when it comes to sustainability science and science done for climate and it was expected that the majority of the funding from the interviewees comes from public funding

Funding

The results showed that most of the researchers linked to SDG3 were mostly dependent on public fundings. One of the researchers also had experiences with private funding through a public-private partnership. This is a combination between public funding and private funding. "*And so the idea is to sort of build connections between academics and industry or certain industry partners." (Interviewee 2).*
When researchers are not able to get funds, they often get paid by the university, which also falls under public funding.

The results showed that most of the researchers linked to SDG13 were also mostly dependent on public fundings. Most of the researchers get their grants from the NWO, the Dutch organisation for scientific research, but it was mentioned that getting grants from the NWO is hard. Regarding private funding, acquiring money depends on the project. Three of the five researchers had experiences with private funding. One of the researchers mentioned that it can be quite hard and risky. The researcher needed 10% industry funding to proceed with a proposal, but the organisation the researcher was working with pulled out at the last minute. Therefore, having this 10% industry funding turned out to be a huge bottleneck. *Actually, those companies can just pull out at the last minute and then you're basically left to hang high and dry without any sort of funding. " (Interviewee 5).*

The other researchers that had experiences with private funding, stated that it is easier compared to getting public funds. One of the researchers moved from Utrecht University to Delft University of Technology. Research here is more project-based, working with companies in which public funding is combined with private funding. Utrecht University is more focused on academic research, and relies most of the time on public funding, as the researcher also described during his time at Utrecht University. Like the researchers linked to SDG3, some of the researchers linked to SDG13 are not completely dependent on acquiring grants from public or private funds, as there is also internal money to do research from the university.

Dependent on:	Public funding	Private funding
Interviewee 1	x*	
Interviewee 2	x*	x
Interviewee 3	x*	
Interviewee 4	x*	
Interviewee 5	x*	x
Interviewee 6	x*	
Interviewee 7	x*	x
Interviewee 8	x*	x

*Table 6. Sources of funding. *= most significant funding source.*

Hypercompetition between researchers

Regarding competition between research, within their own institutions in SDG13 most of these researchers cooperate and form consortiums. *"I think the whole way of thinking is already much different than in other disciplines. Of course there is competition, if you have a consortium or whatever. There are multiple consortia who are applying for the same funding, but in general my feeling is that within the environmental sciences at least, we are much more open for working together than being competitive." (Interviewee 4).* This was also the case within the research linked to SDG3. "*As soon as you* *go beyond sort of your own small sphere and you start competing for grant money, the competition just opens up, becomes incredibly large, and it becomes incredibly competitive for research funds." (Interviewee 2).* Competition outside of the researchers' institutions can be completely different. Unless researchers work with other institutions and are forming consortiums, there is a lot of competition for funding. Besides, there seems to be a lot of competition between countries. The UK and the USA are seen as very competitive societies. One of the researchers worked in the USA for three years and experienced a competitive system for science, also within the country. "*You know people have a certain reputation, certain egos, so there's definitely competition there. In a way, I think it could be healthy because it keeps everybody sharp."* (Interviewee 5).

It takes a lot of time and effort for researchers to write a good proposal, and the chance that researchers are getting funded is not really high. The researchers mentioned that getting bigger grants from the NWO and European Funds are very competitive. As mentioned before, getting grants from the NWO is especially hard. The researchers mentioned that only around 10 to 15 percent of the proposals get funded. Funding agendas do play a role in the success of proposals. Hopping on topics that are trending can increase the opportunity of acquiring grants.

Interdisciplinary researchers also have a hard time to apply at a national level. There is no real funding agency for interdisciplinary research, and funding agencies often point towards each other when interdisciplinary researchers ask for funding. At NWO, they do mention that they want to focus more on interdisciplinary research but when applying for a grant, researchers have to choose a discipline to which their research belongs. This is easier at European level, as they ask a lot for interdisciplinary research. An explanation could be that the disciplines linked to SDG13, like Geosciences, are relatively new compared to other disciplines and therefore it still needs to develop a real funding mechanism. *And this is really a drawback, I think. I mean because if you look at their website (NWO), you have the feeling that they really want to have this interdisciplinary research, but the whole system is not set for this." (Interviewee 6).*

Staff & Equipment

The second part of the credibility cycle is focused on staff & equipment. According to the theory, assessments are done with publication-based indicators, such as the number and amount of funded grants and the number of citations of published papers. Examples of much used indicators are the H-index and the Journal Impact Factor. It was expected that the interviewed researchers would have experience with these methods. The results showed that not every interviewee worked in a team as some of the researchers work alone.

Interviewees	Works alone/in a team	Uses qualitative metrics for evaluation (narratives, background etc.)	Uses quantitative metrics for evaluation (h-index etc.)
Interviewee 1	Team	x	
Interviewee 2	Team	x	
Interviewee 3	Team	x	
Interviewee 4	Alone	n/a	n/a
Interviewee 5	Team	x	
Interviewee 6	Team	x	x
Interviewee 7	Team	x	
Interviewee 8	Team	x	

Table 7. Use of metrics for evaluation.

The researchers that did actually experience the procedures of hiring new members, pointed out that it was mostly done through narratives, instead of using quantitative metrics such as the h-index. This is the case in research linked to SDG3 as well as research linked to SDG13. It is more about the motivation of the researcher and if they have the right skills and background. Though, these experiences were mainly based on the selection of PhD-students, who often don't have any publications or citations yet. When looking at higher positions, like post docs, the quantitative metrics become more important according to the researchers. Getting in high impact journals does not necessarily mean good research, but it means that it is relevant and more impactful research. *Sometimes we look at post docs and then we definitely think that would be a criterion. If they publish in high impact journals, that would really be a plus."* (Interviewee 6).

Regarding the diversity in teams of research linked to SDG3 and SDG13, the researchers worked in teams that are quite diverse. While the researchers are studying the same topics, they often vary in terms of backgrounds. *"But it all comes eventually back that they're all geologists by training, but you have the ones that are more into the biological topics, the ones that use physics or the mathematics for the seismologists, for instance. So I think that our science is that we take from all kinds of disciplines and we don't have actual discipline ourselves." (Interviewee 7).*

Data & Arguments

The third part of the credibility cycle focused on data. The sharing of data was introduced in this section and it became clear that to what extent data is shared differs in every discipline. While it was expected that SDG3 would have restrictions due to privacy and ethical issues, there was not really an expectation for research linked to SDG13.

Data sharing

The researchers working with research related to SDG3 do encounter projects that include sensitive data. Therefore, the degree of data sharing depends on the characteristics of the project. When these researchers work with sensitive data, the data is often held closely by individual groups. A recent development regarding sensitive data is The General Data Protection Regulation (GDPR), a new privacy and security law that has been introduced within the EU. According to the researchers, this regulation makes it harder to share data of European based projects, and to share this data within the EU in order to maintain the privacy protections of European citizens. The preparation to comply with the regulations of the GDPR is the major bottleneck as it takes a lot more time while the final sharing of information was unaffected by the new regulation. As it is a relatively new legislation, some researchers still need to find a way to deal with it. *"Especially now that we have the GDPR as a piece of legislation, sort of data sharing within the EU and European based projects is technically very difficult." (Interviewee 3).*

One of the researchers mentioned a method that could potentially cope with privacy regulations. The idea is the creation of a synthetic duplicated dataset, in which real data is changed in a way that it is not recognizable anymore. This method seems to be quite hard to implement in terms of preventing the disclosure of people. However, the researcher thinks it has potential over time once it's further developed. When the researchers don't work with sensitive data, they tend to upload their datasets, information and script to, for example, GitHub. "*Inside the university, what I think in our department has quite recently changed is that we do Open Access publishing, so putting stuff on GitHub. Making everything reproducible is being valued more." (Interviewee 1).*

Regarding the sharing of data within SDG13, nowadays the researchers share their data most of the time. There has been a shift towards sharing data more compared to a decade ago. Data sharing is done through certain repositories, such as Yoda, which is a research data management service used at the University of Utrecht. Another known repository that was mentioned multiple times is Git. There are still some researchers, especially older generations of researchers, that are holding back on the effort to become more transparent and are resistant to change. It can also be hard to decide when to upload data. Researchers often want to analyse the data first and make sure that the data is being used correctly. The degree of certainty about outputs can differ, which also plays a role in the decision to publish something. On some occasions, researchers work on projects with long timescales that take years to complete, having data that is still work in progress. Data that is still work in progress can sometimes lead to misinterpretations. *" We provide a lot of output variables, some are more robust than others. We know at a certain level the outputs we feel confident about, but you know some intermediate outputs can be much more uncertain, and then the question is, do you publish these?" (Interviewee 6).*

Regarding improvements for data sharing, two of the researchers pointed out that the processes of data sharing could be more standardised. Data can still be fragmented. The facilities for data sharing are getting better in terms of repositories and making it accessible for the public but for new users or PhD students that want to share their data on repositories it is hard to understand how this is done right away. Therefore, standardising the process could help take these uncertainties away when everybody knows how to share and maintain their data.

Paywalls

Regarding paywalls, the theory showed that a lot of papers tend to end up behind paywalls, *"it depends what kind of journal and also the people that I collaborate with."* *(Interviewee 1)*. Papers that are developed in the Netherlands, are most of the time open access. Researchers can send the bill to the university, which in turn pay for the article processing costs. This seems to be a luxurious position especially for rich countries, which was also identified in the theory, as they can afford to pay these costs for their researchers. Poorer countries don't have the ability to do this, which makes it harder for researchers from these countries to publish open access. *"So we publish with Elsevier now, but I also work with Cambridge Press. So Cambridge Press has a deal apparently with the Netherlands that if you have a paper from a Dutch group then it will be automatically Open Access." (Interviewee 5).* Researchers need a DOI, which makes it possible for people to still find it after at least ten years when they publish in this kind peer reviewed journal as well as making the data open. The researchers that are linked to SDG13 fully commit to this process, most of the time their data is not sensitive, so they won't have any privacy issues in that regard. Research linked to SDG3 does not always end up being open access. As mentioned before, it really depends on the journal. While it is an advantage for researchers that processing costs for open access are paid, it also results in some disadvantages like the fact that there is presumably less available for funds. *"The Dutch government pays, and then you can ask how much money will you spend on grants? And they say, we already paid so many millions for the publishing so in the end there's no free money. So if they decide to pay for our open access publishing, that goes off from the grant money." (Interviewee 3).*

Articles

The fourth part of the credibility cycle is articles, which is mainly focused on peer reviewing papers in order to assess the quality of the research. In the theory section two types of peer reviews were outlined, single-blind and double-blind peer review. Though, according to the theory, the objectivity, reliability and consistency of the traditional peer review system seems to be in question. The results in this section will show if the interviewed researchers do have problems with the traditional peer review system, and if there is any need for improvements.

Peer reviewing

Most of the researchers linked to both SDGs did not see any problems with the current peer review methods. Whether they used single-blind or double-blind peer review was dependent on the journal they submitted to. The theory explained that single-blind and double-blind peer review could lead to biassed reviews. However, the researchers did not mention any problems with biassed reviews.
One of the researchers was also an editor and it became clear from his experiences that getting reviewers in the first place is already hard. Among the other researchers were also some reviewers, and the problem that was identified is that there is a high demand for peer reviews. The editors are most of

the time flooded with papers and whenever papers are reviewed it can differ in how much time it takes. *"The amount of time with the review is really highly variable. Ideally it's a matter of weeks, but as someone that's been a reviewer it's difficult to fit in time." (Interviewee 2).*

The researchers were not particularly in favour of a more open process of peer reviewing. In a pragmatic way, open peer review processes could lead to lower workloads on editors. However, one of the researchers did an open peer review process, which completely went out of control. *"People really started to become very aggressive, basically in the review. And I mean it was anonymous, but people still sort of found out who it was and they just took each other apart online and everybody could read it." (Interviewee 5)*, and low participation rates do also happen with more open peer review processes. *"But then people can comment and I think that hardly happens." (Interviewee 3).*

The quality of peer reviewing can also be affected by the type of journal. *"There is a difference between journals that are being run by commercial editors or journals that are run by scientists, and the latter ones usually have lower impact factors, but then your chances are better and more fair review or higher." (Interviewee 3).* Eventually, peer reviewing also comes down to a bit of luck, as mentioned by one of the researchers that also happened to be a reviewer. "*The peer review process is also sometimes a bit of a lucky shot. Because in that sense, who are the two or maybe three reviewers? And are they happy with what you submitted, or if one reviewer is terrible or an enemy?" (Interviewee 8).* The quality of a peer review eventually comes down to the person that is reviewing the researcher.

Recognition

The last section of the theory of the credibility cycle focused on recognition. It showed that there are two types of recognition, formal- and informal recognition. There were multiple sources of formal- and informal recognition identified from the researchers.

Interviewees	Grants	Recognition from peers	(Social) media attention	Medals/ Prizes	Publications / Citations (H-index)	Collaborations	Teaching
Interviewee 1		x			x		
Interviewee 2	x				x		
Interviewee 3	x			x	x		
Interviewee 4	x		x		x		
Interviewee 5	x	x		x	x		
Interviewee 6						x	
Interviewee 7		x	x		x		x
Interviewee 8	x	x				x	

Table 8. Mentioned sources of rewards and recognition

Quality in quantitative terms

When asked about the main sources of recognition, the researchers often answered with grants being the main source as it allowed them to continue doing research. However, it is important to state that the amount of grants can be seen as both the rewards of recognition and a source of recognition. Grants are mostly dependent on other sources of recognition that also indicate the quality of a research, such as the amount of citations. When it comes to funding agencies, "*It helps if you have a high h-index. The more you are cited, the better it is. Sometimes in funding proposals it helps. You can write it down in your CV and your application for funding." (Interviewee 4).* This was also expected to be the case according to the theory. But it also depends on the funding agency and its policies, such as the NWO. "*NWO has changed their systems right, so obviously that's going to make a difference. They're not asking for your full publication list anymore and you can't mention your citations." (Interviewee 1).* This is also happening on European levels. '*I recently applied for some large European grants, we were explicitly not allowed to include things like publication numbers, H factors, because they wanted to move away from that." (Interviewee 2).*

The theory made clear that the primary focus of recognition on universities has been based on research only, while other outputs such as education or societal impact were often left out. One of the researchers confirmed that at the University of Utrecht it was normal to focus on the amount of publications and H-indexes in the past, but that the university drifted away from this. There has been a shift towards including these other outputs within recognition and rewards. Especially at the University of Utrecht, where they started an Open Science programme to stimulate this. The expectation was a shift towards more open outcomes and the researchers agreed that there has been a shift over the recent years in terms of recognition. "*It used to be sort of long lists, like this guy had 500 publications. But I think there has been some sort of shift where people are more critical about what kind of papers are published you know and if the papers are really sort of solid, and if they have the bugs, or have some sort of impact on the field." (Interviewee 5)*

Research impact

Some researchers were more convinced about the shift compared to others. Many agreed that publications and citations are not the main sources of recognition anymore. However, when asked about the recognition of societal impact, there was not a lot of response. Some of the researchers questioned this aspect of the new approach. Their biggest concern was how societal impact was measured. *"Even if people were saying they had an impact on society, it was all a little bit of a dance and the real impact on society is just not known by those workers." (Interviewee 8).*

Interviewees	Did see a shift in recognition	Did not see a shift in recognition
Interviewee 1	x	
Interviewee 2	x	
Interviewee 3		x
Interviewee 4	x	
Interviewee 5	x	
Interviewee 6		x
Interviewee 7	x	
Interviewee 8	x	

Table 9. Shift in recognition.

Overall, it seems that the recognition for researchers linked to SDG13 that work towards climate action has been growing over the years, since climate change and its consequences are rising on the political agendas. These political agendas do have influence on the allocation of money as mentioned by several researchers. Researchers also increasingly reach out to newspapers and social media platforms like Twitter, in order to inform society about the results and empirical data from scientific research. *"It's really much more relevant now in policy making. So that's the reason I think, why there's more interest." (Interviewee 6).*

4.2 Whitley's framework

In this section the framework of Whitley is used to compare the outcomes and organisational characteristics of the scientific disciplines that are linked to SDG3 and SDG13. The interviews will be used to determine the mutual dependency and task uncertainty of both fields. Changes in the institutional environments can influence the organisational structures of scientific fields and in turn have an impact on mutual dependence and task uncertainty. An update of Whitley's framework focusing on this type of research would therefore give a better understanding on the concepts of mutual dependence and task uncertainty applied to the present time.

SDG3

Mutual dependency

One of the two aspects of mutual dependency is functional dependence, which refers to the extent to which a researcher makes use of specific results, ideas and procedures from researchers within their discipline, to what extent they fit in existing knowledge and the extent to which the results of this researcher are useful for others.

In research linked to SDG3, the functional dependence is high. Most of the researchers rely on each other within their disciplines. *"Cancer research has been, in many cases, the first type of biomedical research to adopt certain new developments. For instance, genomics was first used to find it was based on finding cancer driver genes. And now genomics is being used to find genes that make you prone to heart disease, dementia, Alzheimer's, whatever, you know, epigenetics. So the non-Darwinian regulation of genetics is, you know, that has all been driven by cancer biology or cancer researchers, but it has been adapted by many other fields. But all within the biomedical field, I wouldn't say within physics or* *astronomy or whatever." (Interviewee 3).* It shows how researchers adopted ideas, procedures and findings in order to make new contributing knowledge claims within their discipline.

The interviews imply that there is a homogeneous group, as the researchers work mostly within one discipline. "*It's still mostly sort of your biomedical epidemiological science"* (Interviewee 2) and "*in disciplines. Yeah. It's all biomedical." (Interviewee 3)* For researchers that are linked to SDG3, collaborations within their discipline are common, but interdisciplinary research does not happen often and can also take a lot of time to realise. "*What I have learned throughout the years is that if you're going to a different discipline to use a technology, then it takes 5 to 10 years of communication to get on the same level that you understand each other." (Interviewee 3).*

The degree of strategic dependence in the research linked to SDG3 is high as well. The research that is linked to SDG3 is often combined with work within laboratories. *"In our field, we are completely dependent on expensive equipment, and the laboratory is our second home". (Interviewee 3).* The work in the laboratory is often supported by universities or university medical centres like the UMC Utrecht, in which researchers rely heavily on expensive equipment. *"The generation of environmental data can be expensive so when analysing newly collected data I can be quite dependent on expensive lab resources and the availability of environmental samplers." (Interviewee 3).* This has mainly to do with the starting costs of generating the data but the amount of data generated is quite high. Some of the equipment is not supported by the universities, and therefore researchers can be dependent on external funding. *"The costs for equipment in order to do this are approximately one and a half million, and then you have to take in mind that you need to find funds once in three or four years in order to continue." (Interviewee 3).*

There are also some new insights regarding mutual dependence in this field. While the degree of interdisciplinarity in this field is relatively low, the researchers do often interact with external stakeholders, such as policy makers, politicians and organisations. *"I'm now thinking sort of specifically with certain projects I'm doing where we ultimately share our findings with, say, the Centre for Disease Control." (Interviewee 2).* Especially politicians and policy makers are trying to get more involved within research processes, which also has a lot to do with research agendas that set the direction for research. *"It's just they try very hard at the moment." (Interviewee 3).* Dependence upon particular groups of colleagues is therefore also extended towards other external stakeholders, and not only within the scientific field. The organisational structure of this scientific field is changing towards a structure in which researchers also become dependent on these external stakeholders.

Task uncertainty

Regarding the degree of task uncertainty within research linked to SDG3, it can be said that this dimension is rather low. As described in the theory, task uncertainty is also divided into two parts. The strategic uncertainty within research linked to SDG3 is low. While Health Sciences consists of a majority of disciplines, it can be stated that most of the researchers seem to agree upon the priorities of the research within their own disciplines.

The technical task uncertainty is also low in research linked to SDG3, as they often rely on the same expensive resources. As described in the section on mutual dependence, researchers share laboratories in order to produce their data and are therefore using the same technical procedures. As the resources are quite expensive, researchers also often make use of secondary data in the scientific community which has already been collected, such as map or survey data. While the starting costs are high for the collection of data, international collaborations and the extensive amount of data that is generated eventually lowers the threshold. The collaborations can also be linked back to low strategic uncertainty, as these collaborations require mutual understanding of the nature of the research object.

Besides, the production of results often rely on research techniques that have been used in the past, and the knowledge of this is widely spread within disciplines. The methods are standardised to a degree that these are found back within textbooks. "*People have learned the development of the hematopoietic system, you know, classical textbook knowledge. And then people got into the technology of lineage tracing. And now this whole concept, you know, millions of students were raised by this concept of, you know, one stem cell etc." (Interviewee 3).* This is also strengthened by the quote about developments in cancer research, and how this has led eventually to new findings and interpretations in other fields.

For the concept of task uncertainty there are also some new insights that came from this scientific field. As stated in the previous section, external stakeholders are becoming more involved. Radical situations like COVID-19 can have a big influence on how science is approached. While the concept of task uncertainty by Whitley is mostly focused on stakeholders within a scientific field, instances like COVID-19 show that wider society is increasingly trying to get involved with the understanding of the nature of research objects. *"Because you know we had this immediate threat. Pretty much everyone was very interested and addressed them right away. And so huge amounts of focus were placed onto primarily the most important things, prevention and diagnosis." (Interviewee 2).* Researchers are in a sense getting obliged to legitimise their findings towards the wider society, and so the organisation and goals of researchers is also shifting to a structure in which the wider society is informed.

SDG13

Mutual dependency

When analysing the findings regarding *functional dependence*, it seems that Geosciences are leaning towards lower functional dependence. Geosciences is a relatively new discipline, but most of the researchers were capable of producing data without being dependent on the results or procedures of others within their own discipline. Researchers in this field do sometimes have to rely on external resources. One of the researchers mentioned a project in which he needed external laboratories in order to produce data, which increases functional dependence.

Researchers that are connected to SDG13 are often involved in interdisciplinary research. While the researchers are not necessarily dependent on the findings from other researchers in this field, in terms of narratives, perspectives from other disciplines and discussions could strengthen the presentation of results. In turn, this could lead to lower task uncertainty since researchers increasingly get a better grip on the wicked nature of these problems. *"Especially when a project where we really worked together with social scientists we did a really interactive procedure. We produced scenarios with a lot of numbers and then we shared it with their more narrative based approach to see if our numbers actually fit some kind of sociotechnical system analysis." (Interviewee 6).*

However, these were also instances where interactive collaborations led to complicated communication, when disciplines do not align or don't understand each other's methodologies and therefore researchers have to persuade other researchers of the relevance and significance of their issue and approach. This can be linked to a higher *strategic dependence*. *"Like geology and biology. If you study ecosystems in true time and then compare that with a biologist studying a system nowadays. Then it's often quite hard to get them to appreciate the temporal aspects with long timescales and so forth. That can often be an issue that makes communication a bit harder." (Interviewee 7).* Though, it can be said that this is precisely the reason why interdisciplinary approaches are needed. Whenever disciplines don't agree with each other, it can be valuable to share each other's perspectives hoping that this in turn leads to appreciation and an agreement on each other's ideas, procedures and findings.

The research linked to SDG13 has a higher degree of interdisciplinarity. This gave some new insights on the concept of mutual dependence. The interdisciplinary approach, as shown above, shifted in this case the mutual dependence from one discipline towards multiple. Besides, some organisations, like the following example at Copernicus, develop the structure of their organisation and goals according to global political agreements such as the SDGs. *“We are organised around these tags. So all of our research themes are organised within certain genres already, so our work is focused on SDGS and we like to link and create and work together as much as possible based on a lot of SDG based themes” (Interviewee 4).* Another example is the IPCC, for which multiple researchers did some work. The IPCC is an intergovernmental panel, and includes governments and experts from multiple disciplines. The contribution that IPCC makes to science is dependent on the findings from these researchers. *“IPCC wants to give the best advice on the current state. And this is what we know and the work I'm doing is just providing more or decreasing the uncertainties, especially in the land use part of the whole underpinning of global climate change research.” (Interviewee 3).* With the concept of interdisciplinarity taken into account, it can be said that the stage that influences the degree of mutual dependence is broader compared to disciplinary research. This could also hint to an increase in the degree of mutual dependence since there is a wider variety of stakeholders dependent on knowledge.

Task uncertainty

Regarding the analytical aspects of task uncertainty which were expected to be high in research linked to SDG13, the *technical task uncertainty* is most likely to be of a lower nature. Overall, researchers within their own scientific fields do often agree with the techniques that are being used to get to findings, also when the researchers use different methods or techniques. What helps is the fact that researchers also cooperate with other teams that do use different methods, resulting in better understanding about each other’s interpretations. *“Because we do cooperate a lot with teams doing similar work. So we do a lot of knowledge sharing.” (Interviewee 6).* It is unclear which of the methods will eventually produce the best data or findings. *“Like there are different labs with different procedures to produce their own big data. And one doesn't know yet at the moment which lab produces the better data or not.” (Interviewee 7).*

While researchers often agree with each other on findings within disciplines, it sometimes becomes harder to agree upon methods when more or bigger organisations are involved. *“Within IPCC we have huge discussions about tier one and tier two methodology. It's like we have to do it like this and a lot of countries obstruct sometimes because it's not in their favour. But the answer most of the time is: It doesn't matter if the method is not totally right, but if every country is doing the same method, at least* *it's consistent."* (Interviewee 4). The researcher emphasises the importance of sharing the understanding about methods. As described in the previous section, the IPCC is an important organisation taking on an interdisciplinary approach for which multiple researchers have done some work.

The second part of the previous quote on IPCC does also influence the second aspect of task uncertainty, *strategic task uncertainty*. There seems to be inconsistency between organisations with different priorities about the problem being in place and how these priorities are handled. Aside from the certainty about their findings, they seemed to be more uncertain about the approach to tackle the problem of climate change as a whole. This has to do with the nature of the problem "*we use appropriate methods, but if you really specifically talk about problem solving. You know, therefore, you really need a lot of different fields and different approaches, and not only interdisciplinary but also disciplinary approaches. I would say so in the end, that's a very difficult question. We are only one small part of the puzzle." (Interviewee 6).*

The previous section gave some new insights on the concept of task uncertainty when including interdisciplinary research. As described in the last part in the section of mutual dependence, this type of research includes a wider variety of stakeholders that influence the institutional environment which in turn are influencing organisational structures. The concept of task uncertainty is in this situation not restricted to one discipline, but covers multiple disciplines. All these different disciplines and important organisations like the IPCC that are participating in this interdisciplinary approach have their own organisational structures with their own goals, it is much harder to organise a relatively coherent system. "*If you would think in the bigger picture, what sometimes maybe lacks is the integration of the whole thing.*" *(Interviewee 8)*.

As with the example of COVID, so does the trending topic of climate change influence the approach of scientists that are linked to research of SDG13. Social media also increased the access towards information about these topics. Scientists are continuously legitimising findings on this topic. *"We didn't pay attention to having an opinion in the newspaper or Twitter or whatever is less. But now we realise more and more, if we don't take part in those kinds of media, then we get the "wappies" (Dutch word for people that have opinions not based on facts). They shout and they get the attention and now we need to shout out as well like no, these are the facts, these are the results, this is the empirical data, to get the message across." (Interviewee 4).* This shows that scientists started to also inform the wider society to inform about the understanding of research topics. It is important as wrong understandings about such important topics in society could lead to inefficient decisions within organisations that have the ability to build sustainable pathways.

4.3 Open Science

This section will focus on the analysed data that was retrieved from the interviews with individuals specialised in Open Science. Some expectations were formulated in the theory section, and these expectations will be further investigated in the findings.

Open access, Open data & Open code

The first section of the theory of Open Science introduced the first two schools of thought which were focussed on opening up the process of knowledge creation by making it freely available for everyone. It was expected that this would increase scientific efficiency in the creation of research that reacts to societal needs involving more stakeholders within the process, but that it takes more time to produce.

The results showed that scientific efficiency increases with open data, as data becomes accessible for other disciplines and stakeholders that could work upon the available data. This offers more opportunities for everybody and eventually speeds up the process of science in general. However, when looking at individual projects, it often takes more time to prepare data to become open. When working individually on a computer, researchers can save it and use it for their own use. But when others want to make use of the data as well, they have to get access to it and understand it as well. *"But if you want to use it too, then you have to understand what I did and which adjustments I made and you have to be able to open the data. Maybe I have to write a manual for you as well, so that takes more time. " (Interviewee 10).*

Journals increasingly ask about open data and that the pressure from journal editors on researchers will continue to increase over the year. Research funders such as NWO make it obligatory to make a data management plan including an adequate story about data management and data accessibility. This pressure and added procedures do result in increasing open available data, but also slows down the process of knowledge production of individuals.

Regarding societal needs, it becomes clear that researchers do reach out to societal stakeholders when, for example, forming research questions. But also when doing research, working together with other stakeholders in the form of co-production is common. An interesting example was given in which one of the researchers was approached by a big organisation. The researcher and his group published research about water problems around the world, made it open, and this was eventually picked up by National Geographics. This resulted in National Geographics funding the researchers to continue doing research at more local hotspots that are dealing with water problems. *"Because they saw the potential in this, and thought, we could do this for smaller regions, and this was caused by the fact that we shared that data in the first place" (Interviewee 10).*

Another expectation was that ethical issues would form a barrier for sharing data. The results showed that this continues to be an issue. *"Open Science is not going to fix privacy issues, that is a whole other subject. " (Interviewee 11).* Both requests for open data as well as regulations for privacy protection are increasing, resulting in a clash between both. For the majority this is a problem for research linked to SDG3, in which a lot of data is based on personal data. The research linked to SDG13 does not use data in this manner, and is therefore not sensible for ethical and privacy issues.

Two considerations for open data are the quality of open data and the degree of openness of repositories. While data is becoming more open, not all of the open data seems to be reproducible. One of the researchers mentioned that it is shown in some papers that 80% of the open data is hard to reproduce. Another remark is the openness of repositories, when are repositories considered open? Sometimes repositories require email registration and are therefore not always considered to be open, while in fact everybody should able to access it.

Altmetrics

According to the theory discussed earlier, it was expected that the altmetrics would complement the traditional impact assessments. The findings showed that the altmetrics indeed create a different overview that would be able to measure criteria for the changing criteria regarding recognition and rewards.

However, it stated that the altmetrics also have a rather quantitative method when it comes to measuring impact. While the altmetrics extend the set of metrics through, for example Twitter, it still focuses on numbers such as retweets. Within the interviews it was stated that extension to platforms like Twitter could also open the door for people that are good in telling stories, rather than doing good in actual science. A bigger amount of retweets on hot topics could therefore result in more citations, while it is not always the case that this article has a bigger impact. One of the researchers gave an example of an article in 2018 about extreme droughts and this article was picked up a lot by the media. However, in 2019 they published another article about extreme droughts and this was barely seen in the media. It has a lot to do with the right momentum and a bit of luck. *"Those kinds of moments are also a bit of luck, when the best hydrologist with a lot of followers retweets you, then you are in the media, and if they don't, you're not in the media. " (Interviewee 10).* These downsides of altmetrics result in a lack of robustness, which was also described in the theory section.

Adding altmetrics to the traditional metrics when selecting candidates for new research is not used by many people. There seems to be a lot of discussion about how to show your quality and as described in earlier findings, much of the procedures of selection are based on narrative stories. Metrics in this context do have the ability to strengthen the motivation of researchers and therefore their narratives. *"But I think they are not telling the whole story, because I think that in the narrative you can still use metrics. So if you have a very good you know, h-index for example, why not include it in your narrative. " (Interviewee 9)*

Next to that, the researchers stated that the hype around altmetrics was 7 or 8 years ago, and that they don't hear often about altmetrics nowadays. Added to that was that the altmetrics have the opportunity to complement the traditional metrics, but that it currently does not necessarily add to the current use of metrics, due to the ease of gaming.

Open Peer Review

The Open Peer Review was introduced in the theory section with three traits which covered more than 99% of all the definitions of OPR: Open identities, open reports and open interactions. Regarding open identities, there was a consideration of whether people would be more motivated when reviewing as their identity would be known or whether reviewers would be more cautious with critical comments. There are different kinds of social interactions within communities. The interviewees tended to lean towards reviewers being cautious. *" If everybody knows where the comments are coming from, you might have that people are a little bit too lenient. " (Interviewee 9)* and *"I notice myself that I still find it hard, especially with critical reviews, to put my name under it." (Interviewee 11).*

However, it was also stated that on the other hand anonymous reviewing could lead to negative social dynamics in the form of two different schools of thought within a particular discipline resulting in clashes and comments that are too harsh and unnecessary. Therefore, it seems to be hard to choose between blind reviews or signed reviews. Eventually it also has to do with what type of reviewer is assigned to the research, as described in the earlier results of peer reviewing.

Regarding open reports and open participation, in which the reports are publicly available and in which the wider community also has the option to review reports, it seems that more experiences and experimentations are needed. In the credibility cycle some examples were already cited. As peer reviews can take up to three hours of work, a lot of reviewers don't feel the urge to review open reports as well. *" People just don't have time to go and read extra papers and write extra reviews, when I see how many review requests I already get. The concept of OPR is good in terms of accessibility, but it is not used to its fullest potential yet. " (Interviewee 10)*

Another downside identified within the interviews was a potential increase in bureaucracy, as there might be a lot of tinkering involved when working with these open peer reviews. Overall, open peer review still needs time to develop especially when involving the wider community. Whether blinded or signed peer review is better comes down to the social dynamics within disciplines and the type of reviewer.

Citizen Science

As explained in the theory section about Citizen Science, this method could open up knowledge systems to other significant stakeholders such as civil society or the industry, resulting in a more transdisciplinary approach. It was expected that CS would lead to involving civil society more, but that the efficiency of this approach might be below expectations. The findings showed that CS strengthens public engagement which leads to wisdom of the crowd and a more thorough research process. However, to get to the wisdom of the crowd, a lot of people are also required to work on a certain topic, and that could take a lot of time to get right. *"But on the other hand, maybe for example, if you talk about citizen science, it also takes a hell of a lot of time to get this right. " (Interviewee 9)*

And when the procedures of recruiting people for the project are done, it is also necessary that the individuals involved come up with good quality data. So it becomes a challenge to get CS done efficiently. One of the solutions for good management of certain projects is the idea of subsequent projects, creating a string of projects that the people tend to do with the same stakeholders over a couple of years. The stakeholders involved are trustworthy due to earlier experiences and people tend to build up chemistry over time.

Preregistrations and Registered reports

The theory of pre-registrations and registered reports showed that these procedures could help to make current science more reliable. The results of the interviews show that while these kinds of procedures may slow down the process of knowledge production, they do contribute to the quality and the reproducibility of the research. In this way, people can look into the research before it is conducted and see what is going to be expected, creating a more transparent and integer process.

Reproducibility research in that manner should also be more valued as you get only valued now when you do something completely different or completely new. However, this researcher also stated that in some disciplines researchers are only able to publish novel ideas if they are reproducing itself first in a couple of experiments. In that way, researchers cannot publish a single experiment.

Multiple interviewees also pointed out that researchers want to get articles out fast, as part of the rat race for funds and publications. They proposed the idea of publishing less articles including more experiments so that more time is spent on an article. In turn, there is also more time to adhere to these Open Science principles, which could take more time to implement. *"Maybe we should also, next to*

Open Science, start thinking about maybe doing fewer projects or publishing less and devote more time on each article or each project so you have more time to adhere to these open science principles. " (Interviewee 9)

Recognition

According to the theory, much of the recognition and rewards is based on quantitative indicators such as the amount of publications and citations. The Open Science programme that Utrecht University launched is a good example of the developments of recognition and rewards. The results showed that while it might be implemented within the UU, it does not necessarily mean that other universities or other institutes involved are following. Therefore, when a researcher follows the Open Science rationale, would that researcher still be able to make a career switch towards another university that doesn't adhere to the Open Science principles? *"We can be ahead in the Netherlands, or in Utrecht, and that is a good thing, but we have to realise that a lot of PhD-students and postdocs that we educate here, eventually want to look for a job abroad. It can put them on the backfoot, and especially in the US and Australia, if they have a resume that is more focused on Open Science." (Interviewee 11).* Universities depend on national contexts and national institutions. There are different views on the science enterprises, in which some universities are more commercial than others. The idea that the Netherlands are ahead with Open Science can also refers to the institutional theory, in which it was said that organisational changes that maximizes efficiency can also lead to a sacrifice in support and legitimacy.

When the Open Science programme that is used by the UU becomes part of the criteria of every academic system, then eventually researchers will follow as they know they have to follow these criteria to make a career. This could also in turn have an effect on the identity of competition between researchers. When the criteria for funding changes to public engagement, researchers will compete with each other for public engagement, instead of citations in the current system. One of the interviewers mentioned recent developments at NWO, which included societal impact in the personal grants on top of scientific excellence as one of the criteria showing that there are already different kinds of criteria entering the credibility cycle. *"That's absolutely still, you know, the driving motor behind science and even within Open Science, I guess this credibility cycle itself will remain intact, but the parts of the cycle will change." (Interviewee 9)*

This could also be seen as a cynical stance, because you could also say that scientists do it from their own underlying values, and obviously many scientists do share these values. But recognition and rewards are important, and it's therefore interesting to see if such criteria can be set up in such a way that scientists and researchers are moving on towards Open Science principles. Because to a certain degree, researchers and scientists will continue wanting to make comparisons to each other, as science is competitive. During the selection for research, people want to know who they need to hire and if they are good enough. The traditional metrics like the amount of publications are often attractive to use in these situations and will therefore continue to exist.

Transformative change and the future of Open Science

As described in the theory section, it takes time to shift a paradigm. The biggest challenge for this shift is the old-fashioned habits and procedures that form the institutions that are in place at universities and within the academic system. While these do change slightly, older generations of professors within the academic system with higher positions and heads of departments often resist forms of change, and prefer to continue how it is currently done. *"A lot of the young scientists do want this (Open Science), but it's the professors from higher up, the head of departments, that are often old-fashioned and who are forming a sort of layer of loam which makes it impossible for younger scientists to do science in an alternative way." (Interviewee 11).* Though, the results show some promising development for some of the practices of Open Science. In the last decade there have been all kinds of experiments regarding Open Science, and now it has become institutionalised in some universities like the university of Utrecht, but also in certain research councils. With that information, it could be said that Open Science is in the scale-up-phase in which it is interesting to see if more institutes will follow, or that it remains within a certain niche.

Discussion

This section will discuss the theoretical implications and the limitations.

Theoretical implications

The main theories in this thesis focused on the credibility cycle, the organisational structures of two scientific fields through Whitley's framework and opening up knowledge systems through the concept of Open Science.

The theory of the credibility cycle focused on six different areas of knowledge production, in which assumptions were made about the strengths and weaknesses of the institutional mechanisms that researchers with research linked to SDG3 and SDG13 encounter. The findings support that most of the funding for sustainable development is public funding, and it remains hard to get funding for sustainable development. The funding that goes to the research in question mainly comes from internal funding by the university or through governmental institutes like NWO. The high competitiveness among researchers continues to be fierce, since only 10-15% of the proposals at NWO get accepted. Though, the findings did not support the theory that this relies on a students' research performances, since most funding agencies are starting to focus on narratives. Applying for interdisciplinary research is even harder, since there is no real funding agency for interdisciplinary research. A recommendation would therefore be to initiate a funding agency focused on interdisciplinary research. Regarding staff and equipment, the findings do not support the use of quantitative bibliometrics when assessing researchers for hiring. The main implication for this is the policy at the Utrecht University, which focuses on the use of narratives instead of quantitative assessments such as the H-index. Hiring, promotion and tenure of staff is mostly done through narratives. For the area of data, the findings support the theory of data sharing, in which it was stated that the degree of data sharing is different between disciplines. Data sharing in fields with research addressing SDG13 has been increasingly implemented, but new users could have problems understanding the process. The fields with research linked to SDG3 are less able to share data, mainly because of ethical and privacy issues and legislations like the GDPR. Researchers still have a hard time working with this legislation. Further research and experimentations are needed for the standardisation of certain procedures. Regarding paywalls, while globally most articles end up behind paywalls, the findings in this thesis do not support this. Most papers in the Netherlands are open access. An explanation for this is that papers developed in the Netherlands tend to be open access, since the processing costs are paid by the Dutch government. Though, these costs could be another reason why there is high competitiveness for funding, since there is less money available. The findings do not support the theory of the disadvantages of the current peer review processes. While the objectivity, reliability and consistency of the single- and double blind peer review methods are questioned, the researchers did not seem to have any problems with these methods. It was argued that the demand for peer reviews is high and that getting reviewers is hard in the first place. The quality of the peer review also depends on the person and journal reviewing the work. This implies that the problem might not be the type of peer reviewing method, but the current situation in which a lot of publications have to be reviewed which in turn puts pressure on the reviewers.

The last area of the credibility cycle was recognition. The main theoretical implication shown by the findings is that while the H-index is still being seen as an important factor for recognition, certain funding agencies, like NWO, and universities, like UU, are moving away from this system and are focusing more on qualitative measurements. The findings however, showed that further research on the measurement of certain factors such as societal impact is needed.

Regarding the organisational structures of scientific fields through Whitley's framework, the main contribution was that Whitley's framework is mainly focused on disciplinary research, while the focus in this thesis was also on interdisciplinary research and the involvement of society, since interdisciplinary research and mode 2 knowledge have become more prominent over the years. Within research linked to SDG3, collaborations were mentioned, especially with external stakeholders. And while several scientific fields were created based upon the prior knowledge of other scientific fields within Health sciences, collaborations between disciplines did not seem to happen often, which would indicate a low degree of interdisciplinary research. Though, the involvement with external stakeholders was identified and therefore the presence of not only fellow researchers but also actors like politicians and organisations and eventually the wider society through rising interests in science. This implies knowledge that is applied within society, which would make research linked to SDG3 rather interdisciplinary, despite the fact that disciplines are not working together that much. The importance of making the arena wider for Whitley's framework is strengthened by the findings from research addressing SDG13, which is characterised by its interdisciplinary approach. According to the current understanding of Whitley's framework, the degree of mutual dependence was lower. Though the findings show that the outcomes of research within a specific discipline does not necessarily depend on findings within that specialised field, but also on perspectives from other disciplines and organisations. This implies that mutual dependence expands from dependence on scientists within a specialised field towards scientists from other disciplines, and ultimately external stakeholders. Regarding task uncertainty, this implies that research techniques, interpretations, research priorities and the significance of these priorities are taken into account by the different fields that work towards a certain goal. In order for Whitley's framework to work on fields involved with interdisciplinary research, it should be taken into account that looking at single scientific fields is not enough, and that even external stakeholders could have an influence on the organisational structure of scientific field.

Regarding opening up knowledge systems, the aspects of Open Science were analysed to see to which degree it could improve the current knowledge system that was identified in the credibility cycle. Some aspects of Open Science seem applicable to the current knowledge systems. The main findings of Open Access and Open Data were that while it takes more time to prepare data in order to become available, it eventually has the possibility to be easily accessed by relevant actors. It was unclear from the theory if Open Access and Open Data would result in faster research. The findings however imply that actors using that data are not bound to produce the data themselves, as they are able to acquire data from open sources. When you look at the complete picture, more research can be done in less time by a wider variety of stakeholders, increasing scientific efficiency. In turn, this implies more available knowledge and wider distribution of knowledge, increasing the chance of recognizing and overcoming environmental- and social local problems. The concept of Preregistrations and Registered reports could also have a beneficial influence on opening up knowledge systems, as it requires researchers to become more transparent and detailed in their research processes, spending more time on reliable research that easily can be reproduced by other researchers, increasing the overall efficiency.
Regarding recognition and rewards, the University of Utrecht already implemented the Open Science programme on the University of Utrecht shifting away from counting publications and citations, as is the NWO and European organisations who are not accepting proposals that mention publications and citations. It implies that organisations are searching for other options to recognize and reward researchers, instead of relying on quantitative bibliometrics.

A couple of aspects of Open Science imply that further experimentations and standardisation are needed in order for them to be applied to the current system of knowledge production. Regarding Open Peer Review, the findings from the credibility cycle were strengthened by the findings from the interviewees about Open Science. Signed peer review has its strengths, but it does not have the ability to outcompete the traditional methods of peer reviewing yet. Open Participation is for now out of question, as experiments led to a low number of participants and improper comments. It remains hard to choose the preferred method. With Citizen Science, the findings do support the theory of opening up knowledge systems by involving civil society and the industry. And while it increases public engagement, it takes a lot of people and time to set up proper research that leads to usable data.

There is also an aspect which would not work in the current system of knowledge production. The findings do not support the theory of altmetrics being used in assessments. Altmetrics are just like traditional metrics based on numbers and timing. This implies that it does not change the quality of the assessment, but rather the criteria. Assessments are becoming more focused on narratives, and using traditional metrics is enough to complement these narratives.

Limitations

This section will outline the limitations that are encountered that can be linked to the reliability and validity of this research.

One of the limitations regarding the validity of the research, is the limited scope of the research. This research focused on research that was mainly conducted on the University of Utrecht. Therefore, that means that the findings are mainly extracted from researchers that are influenced by the institutional mechanisms that are integrated in the knowledge production system of this university. Experiences of researchers from other universities, inside or outside this country, can alter due to different institutional mechanisms. For example, the University of Utrecht already focuses on Open Science, and therefore the aspects of this phenomenon are already partly implemented within the institutional mechanisms. This means that the university has different procedures for example with impact assessments. Besides, this research takes research linked to two SDGs into account, while there are 15 other SDGs including research that is affected by different institutional mechanisms. This research is therefore not representative for all of the SDGs and generalising the findings is therefore out of question. Though, it still adds value in a sense that it gives a contextualised understanding on the organisational structure of the system of knowledge production. Further research on the institutional mechanisms of knowledge production linked to different SDGs in different contexts would therefore be valuable as well.

Another limitation regarding validity is the findings on Whitley's framework. Instead of looking at one specific scientific field, this research focuses on multiple disciplines that are linked to an SDG when looking at the concepts of mutual dependence and task uncertainty. Findings from people of different disciplines could therefore give different views on the concepts, which could affect the representation of the findings. Though, including researchers from every discipline linked to both SDGs would take much more time in order to realise and while the researchers came from different disciplines, most of the researchers that were linked to SDG13 were active in the same department. The results from the researchers linked to SDG3 were also similar.

During the research, the theory of opening up knowledge systems was discussed and this resulted in the main focus on the theory of Open Science. While there are several aspects of Open Science that could be helpful for the transformation of the knowledge system, it does not cover all of the available possibilities in order to open up knowledge systems. Therefore, the research is only limited to the described aspects of Open Science. An example is public engagement, which is an important factor for opening up knowledge system and the shift towards Mode 2 knowledge. Public engagement was mainly looked at through Citizen Science, but the results on this were quite small.

Conclusion

This research took a closer look at research on SDG3 and SDG13 developed mainly within the Utrecht University and the associated institutional mechanisms with the theory of the credibility cycle, which focuses on six interrelated areas that are part of knowledge production. The institutional theory and section on innovation policies helped to understand the trajectories and development of the current knowledge systems that determine how knowledge is produced, transferred and used. This eventually formed an institutional environment, which ultimately influences the organisational structures of scientific fields. Research in scientific fields do have different organisational structures, and these differences were identified through the use of Whitley's framework.

Lastly, the theory of opening up knowledge systems was applied to see the possibilities of organisational changes within the knowledge systems, with the aim to increase openness that will . Based on the results and answers on the sub questions that were found in the results section, this research will answer the main research question presented in the introduction:

What are the institutional mechanisms that facilitate knowledge production addressing SDG's and what are the corresponding bottlenecks that create a gap between knowledge and action?

Several institutional mechanisms were identified. It seems that the production of knowledge is in a transitional phase, in which certain aspects of trans- and interdisciplinary research and the connection with civil society, the industry and polity is becoming more prominent. Funding is mostly governed by public funding agencies. Researchers and consortiums at the UU still experience high competition for public research funds against researchers outside of their sphere, but funding agencies are moving towards a system in which the amount of publications and citations become less important. This could result in lower pressure to produce a lot of papers, giving researchers the opportunity to create more robust knowledge and the time to spend more time applying it. Staff is hired on the basis of narratives and motivation, and while research in SDG3 is mostly conducted within disciplines, the teams do get more diverse in terms of academic backgrounds, while teams in SDG13 even consist of multiple disciplines. Regarding the mechanisms of data and arguments, it seems that there are already a lot of aspects that are changing for the good, paywalls are almost gone within the Netherlands, since the government is paying for it, and data is increasingly being shared in open repositories such as Yoda and Git. Both increase the accessibility and therefore the opportunity of co-production, in which external stakeholders are involved. Peer reviewing is mostly ruled by the journals. Methods have not changed much, and experiments with more open methods did not work to expectations. Therefore, peer reviewing will continue to be governed by institutes. Recognition and rewards are mostly governed by the universities and funding agencies. There is a significant shift in the system of knowledge production in which quantitative bibliometrics are not relevant anymore and where the focus is rather on narratives since organisations like the UU, the NWO and other European funding agencies don't want the inclusion of publication- and citations lists anymore. It should be noted that this differs between organisations, and that researchers that were educated with focus on Open Science could have harder time with research jobs that are more traditionally focused.

Though, a couple of recommendations can be made from the findings of this research. While the organisations seem to be changing its beliefs, values and norms, real structural changes in organisational structures are recommended to become priority. Funding agencies within the Netherlands like the NWO, for example, could start focusing more on the integration of grants for interdisciplinary research. And since publications are less relevant for the application of proposals, the lower pressure on researchers to produce as many papers as possible, could be a possibility for researchers to put more effort on the application of knowledge, and not only the production of more papers. Less proposals also means more acceptances, making it possible for a wider variety of researchers to conduct valuable knowledge. This could be stimulated by universities, by indicating that quality is better than quantity. It would also lower the pressure on peer reviewers, giving reviewers more time and less papers to review. This could therefore also increase the robustness of research quality assessments. Open participation in this situation could another chance, when reviewers have more time on their hands to participate in this process.

Another recommendation concerns the improvement of data sharing. It is recommended for organisations to start the standardisation of data sharing processes. This is already done at UU in the form of, for example, open repositories. But proper procedures for the preparation of sharing data could be beneficial for the efficiency of work and help new users to overcome the barrier. Manuals and guides could be created which make the process for new users a lot easier. And while data is mainly accessible for free within the Netherlands, this is not necessarily the case in other countries. Since the environmental and social challenges are a global problem, it would be recommended for the richer countries to actively help poorer countries with the accessibility and visibility of knowledge. In that way, the engagement of the wider society could increase also in those parts of the world, which in turn leads to more openness worldwide.

And where the recognition is shifting away from quantitative bibliometrics, researchers still question the best way to measure societal impact. The theory also showed that the complex assessments of societal impact are abundant. A recommendation therefore would be to develop an assessment that truly measures indications of societal impact. The importance of applied of knowledge would therefore be more recognized and therefore rewarded, setting a movement in motion in which applied knowledge would increase.

The implementation of changes that come with philosophies like Open Science towards the application of knowledge and the openness towards societal stakeholders should not be nullified. Paradigms need time to shift, and this eventually begins with making changes. Organisational changes within organisational structures like the implementation of an Open Science programme could be the start of a change in institutional environments that in turn could be imitated by other organisations. This eventually cause a shift towards a system in which knowledge is increasingly being applied in arena consists of researchers and the wider society.

Appendix

Appendix A. Interview Guide 1.

High-level topic	Questions	Answered?
General	Would you like to introduce yourself a bit? Would you say that you contribute to knowledge development for sustainability?	☐ ☐
Mechanisms of emergence and development of research topic	Do you experience competition from other researchers when developing new research? Do you interact with external stakeholders (decision-makers, etc.) in your projects? If so, how (do they have a more passive or active role?) and when (i.e. from the get-go, at a later stage, …)? In your experience, in what ways can policy makers influence the emergence of a new research topic? Do you think there is a difference in that regard between government levels (local vs. regional vs national)?	☐ ☐ ☐
Funding of research	What do you consider that are the main barriers in getting funds to undertake research in sustainability? In what extent do you consider these barriers are different to any other research field? To what extent is your research based on private or public funding? What is your experience getting private investment? What is your most significant funding source?	☐ ☐ ☐
Interaction with other communities	What are the practices behind data sharing in your field, and how do you participate in this exchange? How do you think this could be improved? What are the main barriers when dispersing knowledge and other resources across multiple organisations (government entities, firms and other universities)	☐ ☐

	Do you create your own data or are you dependent on data from other sources? (e.g. data sharing) Do you feel that the data that is being produced is influenced by the research agenda of funding sources? And by societal stakeholders that are calling for particular scientific knowledge?	☐ ☐
Mutual Dependence	Is the development of your research dependent on other scientific fields when it comes to ideas, procedures or results? And is research in other scientific fields dependent on your findings?	☐
Staff and equipment	In your team/department, what are the procedures for selecting candidates for new research? Do you think there are has been any shifts within these procedures recently? Are teams diverse in terms of disciplines? (multidisciplinary, transdisciplinary)	☐ ☐
Arguments & Articles	Do you know what Open peer review is? If yes, did you ever work with it? Does your research tend to end up behind pay walls, or does it tend to be open access?	☐ ☐
Recognition	In your field, and based on your experience, what are the sources of recognition? (e.g. amount of fundings received for next research, making a visible change in society, being published) Which of those are more prevalent? Do you think there has been a shift in the sources of recognition? *For example, securing funding has become something more recognized (in terms of contributing to solidify an academic career) than before?*	☐ ☐
Task uncertainty	Do you think the methods used for sustainability science are adequate for problem-solving, are the used concepts clear and agreed upon the scientific community? In your experience, have you encountered problems that resist solution (anomalies) when developing new research for sustainable pathways?	☐ ☐

Policy intervention	How do you think about policy interventions to solve problems/make an impact? Do you encounter policies that actually make it harder to resolve problems/make an impact? How do you deal with certain policies?	☐ ☐ ☐
Human-environment interactions	What are the human-environment interactions that you study? How do you think that this understanding can generate different sustainability pathways? Do you think there are solutions for sustainable development that have led to negative consequences for human-environment interactions? If so, how do you deal with this knowledge? In what ways can solutions for sustainable development be adapted to these human-environment interactions?	☐ ☐ ☐

Appendix B.

High-level topic	Questions	Answered?
General	Who are you , and what it is that you do? And in what way do you participate in Open Science? Why is Open Science needed? What is in your opinion wrong with the traditional system of science? What are the major challenges for Open Science? Do you think these need time to be solved?	☐ ☐ ☐
Money	The traditional system of science is among other things characterized by the hypercompetition between researchers. Do you think Open Science could counter this hypercompetition? And how?	☐
Staff and Equipment	Do you think that complementing or replacing the traditional bibliometrics with altmetrics will result in a better representation of research impact? And in what way? What do you consider challenges for altmetrics? (do you think lack of robustness also plays a role?)	☐ ☐
Data	How do you think Open Science will contribute to limited data sharing which comes in the form of paywalls, and for example privacy issues? Did open data improve the democratization of scientific knowledge (more access, participation of wider community, better understandable). Does Open Data contribute to societal needs as local problems become more visible? (and for fixing things like tragedy of the anticommons)	☐ ☐ ☐
Arguments & Articles	What do you think about Open Peer Review? Could it replace the traditional peer review, or complement, or is it not adequate enough?	☐

	There have been some recent developments of scientific fraud and irreproducible research. Do you think that Open Science can contribute to the reproducibility of research? Would you say that Open Science research takes a longer time to produce?	☐ ☐
Recognition	A lot of knowledge within our academic systems is created, yet the minority of this is actually applied to society. Do you think the form of Open Science can create a bigger socio-economic impact? And if so, how? Citizen Science is a way to include civil society more within scientific knowledge development. Do you think this has been effective in any way?	☐ ☐
SDGs	Are you familiar with the Sustainable Development Goals? Are you involved with them in any particular way? An important factor for the creation of sustainable pathways is interdisciplinarity or transdisciplinarity, how do you think Open Science can contribute to these? Not all SDGs are on track to reach their targets for 2030. Do you think Open Science can help accelerate progressions to reach these targets? Do you think Open Science is capable of creating the sustainable pathways that are currently missing? Optional: How do you think Open Science will develop in the future?	☐ ☐ ☐ ☐

Appendix C

SDG Research Credibility Cycle. Consent form dd-mm-yyyy

I have read and understood the study information sheet dated dd-mm-yyyy, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.

I voluntarily agree to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without any questions of any kind.

I understand that taking part in the study involves being interviewed by one of the researchers about my research topics that are related to the SDGs. The interview will focus on the different areas of the credibility cycle that occur in the development of my SDG-related research, as well as the collaboration with others and the barriers and opportunities of the system of knowledge production.

I agree to my interview being audio-recorded and transcribed as text. The audio-recording will be deleted after transcription.

I understand that the information I provide will be used for a final report, as well as a scientific publication and presentation.

I understand that information I give in this research will be treated confidential. I understand that personal information collected about me that can identify me, such as my name, will not be shared beyond the study team.

I agree that my information can be quoted in research output. I understand that in any report on the results of this research my identity will remain anonymous.

I understand that the signed forms, transcripts and audio files will be safely stored and only opened by the research team.

I understand that I can request the transcriptions or audio files of my interviews at all times.

I understand that I can approach the researchers at all times to seek further clarification and information.

Signature of research participant

		dd-mm-yyyy
Name of participant	Signature	Date

Signature of researcher

		dd-mm-yyyy
Name of researcher	Signature	Date

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