



Towards an Open Future

ITC's Strategic Plan for Open Science 2021 - 2025

ITC

Executive Summary

Open Science (OS) is an umbrella term comprising principles to increase the transparency of research. Besides Open Access to scientific articles, these principles contain public availability of reusable methods (e.g., code and tools), data, and educational materials. This document outlines a plan to achieve the transition towards OS. *ITC's Strategic Plan for OS 2021-2025 - Towards an Open Future* contains five initiatives:

1. **OS at ITC** aims to provide guidelines and OS capacity building for ITC researchers and students to address the obstacles they encounter when doing OS.
2. **The ITC Knowledge Hub** will provide services and tools to access, create, and publish open research, including scientific results based on qualitative/quantitative analyses using computational workflows.
3. **Open Educational Resources** will be addressed by exploring options to realise Open Educational Resources at ITC and providing lecturers with guidelines and support to create them.
4. **The OS Community Twente** serves as an inter-disciplinary, bottom-up community to promote, learn, share, and discuss OS practices.
5. **Research & Funding** aims to address challenges in OS through innovative developments and user studies. A further output is to generate funding to realise the ambitious aims presented in the plan.

For a successful OS transition, the initiatives aim to address the *Rewards & Recognition* system, valorise *Sharing & Collaboration*, develop *OS Knowledge & Skills*, and foster *Cultural change & Societal impact*.

Statement of Support (Draft)

Our departments endorse this OS plan and will take, where possible, the following actions to support the transition to Open Science (OS) at ITC:

- Integrate and establish OS practices in our way of working
- Support the five initiatives listed in this document by
 - Participating in the survey
 - Contributing (where possible) to the ITC Knowledge Hub by providing materials in the form of (existing or in progress) publications, data, and code
 - Discussing opportunities regarding open educational resources
 - Joining the OS Community Twente
 - Use the support offered to incorporate OS principles in grant proposals and papers
- Consider OS practices in evaluation, hiring, and promotion, thereby adhering to the [Room for everyone's talent](#) strategy, the [San Francisco Declaration on Research Assessment](#) (DORA), and the [Hong Kong Principles](#).

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Organisation

The OS plan will be managed and coordinated by the Open Science Officer under the supervision of a steering committee and a user committee. The steering committee currently consists of the following three ITC staff members

- Drs. Marga T. Koelen (or Research support officer), Prof. Dr. Andy Nelson, Prof. Dr. Raúl Zurita-Milla who provide technical and scientific advice, and the portfolio holder Operational Management of the faculty, Drs. David Korringa, who advises regarding logistics and HR-related issues. The tasks are to
- guide the strategic vision/plan for Open Science in the ITC and contribute to realizing it
- report twice a year to the Faculty Board about results and upcoming activities
- together with the Open Science officer, request advice and approvals from relevant faculty and university bodies and committees

The User Committee consists of one representative from each of the scientific departments of the faculty and a representative from the ITC supporting department(s):

- Dr. Ling Chang, Andre Da Silva Mano, MSc, Dr. Fiorenza Deon, Ralph Mettinkhof, Dr. Frank O. Ostermann, Dr. Ing. Roelof Rietbroek, Valentijn Venus, MSc

The OS Officer will chair this committee. The tasks of the User Committee are to

- review, contribute and approve the vision and annual plans for embedding OS at ITC
- be a sounding board for the steering committee and the OS officer, which amongst other tasks signals essential OS-related developments/needs inside and outside the faculty
- actively communicate OS-related activities and procedures to staff in their respective departments.

Author Contributions

The author contributions are based on the [CRediT taxonomy](#) and tenzing (Holcombe et al., 2020).

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Motivation

Open Science (OS) comprises a set of practices to increase the transparency of research. These practices go beyond well-known principles, such as Open Access and Open Data. Just as important are the publication and use of open-source software and infrastructure, public access to reusable educational resources, and society's engagement in the research process (UNESCO, 2021).

There is an intrinsic and extrinsic motivation for ITC to do OS. The intrinsic motivation comes from ITC's strategic goals, i.e., reducing the knowledge divide among countries and tackling global challenges, such as climate change, natural hazards, urbanisation, digitisation, and pandemics (ITC, 2021). These goals are interconnected with the aims of OS, i.e., improving research quality, accelerating scientific progress, and counteracting society's tendency to deny scientific findings (Haslinger, 2019). Consequently, OS valorises research output to society's benefit and is a key requirement to achieve the ambitions set by ITC.

Besides, ITC also has an extrinsic motivation. For a couple of years already, OS is on the rise and driven by several high-level organisations (e.g., [UNESCO](#), [EU](#), [GEO](#)), funding programmes ([NWO](#), [Horizon Europe](#), [cOAlition S's Plan S](#)), projects ([Open Research Europe](#), [European Open Science Cloud](#)) and bottom-up initiatives ([OS Communities](#)). Also, the University of Twente (UT) considered OS practices in [Shaping2030](#) – “*UT's mission, vision, and strategy to increase the societal impact of research as well as diversity and inclusion in science*” (University of Twente, 2019). All these initiatives have significant implications on the current scientific landscape and the involved stakeholders.

The geosciences have specific challenges, such as big geodata and the plethora of data sources, e.g., satellites, social media, and mobile devices (Boeing and Arribas-Bel, 2021). ITC, as the Faculty of Geoinformation Science and Earth Observation, can play a leading role by promoting and realising OS in the geosciences (ITC, 2021). The first step is *ITC's Strategic Plan for Open Science 2021-2025 - Towards an Open Future*. It aims to help ITC realise the transition to OS and create a research environment that values sharing instead of competition. The plan targets ITC, but other research units might use it as a blueprint.

OS is often associated with extra costs and effort. Hence, it is crucial to point out the benefits and incentives of OS (McKiernan et al., 2016). OS can help researchers make their outputs widely available to advance the scientific field. By publishing code and data, researchers can increase the impact on society since others can reuse the materials in other contexts. This increased reach can also lead to new collaborations to further develop the code. OS practitioners might have better chances to find an academic position since OS principles are increasingly considered in [job calls](#). A further benefit is that OS is less prone to be flawed, thus protecting the researchers' reputation (Markowitz, 2015). Also, accessible code can help reviewers understand what researchers mean, thereby reducing delay and review duration.

Besides these benefits, the initiatives in this plan will also consider challenges that come with OS, which is crucial to increase researchers' acceptance of OS. For example, everyone can read Open Access (OA) articles for free. However, not all researchers from the majority world can pay article processing charges (APCs) (Nobes and Harris, 2019). Fortunately, OA Diamond journals allow publishing OA without paying APC (Bosman et al., 2021). Infrastructure is often unavailable in the majority world (Onie, 2020), yet more and more organisations fund or support OS infrastructures. Being able to find errors in an analysis is a benefit for science and society (see Herndon et al., 2014) but also a concern of scientists. We need a research culture where unintentional errors do not damage the researcher's reputation, particularly to protect early-career researchers (Allen and Mehler, 2019). Open Peer Review can make the evaluation process transparent, but disclosing identities can cause bias based on gender, affiliation, and career stage (Tennant and Ross-Hellauer, 2020). Many OS principles focus on quantitative research to the disadvantage of qualitative researchers, where most are women (Plowman and Smith, 2011). Finally, the fear of becoming scooped by competitors (Konkol et al., 2018) can be mitigated through data embargos.

While there are solutions that address researchers' concerns, we recognise some remaining doubts associated with OS. The initiatives in this plan will provide space for raising these concerns and discussing solutions. We also recognise legitimate reasons to restrict data access, including, e.g., issues relating to privacy, national security, law enforcement, confidentiality, and intellectual property. Moreover, by requiring Open Data, people might become mere suppliers of raw data analysed by others to produce new knowledge (Traynor et al., 2019). In such cases, the *FAIR* Principles (Wilkinson et al., 2016) might still be applicable, i.e., storing the (meta)data not necessarily in an open but findable, accessible, interoperable, and reusable way. Also, the *CARE* Principles (Collective Benefit, Authority of Control, Responsibility, Ethics) can ensure responsible work with sensitive data (Carroll et al., 2020).

The initiatives in this plan will take these challenges and concerns into account, e.g., through *situated openness*, "a way of doing research that assumes knowledge production and dissemination is situated within particular historical, political, socio-cultural, and legal relations" (Traynor et al., 2019). The goal is to create a mind shift where openness is the default and restricted only in justified cases (see above). Thus, the guiding principle is "as open as possible, as closed as necessary" (European Commission, 2016).

The Bigger Picture

Figure 1 depicts the structure of ITC's Strategic Plan for Open Science 2021-2025. The plan consists of five interrelated initiatives: *OS at ITC*, *ITC Knowledge Hub*, *Open Educational Resources*, *OS Community Twente*, and *Research & Funding*. Each initiative will result in deliverables for researchers, lecturers, PhD candidates, students, and the general public. These deliverables will include software, training materials, policies, community events, and new solutions to address OS issues. We will release all outputs following the OS principles. The following sections briefly describe each initiative. The goals of the initiatives are to address the *Rewards & Recognition* system, valorise *Sharing & Collaboration*, develop *OS Knowledge & Skills*, and foster *Cultural change & Societal impact*.

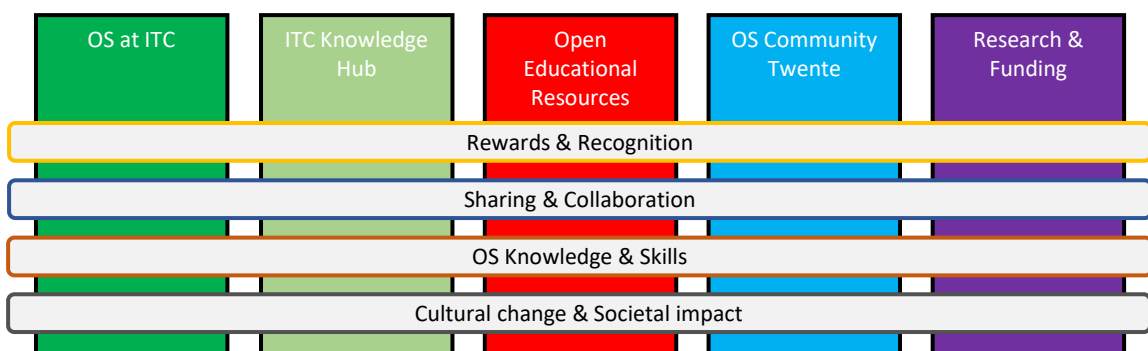


Figure 1: The five initiatives and cross-cutting goals composing the strategic plan

Rewards & Recognition

The current evaluation system for research and researchers can pave the way for closed and questionable research practices by focusing on *perverse incentives* (Bouter, 2020). These incentives often come in the form of quantitative metrics, e.g., the h-index or Journal Impact Factor. The [Strategy and Evaluation Protocol](#) states: “*The research unit should take into account that it is not allowed to use the Journal Impact Factor in a SEP evaluation. [...] The use of the h-index is advised against.*” The successful transition towards OS requires a rewards and recognition system that values open practices in science, education, and society (see [Room for everyone's talent](#)). The initiatives will provide recommendations for such an evaluation system. We will consider evaluating researchers and research separately and integrating alternative frameworks, e.g., the [San Francisco Declaration of Research Assessment](#) (DORA). Still, the rewards and recognition system is a global issue. A new internal evaluation system that adheres to OS principles needs to consider that ITC's graduated PhD candidates and staff may need or have aspirations to work elsewhere and be evaluated by traditional metrics.

Sharing & Collaboration

The lack of incentives negatively impacts sharing and collaboration activities in research and education. The initiatives will pay attention to issues that might come with sharing and collaboration, e.g., intellectual property, copyright, licenses, and cooperation between researchers and non-academic partners, e.g., the private sector. We will address them by developing incentives and recommendations.

OS Knowledge & Skills

Researchers and lecturers aiming to open up their work need to develop knowledge and skills to realise OS principles. The initiatives will result in teaching materials, considering the researchers' and lecturers' individual backgrounds, career stages, and research processes. We will develop training materials (e.g., webinars) to gain these skills and design tools that help researchers adhere to OS principles. Due to the importance of these skills beyond OS, this form of capacity building can be seamlessly integrated with the researchers' career development. For example, using versioning tools is a helpful OS practice and an essential skill for everyone's career.

Cultural change & Societal impact

Not all issues can be tackled using technical tools alone but require a mind shift to build an OS culture (Markowitz, 2015). An essential step to achieving that culture is raising awareness for OS, for example, by providing space to raise concerns and discuss solutions. Ideally, OS practices are not perceived as extra effort but as the default way of doing science and teaching to increase the societal impact of the own work. Nevertheless, the activities to create a mind shift need to consider different paths for researchers and lecturers to become more open, considering their individual backgrounds and circumstances. Consequently, we will develop all solutions in a way that is not disruptive but interconnects seamlessly with the existing research workflows of the researchers and lecturers. Furthermore, we will provide OS services that provide clear incentives for researchers to become more open and ensure the validity and trustworthiness of science.

Open Science at ITC

The main goal of this initiative is to develop guidelines, recommendations, resources, and OS training to help ITC researchers realise OS principles. To accomplish this aim, we will use triangulation, including a questionnaire, semi-structured interviews, and a focus group discussion to gain a comprehensive picture of the degree to which researchers at ITC do OS, which obstacles exist, and in which topics they are interested. Furthermore, the study will help to achieve the cross-cutting aims as follows:

- *Rewards & Recognition*: The study will help reveal current shortcomings in the rewards and recognition system. It will provide insights regarding how a research environment might look like that supports OS. Moreover, the study will deliver input to revise the current tenure track policies. The findings will be reconciled with the outcomes of the expert group [Shaping Individuals and Teams](#).
- *Sharing & Collaboration*: The study will reveal cultural and technical obstacles that prevent researchers from sharing and collaborating. The findings will serve as input for policies and guidelines.
- *OS Knowledge & Skills*: The study will reveal which OS skills and knowledge researchers are missing. We will develop OS training (e.g., webinars, guidelines, hands-on tutorials), considering the researchers' individual backgrounds, career stages, and research processes.
- *Cultural change & Societal impact*: The study will help researchers reflect their current research workflow resulting in a stepwise cultural change and increased societal impact.

Key deliverables:

- A report summarizing obstacles relating to OS.
- OS capacity building through training addressing the obstacles of ITC staff and students via presentations, webinars, and a lecture “Introduction to OS”, including how OS principles transcend research. Besides, we will also initiate a dialogue with alumni to understand the OS-related opportunities and challenges in their countries.
- An OS statement indicating that ITC provides a research environment that endorses OS.
- Guidelines indicating which OS practices are relevant at which stage of the research process, considering that not all materials need to be open from the beginning.
- Recommendations to address intellectual property, copyright, and licensing.
- Recommendations to clarify data sharing among project partners, e.g., during the cooperation between researchers and companies (in cooperation with UT's legal office).
- Recommendations to evaluate researchers and research output based on qualitative metrics that consider OS.
- Establish a connection to the [Geo Citizen Science \(CS\) Hub](#), where researchers can receive advice on how to integrate Geo CS in their projects.

Questionnaire

The questionnaire addresses academic staff, including researchers (i.e., postdocs, assistant/associate/full professors) and PhD candidates (employed and with scholarship). Lecturers and support staff will be investigated in follow-up questionnaires at a later time. The questionnaire aims to obtain a quick and comprehensive overview of the topics around OS in which the academic staff at ITC is interested. Moreover, the survey will help identify the obstacles that prevent them from doing OS and needs regarding support for OS. The answers will help determine which knowledge gaps need to be addressed through presentations, webinars, or workshops. The survey results will reveal what kind of policies and guidelines are required to address the barriers and which obstacles need consideration during the implementation of the ITC-KH. The questions of the survey are listed below. See *Appendix B* for the complete questions and response options.

- 1. From which department are you?**
- 2. Which position do you have?**
- 3. How many years have you been working at ITC?**
- 4. Please indicate your degree of agreement with the following statements: I would like to learn more about...**
- 5. Which obstacles prevent you from doing OS?**
- 6. At which stage of the research process do you need support regarding OS?**
- 7. Do you have any comments or questions in the context of OS?**

Semi-structured interviews

While questionnaires provide a quick overview of a particular topic, interviews allow more detailed responses and asking follow-up questions. The interviews will be conducted with academic staff, including researchers (i.e., postdocs, assistant/associate/full professors) and PhD candidates (employed and with scholarship) and focus on the research process, including data collection, data analysis, submission, peer review, and publication. The guiding questions are listed below. See *Appendix C* for the complete interview.

1. Introduction

- What is your understanding of OS?

2. Data collection

- Do you usually produce data for your research?
- Do you usually work with data produced by others?

3. Data analysis

- How do you usually analyse your data?
- Do you produce software to analyse your data?
- Where do you store the data analysis?

4. Before submission

- Have you published any of your research materials before submitting the paper to peer review?
- According to what criteria do you decide in which journal you would like to publish?

5. Peer Review

- Have you ever made your data available for reviewers?
- Have you ever made the data analysis available for reviewers?
- If you review a paper, do you appreciate having access to data and source code?

6. Publication

If the interviewee has not published a paper yet, ask for plans regarding publishing.

- Have you ever published the data alongside the article?
- Have you ever published the data analysis alongside the article?

7. Creating an OS environment

- How does a research environment look like that supports OS?
- Which criteria need to be met to create an environment that stimulates OS?
- How can supervisors and department heads contribute to an environment that encourages OS?

Focus group discussion

OS in general and open reproducible research in particular currently focus strongly on quantitative research. There are several concepts and tools researchers can use to open up their quantitative analysis. For privacy and ethical reasons, OS principles such as Open Data and Open Methods are perceived as less applicable and relevant for qualitative research methods, such as interviews. Even if the transcripts and the Grounded theory analysis were available, there is still tension concerning reproducibility due to the subjectivity of the analyst's interpretations. Consequently, qualitative researchers cannot fully benefit from the incentives OS provides, such as new evaluation approaches that consider transparency in tenure, hiring, and promotion (see, for example, [DORA](#)). Hence, an essential requirement for the transition to OS is to transform how qualitative research is published. To achieve that, we will organise a focus group discussion with experts who collect and analyse qualitative data. The goals are as follows:

1. Identify how OS practices can be applied to qualitative data analyses
2. Design a workflow for authors to publish open, accessible, and verifiable qualitative data analyses
3. Help readers access and reuse qualitative data analyses

Aim 1: Identify OS practices

First, we investigate the role of OS principles in qualitative research. We will identify which OS values can increase the transparency and verifiability of the qualitative analysis. We aim to connect OS principles and ethical standards and check whether qualitative reproducibility is possible and meaningful, considering that the results rely on individuals' interpretations and the context in which the study took place. We will also investigate whether the notion of an executable research compendium (Nüst et al., 2017) can be applied to qualitative data and analyses. Besides, we will engage with UT experts in research integrity and ethical considerations (see [House of integrity](#) and the [Integrity policies at the UT](#)).

Aim 2: Create a workflow

By considering several open-source tools (e.g., [Taguette](#), [QCoder](#), [RQDA](#), [Amnesia](#)), we will design a workflow to increase the transparency of qualitative analyses. Such a workflow can be similar to [WORCS](#), a guide for reproducible research (Van Lissa et al., 2020). Similar to the Bindings concept for spatiotemporal data (Konkol et al., 2019), the workflow will allow creating analysis threads linking the paper with the data and analysis. Taking the example of a Grounded theory analysis and interview data, such fine-grained analysis threads could connect a specific paragraph in the article with the themes, categories, and transcript. Together with the focus group participants, we will work out application possibilities, benefits, and limitations.

Aim 3: Develop an interactive publication

A static research article is not suitable for making the analysis threads accessible for readers. The idea is to implement a prototype to demonstrate how an interactive publication can provide access to the analysis threads. For example, the paper can be augmented with mouse-over effects that trigger pop-ups showing which themes, categories, and statements in the transcript underlie the article's paragraph. Together with the participants, we will evaluate applicability, user experience, and acceptance.

Risks and Challenges

The main risk of the questionnaire, interviews, and focus group is a low number of participants. Support in terms of promotion through the User and Steering Committee might mitigate this risk. A further risk is linked to the pandemic because the focus group discussion is more effective when carried out in person. This risk might be mitigated by conducting the discussion virtually, postponing the meeting, or replacing the focus group with another series of interviews.

The ITC Knowledge Hub

This initiative aims to design, implement, and evaluate the *ITC Knowledge Hub* (ITC-KH). The ITC-KH will be a central place for authors to create and publish and for readers (including reviewers) to access open reproducible research (ORR). ORR refers to achieving the same results (e.g., figures, numbers) as reported in the paper using the same publicly accessible source code and data. In addition, the ITC-KH will implement the outcomes of the focus group to support open practices in qualitative research. Moreover, we will explore options to apply the ITC-KH in education, for example, to make students aware of OS principles or let them submit reproducible assignments that can be checked quickly by lecturers.

The ITC-KH will support publishing transparent, verifiable, and reusable research results at different stages of the research workflow by providing guidelines (cf. Nosek et al. 2015), [CODECHECK](#) services (Nüst and Eglen, 2021), [workflows](#) (cf. Van Lissa et al. 2020), [interactive papers](#) (cf. Lewis et al., 2018), and a variety of [reproducibility tools](#) (cf. Konkol et al. 2020), considering the individual needs of authors and readers. The target group primarily comprises researchers who analyse quantitative or qualitative data using computational methods. **Note:** A qualitative analysis can also be a computational workflow if software is involved. *Figure 2* provides an overview of the research cycle and options to make each step more open. A complete design of the concept is one of this initiative's output and based on the study investigating OS at ITC as well as the user-centred development process.

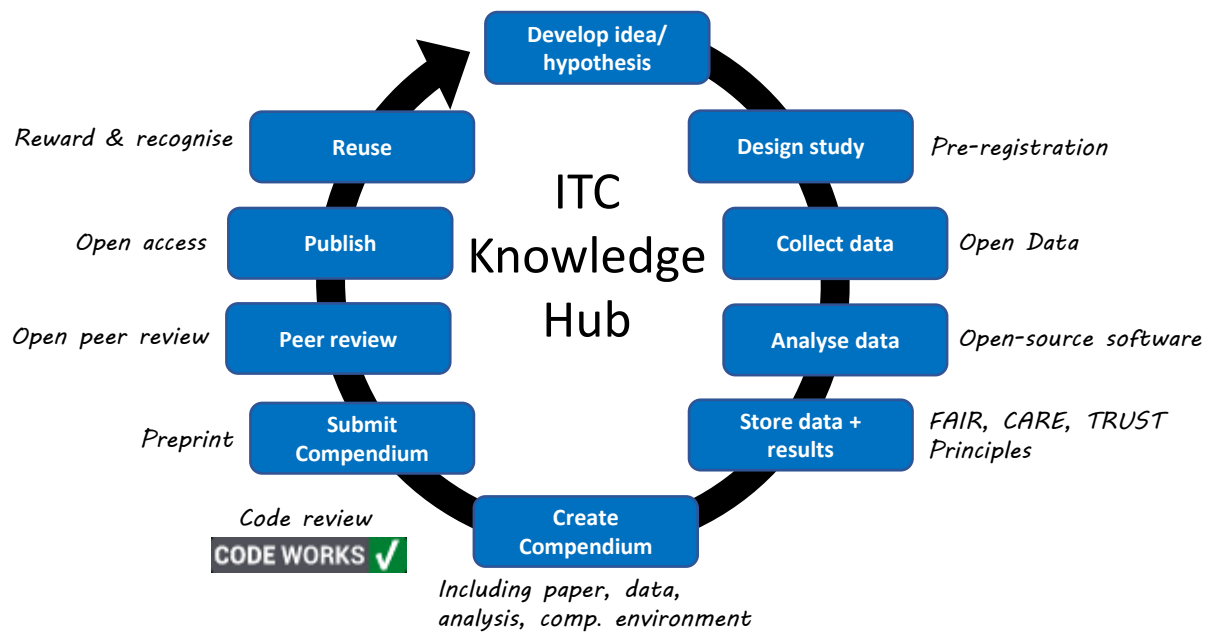


Figure 2: The research process augmented by OS practices

The ITC-KH could work as follows: For the initial phase, the ITC-KH provides guidance to publish the study design before data collection, a so-called *pre-registration*, which is still uncommon in the geosciences and thus optional. Also, it can suggest ways to consider OS from the beginning making it easier to open up research later. Then, the ITC-KH can suggest open-source software and open data formats as alternatives to proprietary tools. It can also provide the research environment for carrying out the data analysis. Next, it can inform about the [FAIR](#) (Wilkinson et al., 2016), [CARE](#) (Carroll et al., 2020), and [TRUST](#) (Lin et al., 2020) Principles for datasets and guide how to adhere to them. The ITC-KH will provide tools to deliver a *research compendium* (Nüst et al., 2017), containing all materials needed to reproduce the results, i.e., the scientific article, data, code, computational environment, and (e.g., spatiotemporal) metadata. A similar concept will be supported for qualitative analyses resulting from the focus group. Before submitting the compendium to a journal or as a preprint, the authors can request a [CODECHECK](#), a process for independent reproduction of computations underlying research. Based on the compendium, we will also explore options to create interactive scientific articles that provide the opportunity for readers to explore results interactively (Konkol et al., 2019).

The ITC-KH is like a *preprint server* (see, e.g., [EarthArXiv](#)), a way for authors to publish their findings before peer review. In contrast to such services, the ITC-KH considers the entire research process and shifts the focus from the article to the data and analysis. Like preprint servers, the ITC-KH might allow commenting on the research compendium (public review). Optionally, people can comment anonymously to avoid that people (particularly early career researchers) may be hesitant to criticise in fear of running into personal conflicts due to unequal distribution of power. Copernicus journals provide such a [hybrid approach](#).

It is crucial to ensure that the ITC-KH is connected to existing services. The ITC-KH should not be yet another platform to upload data and code. Instead, it should connect, e.g., to [DataVerse](#), [Dans Easy](#), and UT's [GitLab](#). The ITC-KH will build upon OS software, e.g., [Open Journal systems](#) (cf. [UT Students Journal of Biometrics and Comp. Vision](#)). Also, we will consider related work, e.g., the [GEO Knowledge Hub](#).

Moreover, we will build on top of the CRIB platform, which already provides a rich set of features (e.g., for handling big geo data, Jupyter Notebooks). The technical realisation will be done in cooperation with the [ITC Library](#), [Digital Competence Centre](#) (DCC), and [ICT Services & Archive](#) (LISA).

The initiative will contribute to achieving the cross-cutting goals in the following ways:

- *Rewards & Recognition*: The ITC-KH will make it possible to shift the attention from the scientific article to the data and analysis. This shift is consistent with an evaluation system that focuses on transparency (DORA) instead of traditional metrics (Journal Impact Factor, h-index).
- *Sharing & Collaboration*: Since the results in the ITC-KH are reproducible, others can easily reuse them, which might encourage collaboration instead of competition.
- *OS Knowledge & Skills*: The authors using the platform will learn how to make their research materials openly available and receive support at different stages of the research cycle.
- *Cultural change & Societal impact*: Since the entire workflow is transparent, reusable, and verifiable, the research results will also increase the societal impact and contribute to the cultural change.

Key deliverables:

- A review of related work, platforms, and initiatives (e.g., the [GEO Knowledge Hub](#)).
- Concept, implementation, and evaluation of the ITC-KH.
- The [CODECHECK](#) service for independent code review.
- Guidelines and workflows for using the ITC-KH.
- A series of webinars to demonstrate the functionalities of the ITC-KH to researchers, lecturers, and students.
- A service providing consulting for individuals while using the ITC-KH.
- A service for accessing, creating, and publishing interactive scientific articles.
- Use cases of already published articles to demonstrate the functionality.
- Use cases to demonstrate the applicability in education and usability for students.
- Success stories (or failures) about users applying OS practices in the form of blog posts or interviews.

Work plan

Table 1 provides an overview of the work plan for the survey and the ITC-KH. The first year is dedicated to carrying out and analysing the survey, including the questionnaire, semi-structured interviews, and the focus group discussion. In parallel, we will work on the design of the concept, which, together with the CRIB platform, will result in a first prototype of the ITC-KH. The prototype will be tested using already published scientific articles. In addition, users will be invited to contribute to the platform with their research compendia. The evaluation of the concept concerning challenges and applicability will be used to improve the ITC-KH in a second iteration. Similarly, the evaluations considering the perspective of the involved stakeholders (i.e., author, readers, reviewers, editors, lecturers, and students) will result in an improved ITC-KH.

Tasks	Year 1				Year 2				Year 3				Year 4				Year 5			
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
Questionnaire	■																			
Interviews	■	■																		
Focus group		■																		
Analysis			■	■																
Concept	■	■			■	■	■	■							■			■	■	
ITC-KH					■	■	■	■	■	■					■			■	■	
CRIB					■	■	■	■							■			■	■	
Impl. use cases										■	■	■								
Eval concept													■	■						
Eval authors																■	■			
Eval readers																■	■			
Eval reviewer																■	■			
Eval editor																■	■			
Eval lecturers																■	■			
Eval students																■	■			
Report																			■	

Table 1: Work plan of the ITC-KH. **Note:** Quarter 1 (Q1) starts on 1st June 2021.

Development process

The development process (see Figure 3) will follow a user-centred design starting with the survey. Furthermore, we will involve users through brief monthly update sessions. We will demonstrate new developments and provide information about design decisions. These sessions will be complemented by quarterly workshops in which users can try out the platform and suggest changes. The meetings will help us collect early feedback from users and identify potential use cases, for example, research work in progress. Furthermore, the users become acquainted with the overall idea and the platform, which eventually increases the chances for uptake and acceptance.

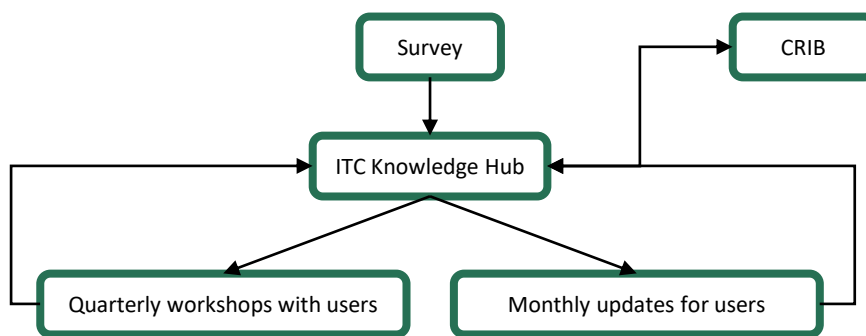


Figure 3: User-centred development process.

Challenges & Risks

The ITC-KH is progressive and ambitious. Consequently, there are some risks. Compared to the traditional publishing system, the ITC-KH might be perceived as a disruptive approach resulting in fewer submissions. Thus, it is essential to convey and support the incentives clearly, e.g., facilitated verifiability, higher reusability, increased research impact, and improved understandability. Allowing the re-publication of research published under an open license might mitigate this risk. Re-publishing existing papers and the underlying materials should be considered in any case since a knowledge hub should not be limited to upcoming articles. Moreover, these articles can be used as use cases to help undecided researchers obtain a concrete impression of the outcome.

A further issue is the required infrastructure. It remains unclear how much it costs to run the infrastructure composed of the preprint system, the CRIB platform, and other required tools. Unfortunately, similar projects rarely release data on this issue. Finally, reproducibility is still a technical challenge, particularly when it comes to *one-click reproducibility*. Providing a diverse set of existing tools for different use cases might mitigate this issue but also pose an issue regarding interoperability.

All in all, there are several challenges. However, the ITC-KH is a unique opportunity to take the next step towards OS and change the scientific landscape.

Open Educational Resources

Open Educational Resources (OER) are teaching materials released publicly and under an open license allowing free access, use, modification, and redistribution (Wiley et al. 2014). OER are an essential aspect of OS and play a crucial role in lifelong learning, educating the public, and distance learning. For these reasons, OER is becoming increasingly relevant for universities in general and ITC in particular since the capacity building is an essential pillar of ITC's mission. However, there are several open questions regarding how ITC positions itself to OER: Does ITC contribute to OER, and if so, how? How does ITC address lifelong learning and the education of the public considering OER? How could (distance) teaching at ITC based on OER look like in five years? What are potential business models around OER (e.g., open materials but closed recognition in the form of fees for certificates)?

The initiative will contribute to achieving the cross-cutting goals in the following ways:

- *Rewards & Recognition*: The guidelines and policies will suggest ways to give lecturers who publish OER rewards and recognition.
- *Sharing & Collaboration*: Sharing OER paves the way for collaborations, which will increase the quality of the materials.
- *OS Knowledge & Skills*: Free access to OER will reach more people and at the same time inform them about OS practices.

- *Cultural change & Societal impact*: OER will help reduce the knowledge divide, educate the public, and facilitate development for lifelong learners.

Key deliverables:

- A [report](#) to inform about the basic concepts, challenges, incentives, and business models around OER.
- Guidelines and policies for creating and publishing OER (e.g., how to deal with copyright content), considering ITC's business model.
- Training materials and hands-on support for scientific staff to create and publish OER (see, e.g., [FORRT](#)).
- Training materials and hands-on support to convert existing educational materials to OER (e.g., using open-source software and the ITC-KH).
- Establish a connection to the [Joint Education Partners](#) (JEP) "*with the aim of facilitating access to ITC education*".

Risks and Challenges

As in most universities, tuition fees are an essential pillar of ITC's business model. An often-mentioned (but unproved) concern is that offering OER might decrease the inflow of paying students (Janssen, 2012). It might be challenging to find a business model that conforms with the idea of OER *and* generates money. One possibility to mitigate this issue is to make a subset of the materials available and sell the course experience to students, for example, lecturers answering questions, giving feedback on submissions, supervising exams and theses, and delivering certificates. A further opportunity is to carry out a case study by publishing one particular course and investigating how this affects enrolments.

Another challenge is to update existing materials that make use of licensed software. It will take some effort to include OS principles and practices into the teaching materials. Clear guidelines and hands-on support can help to mitigate this issue.

Open Science Community Twente

The successful transition towards OS cannot be achieved by technical solutions alone. The goal of this initiative is to support cultural change by addressing researchers' questions and concerns. To achieve this goal, we will build up the OS Community Twente ([OSCT](#)). OSCT is an inter-disciplinary, bottom-up community to promote, learn, share, and discuss OS practices (Armeni, 2021). All researchers and students of varying expertise ranging from OS novices to experts can become community [members](#) and share their knowledge. Such communities exist in many universities. We will also take a leading role in the *International Network of Open Science Communities* (INOSC). This network connects all existing OSCs and aims to increase the number of OSCs, make local OSCs more successful, and shape OS policies and developments.

The initiative will contribute to achieving the cross-cutting goals in the following ways:

- *Rewards & Recognition*: The events organised by OSCT will inform about rewards and recognition, discuss existing alternatives, identify limitations of the traditional metrics (e.g., h-index), and recommend alternative metrics as part of a qualitative evaluation system (DORA).
- *Sharing & Collaboration*: The members will learn from others who successfully shared materials and directly experience the benefits of sharing and collaborating ("success stories").
- *OS Knowledge & Skills*: The members can suggest topics around OS. Based on their ideas, we will develop webinars, seminars, workshops, or similar events.

- *Cultural change & Societal impact*: The first-hand experiences and the continuous advent of OS topics will raise awareness for OS and a cultural change towards OS.

Key deliverables:

- A series of OS events to increase its visibility, e.g., webinars addressing different topics (see, e.g., [Open Science Kitchen](#)).
- A series of outputs to inform about current developments ([blog posts](#), [newsletter](#), [website](#)).
- Invite UT colleagues to join the community and share their ideas and concerns about the transition towards OS.
- Becoming a member of the INOSC steering committee.
- Provide support for the Student Initiative for Open Science ([SIOS Twente](#)).

Risks and Challenges

The main challenge is to reach people and create a community feeling. People might also be tired of online events. We will address this issue by highlighting what people can learn from these events. The attendees should understand that the OSCT is a central place for gaining OS knowledge and updates on recent OS developments. Furthermore, we will bring variety into the presentations using interactive tools (online surveys) and inviting OS experts as guest speakers. Another risk is not receiving enough attention from all faculties, which might limit the representativeness of the community. Furthermore, there might be an asymmetric engagement of supporting and scientific staff.

Research & Funding

The OS strategy proposed in this plan is not only about adhering to current OS requirements. We also aim to bring OS to the next level and address current shortcomings through innovative concepts and developments. We will consequently address several interesting research questions around the transparency of qualitative data, peer review, the understandability of reproducible research results, and the reusability of existing materials. The ITC-KH can provide the basis for answering these questions. The results can be used to improve the system continuously.

Doing research around OS and realizing the ambitious aims presented in this plan will require additional funding. Hence, we will write grant proposals to request resources for carrying out workshops (e.g., to invite speakers) and conduct studies (e.g., to pay participants). Moreover, we will apply for funding to share the responsibility among so-called [OS ambassadors](#) (see also European Open Science Cloud's [Ambassador programme](#)) to accomplish the transition towards OS. OS ambassadors foster OS conversations, raise awareness for OS, and facilitate the application of OS principles. For example, one OS ambassador could be allocated to each department and ensure that OS-related questions and concerns are addressed efficiently, and new developments are communicated early. Potential funding opportunities are, for example, [UT's incentive fund](#), ITC's ingenuity programme, [NWO's Open Science Fund](#), or [Wellcome's Open Research Fund](#).

The initiative will contribute to achieving the cross-cutting goals in the following ways:

- *Rewards & Recognition*: The findings will help improve the credit system and develop new incentives to do OS, for example, by providing means to create interactive papers.
- *Sharing & Collaboration*: Making computational research better understandable will increase its reusability and make sharing and collaboration more effective.
- *OS Knowledge & Skills*: Users will gain skills for making their research better understandable.
- *Cultural change & Societal impact*: Improving the reusability of research materials will increase the societal impact of research findings.

Key deliverables:

- Writing of grant proposals.
- Series of studies and scientific articles to answer the research questions.

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Note: Last access for all URLs in this document: 10th June 2021.

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Appendix A1

Changelog: Version 1.0 → 2.0

Chapter	Change
Executive summary	Added an executive summary
	Added definition of OS
Statement of Support	Added SoS addressing all departments
Motivation	Added benefits and limitations
	Make link to ITC's mission more explicit
	Added Coalition S's Plan S, EOSC, ORE
The Bigger Picture	Replace projects by initiatives
The Current State of OS at ITC	Specify academic staff
	Put response options and detailed questions in appendix.
	Complete response options of questionnaire
	Added easy first question to interview
	Removed questions on data preparation
	Added questions on research environment
	Added questions to let interviewees take perspective of reviewer
	Added concrete questions on obstacles
The ITC Knowledge Hub	Add more information in introduction
	Added definition for open reproducible research
	Added concept of a research compendium
	Added three scenarios how researchers can publish using the ITC-KH
	Specified target group of ITC-KH
	Modified timeline
	Showed potential connections to existing services at ITC and LISA
Added San Francisco Declaration on Research Assessment (DORA)	
Open Educational Resources	Added definition of OER
	Added open questions ITC needs to address
	Concretised contributions of this initiative
	Specified what course experience means
Open Science Community Twente	Linked to member list, activities, and INOSC
Research and Funding	Separated between support and doing research

Appendix A2

Changelog: Version 2.0 → 3.0

Chapter	Change
Title	Rename to ITC's Strategic Plan Open Science 2021-2025
Executive summary	Removed reproducibility to be more inclusive w.r.t. qualitative research
Motivation	Added urbanisation and digitisation as global challenges
	Added that other faculties can use the plan as a blueprint
	Replaced global south by majority world
	Added solutions to mitigate the limitations of OS
	Added CARE Principles and situated openness
	Added further OS limitations (errors and the researchers' career)
The Bigger Picture	Added paragraphs on the cross-cutting goals
OS at ITC	Rename "Current state of OS at ITC" to "OS at ITC"
	Added research evaluation and researchers' individual backgrounds
	Added more details to the list of key deliverables (guidelines etc.)
	Clarified that lecturers and support staff will be investigated in follow-up surveys
	Added further details (background, aims) to the design of the focus group study
The ITC Knowledge Hub	Removed journal scenario since many were sceptical (too disruptive, last ITC journal went to Elsevier, conflict of interest between editors already working for other journals – "competition for content")
	Included outcomes of focus group to also consider qual. research
	Added possibility to explore ITC-KH in education
	Added more details what ITC-KH contains (guidelines, services, workflows, tools)
	Added information on how the ITC-KH can support the research cycle
	Clarified difference to preprint servers
	Added Digital Competence Centre as cooperation partner
	Added more details to the list of key deliverables (services etc.)
	Added option of anonymous or attributed reviewer comments + reference to Copernicus journals
	Added possibility to connect to Dans Easy
Open Educational Resources	Moved aspects referring to providing teaching on OS to "current state..."
	Mentioned importance of tuition for ITC and corresponding reservation regarding OER
Open Science Community Twente	Clarified our contribution to INOSC
Research and Funding	Add that realisation will be achieved through funding to share responsibilities

Appendix A3

Changelog: Version 3.0 → 4.0

Chapter	Change
Executive summary	<ul style="list-style-type: none"> • Replaced programme by plan • Rephrased to access, create, and publish open research • Changed shortcoming to challenges
Organisation	<ul style="list-style-type: none"> • Added author contribution statement
Statement of support	<ul style="list-style-type: none"> • Added providing materials in the form of (existing and in progress) publications, data, and code • Rephrased to Use the support offered to incorporate OS principles in grant proposals and papers • Added Hong Kong Principles
Motivation	<ul style="list-style-type: none"> • remove citations as an OS incentive which not compliant with DORA • Changed indig. People to people • Simplified paragraph on errors in papers
The Bigger Picture	<ul style="list-style-type: none"> • fosters closed and questionable research practices --> can pave the way for • added staff having aspirations to work somewhere else • Added link to Strategy and evaluation protocol + quote • Change from guidelines to recommendations • Everyone working in a software company to everyone's career • Added "OS has the purpose to ensure validity and trustworthiness of science" • Remove hybrid evaluation system
OS at ITC	<ul style="list-style-type: none"> • Add that we contact alumni to learn from their experiences • Change to Geo Citizen Science Hub and link to website including introduction of the Ingenuity proposal • Remove that studying qualitative materials takes too much effort and add instead that the main issue the subjective interpretation which limits reproducibility • Replace interview data by qualitative data (more general) • replace grounded theory analysis by qualitative analysis • Add reference to integrity action plan • Removed blueprint from key deliverables • Remove hybrid evaluation --> we will go for qualitative instead • Replace guidelines by recommendations • Change companies to project partners • Added hands-on tutorials
The ITC Knowledge Hub	<ul style="list-style-type: none"> • Add note that also qualitative analyses can be computational workflows if software is involved • define pre-registration • Added success stories as key deliverable • Remove implementation of rewards and recognition system • Added review of related approaches as a key deliverable
Open Educational Resources	<ul style="list-style-type: none"> • Added business model example to introduction • Merged bullet points with key deliverables • Added connection to Joint Education Partners (JEP)
Open Science Community Twente	<ul style="list-style-type: none"> • Added further risks • Added SIOS Twente

Appendix B

Questionnaire

Thank you for participating in this study on the current state of Open Science at ITC. The questionnaire addresses academic staff, including **researchers** (postdocs, assistant/associate/full professors) and **Ph.D. candidates (employed and with scholarship)**. It aims at identifying your interests regarding Open Science and which obstacles prevent you from doing Open Science. It will take around 10 minutes to complete.

1. From which department are you?

- a. Earth Observation Science (EOS)
- b. Earth Systems Analysis (ESA)
- c. Geo-Information Processing (GIP)
- d. Natural Resources (NRS)
- e. Urban and Regional Planning and Geo-information Management (PGM)
- f. Water Resources (WRS)

2. Which position do you have?

- a. Postdoc
- b. Assistant professor
- c. Associate professor
- d. Full professor
- e. Ph.D. candidate employed at ITC
- f. Ph.D. candidate with a scholarship

3. How many years have you been working at ITC?

4. Please indicate your degree of agreement with the following statements: I would like to learn more about...

- a. Open Access and Preprints
- b. Preregistration and Registered Reports
- c. Open Data
- d. Open Code and Methods
- e. Open Reproducible Research
- f. Open-Source Software and Hardware
- g. Open Infrastructures (e.g., platforms and repositories)
- h. Open Peer Review
- i. Open Evaluation (e.g., San Francisco Declaration on Research Assessment, Room for everyone's talent)
- j. Open Educational Resources
- k. Citizen and Participatory Science
- l. Openness to Diversity and Inclusivity
- m. Open Licenses

- 5. Which obstacles prevent you from doing Open Science? (Multiple answers possible)**
- a. It takes too much time and work (At which stage?)
 - b. The tools are missing (For which task?)
 - c. It was not yet relevant (Why not?)
 - d. I use commercial software (Which software?)
 - e. I work with sensitive data (What kind of data?)
 - f. The pressure to publish
 - g. I do not think that others will need the materials
 - h. I do not want to lose my competitive advantage
 - i. The company/institution I am working with does not allow sharing
 - j. Lack of funding.
 - k. I do not know how (Where do you need help?)
 - l. I do not know how to license data and code
 - m. I do not know where to publish my materials
 - n. My materials may be misinterpreted
 - o. My materials may be misused (In which way?)
 - p. Because of copyright concerns (in which sense?)
- 6. At which stage of the research process do you need support regarding Open Science? (Multiple answers possible)**
- a. Preparing a data management plan for funding that adheres to Open Science principles
 - b. Preregistering a study/Writing a registered report
 - c. Collecting data
 - d. (Pre-) Processing and analyzing data
 - e. Storing and long-term preservation of data and results
 - f. Choosing a license for data/software/papers
 - g. Publishing preprints
 - h. Publishing the materials underlying the results (i.e., data and code)
 - i. Publishing articles
 - j. Reusing others' work
 - k. Other:
- 7. Do you have any comments or questions in the context of Open Science?**

Appendix C

Semi-structured interviews

The interviews will be conducted with academic staff, including researchers (i.e., postdocs, assistant/associate/full professors) and PhD candidates (employed and with scholarship). The guiding questions are shown in **bold**, follow-up questions are indented.

1. Introduction

- **What is your understanding of OS?**

2. Data collection

- **Do you usually produce data for your research?**
 - What kinds of data do you usually produce for your research? *E.g., satellite data, etc.*
 - How do you produce data?
 - Are you using software to produce data? If so, which one?
 - Is the software open-source or proprietary?
 - *If proprietary:* Are you aware of any open-source alternatives?
 - *If yes:* Is there a reason that you do not use them?
 - Have you encountered any obstacles while producing data?
 - Is the data ready for the analysis or are there some preparation steps required?
 - Where do you store the data after you finished producing it? *E.g., locally or online*
 - Which data file formats are you using to store the data?
 - Have you encountered any obstacles while storing the data?
- **Do you usually work with data produced by others?**
 - What kinds of data produced by others do you usually work with? *E.g., satellite data, etc.*
 - How do you access the data?
 - Are you using software to access data? If so, which one?
 - Is the software open-source or proprietary?
 - *If proprietary:* Are you aware of any open-source alternatives?
 - *If yes:* Is there a reason that you do not use them?
 - Have you encountered any obstacles while accessing the data?
 - Is the data ready for the analysis or are there some preparation steps required?
 - Where do you store the data after you accessed it? *E.g., locally or online*
 - Which data file formats are you using to store the data?
 - Have you encountered any obstacles while storing the data?

3. Data analysis

- **How do you usually analyse your data?**
 - Which software are you using to analyse the data?
 - Is the software open-source or proprietary?
 - *If proprietary:* Are you aware of any open-source alternatives?
 - *If yes:* Is there a reason that you do not use them?
 - Have you encountered any obstacles while using the software?
- **Do you produce software to analyse your data?** *E.g., source code*
 - Do you use a versioning software during the development?
 - Do you usually encounter any obstacles while producing software for the data analysis?
- **Where do you store the data analysis?**
 - Have you encountered any obstacles while storing the data analysis?

4. Before submission

- **Have you published any of your research materials before submitting the paper to peer review?**
E.g., data, analysis, preprints
 - *If yes:* Which materials?
 - Where have you published them?
 - For what reason have you published them?
 - Would you do it again? Why/Why not?
 - Do you encounter any obstacles when pre-publishing materials?
 - *If no:* Is there a reason that you have not published them beforehand?
 - Are there any obstacles when it comes to pre-publishing materials?
- **According to what criteria do you decide in which journal you would like to publish?**
 - Do OS principles play a role? Supplemental materials? JIF?

5. Peer Review

- **Have you ever made your data available for reviewers?**
 - *If yes:* How have you made the data available?
 - For what reason have you made it available?
 - Would you do it again? Why/Why not?
 - Do you encounter any obstacles when publishing data?
 - *If no:* Is there a reason that you have not made the data available for reviewers?
 - Are the journal guidelines not requiring it?
 - Are there any obstacles when it comes to making data available for peer review?
- **Have you ever made the data analysis available for reviewers?**
 - *If yes:* How have you made the data analysis available?
 - For what reason have you made it available?
 - Would you do it again? Why/Why not?
 - Do you encounter any obstacles when publishing the data analysis?
 - *If no:* Is there a reason that you have not made the data analysis available for reviewers?
 - Are the journal guidelines not requiring it?
 - Are there any obstacles when it comes to making the data analysis available for peer review?
- **If you review a paper, do you appreciate having access to data and source code?**
 - Why/Why not?
 - How do you investigate these materials?
 - Do you encounter any obstacles while reviewing the data and code attached to a paper?

6. Publication

If the interviewee has not published a paper yet, ask for plans regarding publishing

- **Have you ever published the data alongside the article?**
 - *If yes:* Where have you published it?
 - Which license have you used?
 - For what reason have you made it available?
 - Would you do it again? Why/Why not?
 - Do you encounter any obstacles when publishing data?
 - *If no:* Is there a reason that you have not made it available?
 - Are there any obstacles when it comes to publishing data?

- **Have you ever published the data analysis alongside the article?**
 - *If yes:* Where have you published it?
 - Which licensing have you used?
 - For what reason have you made it available?
 - Would you do it again? Why/Why not?
 - Do you encounter any obstacles when publishing the data analysis?
 - *If no:* Is there a reason that you have not made it available?
 - Are there any obstacles when it comes to publishing the data analysis?

7. Creating an OS environment

- **How does a research environment look like that supports OS?**
- **Which criteria need to be met to create an environment that stimulates OS?**
- **How can supervisors and department heads contribute to an environment that encourages OS?**

Appendix D

List of Abbreviations

AIO – Assistant-in-opleiding
CARE Principles – Collective benefit, Authority to control, Responsibility, Ethics
CfP – Call for papers
CRIB – Centre of Expertise in Big Geodata Science
DORA – San Francisco Declaration on Research Assessment
EU – European Union
FAIR Principles – Findable, Accessible, Interoperable, Reusable
FORRT – Framework for Open and Reproducible Research Training
GEO – Group on Earth Observations
INOSC – International Network of Open Science Communities
ITC-KH – ITC Knowledge Hub
ITC – Faculty of Geo-Information Science and Earth Observation
JEP – Joint Education Partners
JOSIS – Journal of Spatial Information Science
LISA – Library, ICT Services & Archive
NWO – The Dutch Research Council
OER – Open Educational Resources
OJS – Open Journal Systems
OS – Open Science
OSC – Open Science Community
OSCT - Open Science Community Twente
ORPE – Open Research Platform Europe
TRUST Principles - Transparency, Responsibility, User focus, Sustainability
UNESCO – United Nations Educational, Scientific and Cultural Organisation
UT – University of Twente
EOS –Earth Observation Science
ESA – Earth Systems Analysis
GIP – Geo-Information Processing
NRS – Natural Resources
PGM – Urban and Regional Planning and Geo-information Management
WRS – Water Resources