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Lighthouse Programmes in Sustainability Research and Innovation

SDGs: The international UN Sustainable Development Goals

With this report, the Swiss Academies of Arts and Sciences contribute to achieving the SDGs: **With a view to meeting Switzerland's commitments under the 2030 Agenda as a whole, it outlines the special requirements of research and innovation for sustainable development and how these could be effectively achieved by large, integrated funding programmes.**

> sustainabledevelopment.un.org

> eda.admin.ch/agenda2030/en/home.html



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Preface

The first important product of a focused discussion on science for sustainability initiated by the Swiss Academy of Sciences (SCNAT) was the white paper, Priority Themes for Swiss Sustainability Research, published in late 2020.¹ In addition to providing a roadmap for sustainability research, this white paper outlined the role of science in achieving the UN Sustainable Development Goals (SDGs) at national and global levels. The ideas presented in the white paper attracted considerable interest, both nationally and internationally, and were widely used by academic institutions in Switzerland in developing their own strategies for sustainability research.

Following the publication of the white paper, continuing discussions and reflections have underlined the need for large, integrated, transdisciplinary research and innovation programmes. Such programmes would provide an optimal environment for interdisciplinary collaboration on interconnected sustainability questions over an extended period, involving researchers from academic and non-academic partner organizations and public-private partnerships. The programmes, referred to here as 'lighthouse programmes', would not only provide a solid intellectual foundation for more focused work on specific, urgent priority research questions, but would also significantly strengthen the capacity of academic institutions to carry out sustainability research and innovation in and for Switzerland and beyond.

Given these challenges and opportunities, it is a great pleasure to introduce the present report, which provides recommendations on how lighthouse programmes could be developed. The report, which is the result of extensive research and consultation, details the most promising and desirable design elements for research and innovation to support sustainability transformations.

We are deeply grateful to the team of highly committed scientists and key representatives of public, private, and charity research funders who contributed to this report. By evaluating best practices and novel ideas from around the world, they have developed a realistic roadmap for large research programmes designed to support societal progress towards sustainability.

We sincerely hope that this report will serve as a reference, stimulus, and inspiration for funding agencies/foundations, to develop, promote, and manage lighthouse programmes. At the same time, we hope that it will inspire leaders of public and private academic institutions/groups to support the establishment of such programmes. We congratulate the team for bringing this inspiring report into the wider debate and trust that it will open up new dimensions of collaboration in advancing sustainability science and action.

Marcel Tanner
President, Swiss Academies of Arts and Sciences

¹ Wuelser G et al. (2020) Priority themes for Swiss sustainability research. Swiss Academies Reports, 15 (5). Available at: zenodo.org/record/4337939.

Executive Summary

This report argues that one of the most effective ways to support sustainable development through research and innovation is to establish large, integrated funding programmes, referred to here as lighthouse programmes. As well as producing impact-oriented knowledge on key sustainability challenges, these programmes would bring many other societal, scientific, and institutional benefits. These include: building closer relationships between science, society, and policy, and encouraging changes in the academic system itself, for example by increasing its capacity for inter- and transdisciplinary research.

Achieving sustainability is perhaps the greatest challenge of our time. Not only is the need for effective action urgent, but it will remain so for the foreseeable future. The academic community has a major role to play in proposing solutions and helping societies understand the consequences of different courses of action. In order to fulfil this role, more emphasis must be given to research that is interdisciplinary, transdisciplinary and impact-oriented.

Impact-oriented sustainability research has several distinct characteristics with implications for researchers, research funders, and research institutions. Essential features include its strong normative dimension, the need to co-produce knowledge jointly with societal actors and stakeholders, the use of novel experimental systems such as real-world laboratories, and the fact that the research is transformative in the sense that its goal is to produce major changes in thought patterns in society.

This report was produced by the Sustainability Research Initiative of the Swiss Academy of Sciences in collaboration with many experts from the research community and funding institutions. It describes the special requirements of research and innovation for sustainable development and how these could be effectively achieved by lighthouse programmes. Each section of the report briefly explains key issues and then presents various design options, usually in the form of recommendations, that might be useful in designing or managing a programme.

Chapter 2 outlines essential features of lighthouse programmes and how these could be incorporated into the design of a programme. The first three sections of the chapter concern the level of individual projects funded under the umbrella of a lighthouse programme, including how to frame complex sustainability questions, how to ensure that the research and innovation is societally relevant, and how to plan a project so that it links to an intended societal impact. The final section makes recommendations on how the funded projects can be supported at the overall programme level. Helpful features comprise providing training in transdisciplinary work, making the data produced accessible to those who can use it, establishing a forum for dialogue and debate on sustainability issues, and tracking changing research needs.

Chapter 3 discusses issues related to preparing and managing lighthouse programmes and makes recommendations directed towards funding agencies for assessing proposals and evaluating research impact. The topics covered in this chapter are how to redefine programme development, expand programme leadership, redesign proposal assessment, and integrate formative impact evaluation.

Chapter 4 discusses specific opportunities for universities and research institutions that can be reinforced through lighthouse programmes. It addresses issues around making sustainable development an institutional priority, fostering cross-cutting structures for research and innovation in broader contexts, building capacity, and improving career opportunities for those who engage in sustainability research and innovation.

1 Introduction

1.1 Science as a partner in sustainable development

Our world is facing great environmental and social challenges. Unsustainable levels of production, consumption, and resource depletion are causing widespread biodiversity loss, soil damage, environmental pollution, and a warming climate. At the same time, over one billion people live in extreme poverty and growing inequality is leading to political instability and large-scale migration.

The goal of sustainable development is to ensure that all people can enjoy a decent life within the capacity of the planet's life support systems. It is increasingly clear that achieving this goal will require radical changes in our relationship with the natural environment and our use of resources, changes that must occur within the next few years (Independent Group of Scientists appointed by the Secretary-General, 2023). Nothing less than societal transformation is needed, based on a common understanding of the problems we face and a shared vision of the way forward. While people in positions of influence and authority in business and policymaking may have special roles to play, responsibility for shaping this future – in the sense of a global partnership – falls upon everyone.

The research and innovation communities are increasingly committed to providing the knowledge and ideas needed to progress towards sustainable development. While much knowledge already exists, there are many gaps in our understanding of sustainability problems and how to tackle them. In 2020, the Swiss Academies of Arts and Sciences published the white paper titled *Priority Themes for Swiss Sustainability Research*, which identified an initial set of globally relevant topics that urgently require research (Wuelser et al., 2020). The ideas presented in the white paper attracted considerable interest and were used by several academic institutions in Switzerland to develop their own strategies for sustainability research.

Research for sustainable development is impact-oriented, with distinct characteristics that have implications for researchers, research funders and research institutions. First, it is framed around a societal vision of a desirable future and therefore has a strong normative dimension (Box 2). Second, it often adopts collaborative approaches, referred to as the 'co-production of knowledge' or 'transdisciplinary research', to ensure that the research is societally relevant and integrates the experience and expert knowledge of non-academic actors and stakeholders (Box 3). Third, experimental systems such as real-world labo-

ratories may be needed to investigate processes of societal transformation in pilot settings. These systems are valuable for understanding the impact pathways by which new knowledge can contribute to sustainable development; they can also be an inspiration for others to emulate (Box 4). Finally, sustainability research is often transformative research, in the sense that its goal is to stimulate major changes in thought patterns that affect not only society as a whole, but also the individual researcher (Box 5).

Evaluations of research and innovation funding programmes have underlined the need to provide greater and more consistent support for such approaches.¹ This will require research funding at scale that is explicitly sustainability-oriented, something that would also offer novel opportunities for research institutions. While the excellent disciplinary work relevant to the goals of sustainable development will remain important, the academic system must be expanded to include greater inter- and transdisciplinarity to generate effective sustainability research and innovation. To quote a report of the International Science Council (2021, p. 9): 'As it is currently organised, the international science system produces significant but narrowly-focused, fragmented and compartmentalized knowledge that is often disconnected from society's most immediate needs.'

1.2 Why lighthouse programmes?

One promising approach to providing the necessary support for impact-oriented sustainability research and innovation would be to establish highly interdisciplinary funding programmes that involve experts from many academic and non-academic fields. We refer to such programmes as **lighthouse programmes**, which we define as 'large, integrated funding programmes designed to support impact-oriented research and innovation for sustainable development'. Various points need to be made about this definition. First, the term 'funding programme' implies that a lighthouse programme has funds that it can independently allocate to projects and other activities that fall within its mandate. Second, although knowledge co-production would be a prominent feature of any lighthouse programme, other modes of research, including both basic and applied research, might often be needed to achieve the overall goals of a lighthouse programme. Third, the term 'innovation' is used broadly to include not only new technologies but also social innovation, i.e.

¹ E.g. the Swiss Energy funding programme 2013–2020: innosuisse.ch/inno/en/home/about-us/publications/evaluation-programme.html

Table 1: Overview of funding programmes considered in this report

Abbreviation	Name of Programme	Funding Agency
Biodiversa+	The European Biodiversity Partnership	European Commission and multiple co-funders
CRAs	Collaborative Research Actions	Belmont Forum
ETH4D	ETH for Development	ETH Zurich
Extremes	WSL Research Programme Extremes	Swiss Federal Institute for Forest, Snow and Landscape Research WSL
FID	Fund for Innovation in Development	French Development Agency (AFD)
GCRF	Global Challenges Research Fund	UK Research and Innovation UKRI
ICT Agri-Food	ICT-enabled agri-food systems	ERA-Net Co-fund (European Union)
IDRC	International Development Research Center	Government of Canada
LIRA 2030	Leading Integrated Research for Agenda 2030 in Africa	International Science Council, Network of African Academies of Sciences (NASAC), Swedish International Development Cooperation Agency (Sida)
NCCR	National Centres of Competence in Research	Swiss National Science Foundation (SNSF)
NRP	National Research Programmes	Swiss National Science Foundation (SNSF)
r4d	Swiss Programme for Research on Global Issues for Development	Swiss National Science Foundation (SNSF) and Swiss Agency for Development (SDC)
SCCER	Swiss Competence Centers for Energy Research	Innosuisse – Swiss Innovation Agency
SDU	Sustainable Development at Universities Programme	Swiss federal government and higher education institutions
SOR4D	Solution-oriented Research for Development Programme	Swiss National Science Foundation (SNSF) and Swiss Agency for Development (SDC)
SPP Umwelt	Schwerpunktprogramm Umwelt	Swiss National Science Foundation (SNSF)
SWEET	Swiss Energy Research for the Energy Transition	Swiss Federal Office of Energy
U Change	U Change – Student initiatives for sustainable development	Swiss federal government and higher education institutions
Wings	Water and sanitation innovations for non-grid solutions	Eawag – Swiss Federal Institute of Aquatic Science and Technology
-	#ConnectingMinds	Austrian Science Fund FWF
-	DATIpilot	German Agency for Transfer and Innovation DATI
-	Flagship Initiative	Innosuisse – Swiss Innovation Agency
-	Horizon Europe	European Union
-	Implementation Networks	Swiss National Science Foundation (SNSF)
-	Innovation Booster	Innosuisse – Swiss Innovation Agency
-	Joint Initiatives of the ETH Domain	ETH Domain
-	SDG Labs	Future Earth
-	Societal Transformations	Volkswagen Foundation
-	The Global Fund	Various government donors
-	Wissenschaft für Nachhaltige Entwicklung	Ministry for Science and Culture of Niedersachsen, Volkswagen Foundation

novel approaches to solving challenging and often systemic social and environmental issues, often requiring the active collaboration of stakeholders from government, business, and the non-profit world.

An important goal of lighthouse programmes is to provide a platform for the co-production of knowledge that ensures that societal concerns are heard and addressed. In the sense of ‘science in society’, lighthouse programmes would be intended to develop an active dialogue with policymakers, business leaders, and the general public. They thus lead to empowerment through knowledge gain, network building, and capacity development in society, based on research collaborations and knowledge exchange activities.

Lighthouse programmes would also help strengthen the scientific capacity for more integrated and systemic research and innovation, anchoring this approach more widely in the academic community. The interconnected nature of sustainability goals requires a special focus on synergies and trade-offs between different equally important sustainability goals while keeping in mind the ‘big picture’, so that any suggested interventions are as beneficial as possible for the whole system.

Overall, lighthouse programmes would build national capacity for sustainability research and innovation. They could encourage changes in the academic system itself, for example by increasing investment in bridging disciplines, and broadening the academic incentive systems to recognize outstanding achievement in transdisciplinary research. Box 1 provides an overview of the manifold societal, scientific, and institutional benefits of lighthouse programmes. Indeed, the name lighthouse programme was chosen to emphasize their role as beacons by which society navigates towards greater sustainability.

Lighthouse programmes can only fulfil their role, however, if they enjoy strong support from policy and government. In particular, public funders of research and innovation must be given the necessary resources to fund lighthouse programmes at an appropriate level over an extended period.

Box 1: Benefits of lighthouse programmes

Goals to be achieved through lighthouse programmes for sustainable development

Scientific goals

- Work on sustainability problems in their broader contexts
- Develop new theoretical and methodological approaches
- Provide actionable knowledge on case-based, specific problems
- Develop metrics and monitor progress towards sustainability
- Track changing research needs (and respond at short notice to emerging issues)
- Provide a scientific underpinning for more focused research

Institutional goals

- Strengthen the institutional capacity to address questions related to sustainability
- Establish true interdisciplinarity across faculties, departments and institutions
- Develop strong capacities in transdisciplinarity and science–society–policy dialogue
- Establish enduring networks with non-academic stakeholders
- Build strong international collaborations
- Provide a model for future transdisciplinary research structures within institutions

Societal goals

- Build a platform for co-production between academia and society
- Create an information hub in support of science-based decision making
- Provide a forum for public debate on issues of sustainability
- Establish a dialogue with decision-makers
- Societal transformation

1.3 Origins and structure of this report

This report presents design options for lighthouse programmes. It is aimed not only at research funders and academic institutions but is also intended to inspire policymakers and the wider scientific and innovation community. It is the product of collaboration with experts from science and funding institutions, aimed at identifying how such programmes could most effectively be designed. The recommendations presented here have been assembled from two main sources. First, the Swiss Academy of Sciences organized two workshops at which experts discussed their ideas and experiences concerning funding instruments for sustainability research and innovation. These were complemented by nine bilateral expert consultations to learn how particular challenges can be met. Second, a desk study was conducted, reviewing the literature and specific design elements adopted in recent research and innovation funding schemes.² We refer to these schemes throughout this document using the abbreviations given in brackets in Table 1. A selection of funding instruments with interesting features are presented in six boxes throughout this report, while others are mentioned in the text. This report was written by the main authors in collaboration with several contributing authors, based on inputs by a number of consulted experts.³

The report has four chapters. The heart of the document is Chapter 2, which presents our main recommendations on how integrated research and innovation funding instruments for sustainability can be framed and designed. Chapter 3 discusses development, governance, and impact evaluation of large integrated sustainability research and innovation programmes. Finally, Chapter 4 specifies the role of research institutions and particularly how they can provide an enabling environment for sustainability research and innovation.

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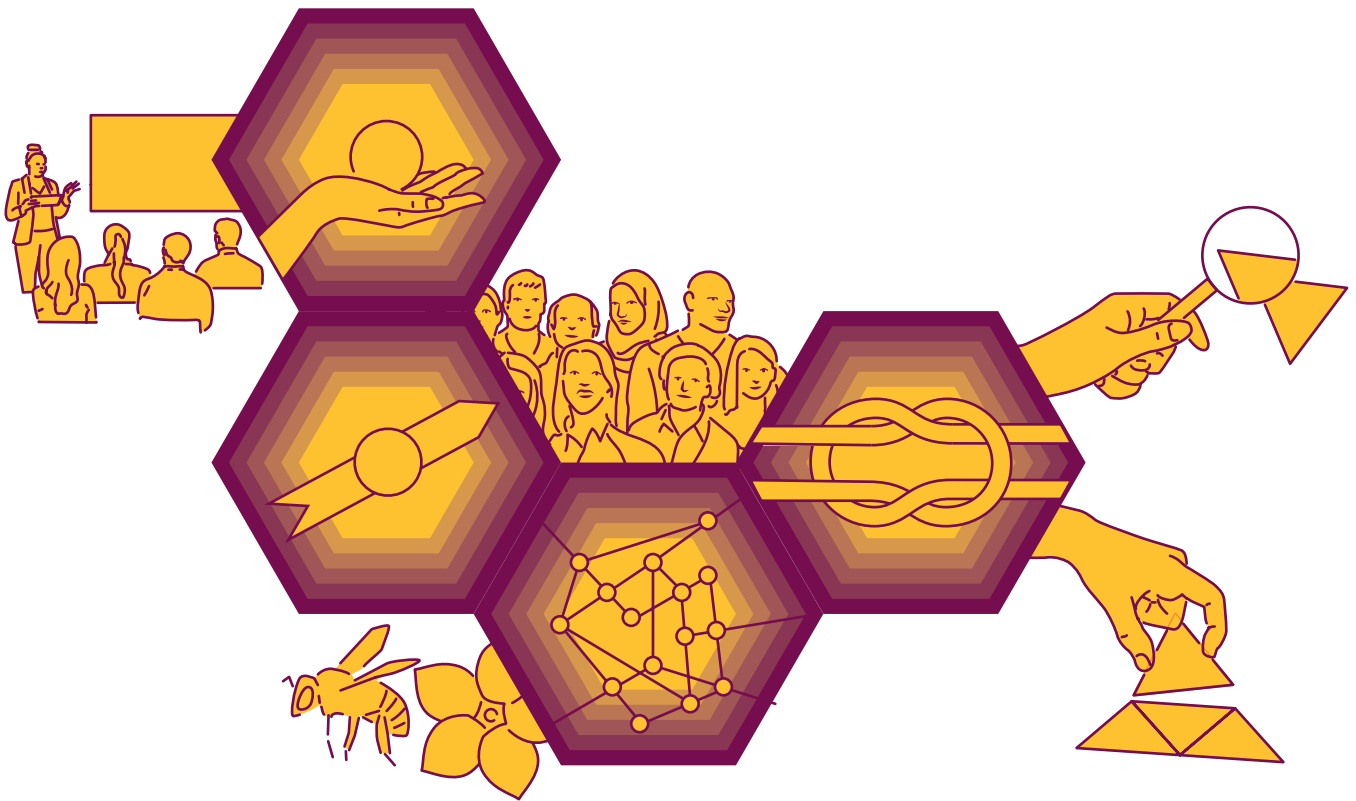
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Wuelser G et al. (2020) **Priority themes for Swiss sustainability research**. *Swiss Academies Reports*, 15 (5). Available at: <https://zenodo.org/record/4337939>.

² A full list of funding schemes considered in this report is provided in Table 1.

³ For an overview of all contributors, see imprint

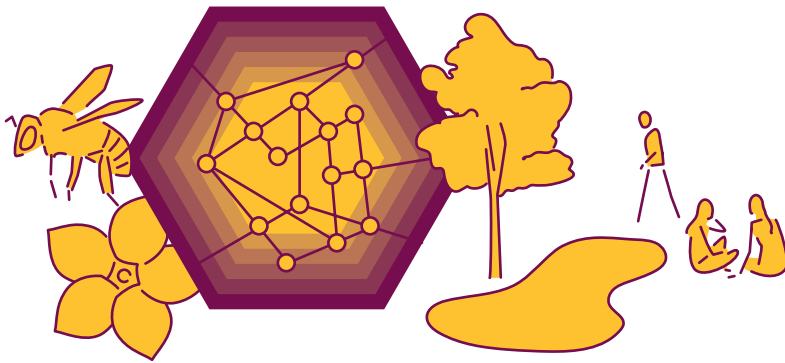


2 Essential features of lighthouse programmes

The ultimate goal of research and innovation for sustainable development is to support societal transformation (cf. Box 5). This chapter suggests how funding instruments can be designed and organized to support this goal. By ‘programme’, we mean lighthouse programme as defined in Chapter 1, while we use ‘project’ to refer to the separate research and innovation components that make up such a programme. The first three sections address issues that are most relevant at a project level, namely: embracing the complexity of sustainability questions (2.1), ensuring societal pertinence (2.2), and planning for impact (2.3).

The final section (2.4) discusses what needs to be done by the programme as a whole to support individual projects, such as provide training in transdisciplinary methods or a forum for discussions with policymakers. Each section briefly explains key issues, usually in the form of recommendations, and then presents design options that could be useful in realizing these recommendations. Since the issues covered in this chapter are closely interlinked, some repetition is inevitable when presenting them in a linear fashion.

The symbol  indicates design options that would require special funding.



2.1 Embracing the complexity of sustainability questions

Sustainability problems are not only referring to political goals but also strongly interlinked, which means they must be considered together and also across temporal and spatial scales and sectors. In attempting to solve a particular problem – for example, related to ecosystem health, social justice, or cross-generational equity – it is important to consider how a suggested policy or action could impact other areas of sustainability concern. This section provides suggestions on how lighthouse programmes can maintain this holistic view of sustainability challenges while considering their normative nature.

2.1.1 Aligning research to political goals of sustainable development

Sustainable development is a normative concept about the kind of future we want as societies (Box 2). As a political vision, the concept has been elaborated in global policy frameworks such as the 2030 Agenda, which was adopted by UN member states in 2015. Like other political concepts, such as democracy or freedom, the general meaning of sustainable development is widely accepted, but a variety of interpretations are legitimate in specific contexts (Jacobs, 1999). A local energy provider, for example, may have a different understanding of what sustainability means in terms of energy production and consumption than a scientific group developing possible energy sufficiency models. Science for sustainable development must find ways of dealing with different, shared, or contested views of what sustainable development means in the context of a research or innovation project, and in doing so, refer to a normative stance (Wuelser, 2014; Schneider et al., 2019).

One approach often used in transdisciplinary research is to develop – i.e. to co-define – a common understanding of sustainability priorities together with relevant actors

and stakeholders. While this offers considerable freedom to define the most desirable future in a particular context, the results should be compatible with the overall goals of sustainable development, which have been politically legitimized since the 1987 Brundtland Report (WCED, 1987). These include commitments to protect the integrity of natural systems and strive for intra- and intergenerational equity.

Design options

- **Ask applicants to specify how they define sustainable development in the context of their project.** This is important because many programmes use rather broad definitions (e.g. the Brundtland definition) or limit themselves to asking applicants to list the relevant UN Sustainable Development Goals (SDGs) without further contextualization. Applicants to two Swiss programmes – Sustainable Development at Universities Programme, SDU (Akademien der Wissenschaften Schweiz, 2017) and U Change – were asked to explain the link between the general and the project-specific meanings of sustainable development. The German programme ‘Wissenschaft für nachhaltige Entwicklung’ was even more demanding, requiring applicants to describe the current state of the scientific sustainability discourse, explain their own understanding of sustainability, and justify the relevance of their proposed research against this background. To be even more specific, funders could ask how researchers will contextualize the meanings of specific SDGs or how they expect to address SDG trade-offs.
- **Ask applicants to co-design normative target questions with actors and stakeholders from science and practice.** The process of co-designing visions of the future in the form of target questions (i.e. desirable sustainability goals and outcomes) inevitably uncovers the values and normative understandings of stakeholders, which is an important step towards prioritizing sustainability problems and transformative actions. The LIRA 2030 programme, for example, asked project teams composed of researchers and non-academic stakeholders to formulate their answers to the question, ‘what are de-

sirable urban futures?'. The goal of the research should then be to co-produce actionable knowledge towards achieving these objectives.

- **Frame research around a specific conception of sustainability.** Examples of possible conceptions include the doughnut of social and planetary boundaries (Rockström et al., 2023), regenerative sustainability (see e.g. Gibbons, 2020), or *buen vivir* (Chassagne, 2019). This method is especially useful in programmes aimed at developing innovative approaches to sustainable development, at co-producing actionable knowledge in specific cultural settings (e.g. South America), or in fostering discussion about what comes after the SDGs.
- **Run workshops or other activities at which researchers reflect upon their own normative stance.** Self-reflection is a valuable process that promotes awareness of the normative nature of sustainable development and ideally makes the researchers aware of their own biases (Schneider et al., 2019). Expert facilitation can strongly enhance the outcomes of such reflection processes, but requires additional funding (cf. 2.4.1).

2.1.2 Taking an integrative and systemic approach

Many sustainability issues can be considered ‘wicked problems’, meaning that complexity is high, with interdependencies of different aspects numerous and often conflicting. Finding a way to address any given sustainability problem thus requires a systemic perspective to understand the potential synergies and trade-offs among different sustainability goals. Synergies are valuable because they offer an opportunity for rapid progress towards sustainability. Experts argue that a sustainable future will only be possible if we consciously and globally harness the power of positive feedback loops. On the other hand, trade-offs require careful analysis of benefits and costs as well as winners and losers. Where trade-offs are unavoidable, investment should be made into finding ways to ‘compensate’ those who are adversely affected. In principle, efforts to achieve one goal should never be at the expense of another, equally important goal.

Determining which synergies and trade-offs are likely to be most important for the system as a whole is a core task for any research and innovation project. It requires identifying potential winners and losers across administrative sectors or societal groups, across generations, and at different spatial scales from the local to the global. This, in turn, may require bringing together experts from many academic and professional fields, as well as representatives from civil society (cf. 2.2.1). However, bridging the different heuristic approaches of science and technology,

Box 2: The normative dimension of sustainability

Because of its normative dimension, research and innovation for sustainable development presents a profound challenge for academic institutions. Positivism, the dominant scientific paradigm in academia, asserts that reliable knowledge can only be gained through observation (the senses), including measurement. In contrast, issues related to morality are matters of subjective preference that cannot be further justified and are therefore excluded from the domain of science (Vogt and Weber, 2020). This is essentially the view advocated by the German sociologist and political economist Max Weber, who maintained that decisions based on value and meaning lie outside of science. He did consider, however, that scientists have a moral responsibility to confront politicians, students, and others with their empirical findings, thereby stimulating them to reflect on, and perhaps reconsider, their value positions. Many scientists in academia also regard social or political judgements as lying outside their professional domain, perhaps arguing that normative questions should be resolved through a democratic process (Tholen, 2021).

In research for sustainable development, it is impossible to maintain a clear separation between science and values (Funtowicz and Ravetz, 1993). For example, the UN Sustainable Development Goals (SDGs) are policy goals based on moral and ethical values, and scientists are called upon to provide the knowledge needed to implement them. Whereas understanding the causes and consequences of our environmental predicament (e.g. climate change) may fall comfortably within the domain of positivist science, determining the most effective remedial actions inevitably involves deliberation of opinions and ethical judgments on what should be (ProClim, 1997).

Section 2.1.1 provides an overview of how research and innovation projects can identify, make explicit, and deal with normative positions with respect to sustainability goals.

the arts and humanities, sustainability practitioners, and of Indigenous People and Local Communities (IPLCs) can be a very challenging task.⁴

Design options

- **Require projects to analyse the significant interrelations among different sustainability goals related to their topic.** This analysis could take various forms, such as a systematic mapping of most impactful (enhanced) synergies and (mitigated) trade-offs, or a plan of how the project intends to identify and prioritize them. Another option is to list processes acting at different spatial-temporal scales, such as spill-over effects on distant social-ecological systems. Such analyses are helpful in showing how particular sustainability goals can be achieved by harnessing synergies (Pham-Truffert et al., 2020). The LIRA 2030 programme explicitly asked projects to look at the interlinkages between various sustainability goals, and several LIRA 2030 projects focused on nexus challenges, such as climate change and health, energy and gender, and water–energy–food. It thereby became clear that tackling complex nexus challenges requires building strong systems capacities. One evaluation criterion for proposals to the SOR4D programme is the ‘suitability and feasibility of the systemic approach’. Furthermore, applicants must describe a pathway towards a validation process of intended systemic solutions through a Theory of Change (cf. 2.3.1) that is also an integral part of the project evaluation.
- **Focus calls on particular aspects to reduce complexity while ensuring a sufficiently broad perspective.** The Global Sustainable Development Report (2023) recommends framing research programmes in terms of broadly conceived areas of sustainability concern (entry points) that encompass, not individual or even clusters of goals, but rather the underlying systems. Examples of such topical aspects are the priority themes for Swiss sustainability research (Wueller et al., 2020). NRPs use challenges of similar size defining their thematic scope. While broad perspectives are crucial, focused programmes better manage to bring together individual projects for a coherent and targeted programme synthesis. Such themes can also consist of several interconnected ‘grand challenges’: The Belmont Forum’s CRA ‘Climate, Environment, and Health II’ research consortia for example are asked to investigate and address the linkages between climate, environment, and health, with a particular emphasis on system-level project design. Horizon Europe missions are designed so that they support citizens and regions in coping with future

challenges.⁵ In its ‘Strategic Research and Innovation Agenda’ (Eggermont et al., 2021), Biodiversa+ outlines three ‘topical themes’: biodiversity protection and restoration, transformative change, and EU’s global action, along with associated knowledge needs. Additionally, two cross-cutting themes address overarching issues relevant to all the topical themes: Biodiversity and its dynamics, and Nature-based solutions. IDRC has identified five priority areas for its work in developing countries over the next decade to contribute to achieving the SDGs. These focus areas are climate-resilient food systems, global health, education and science, democratic and inclusive governance, and sustainable and inclusive economies.

- **Assemble or ask for a portfolio of projects that together form an interrelated structure.** NCCR proposals – prepared by large groups of 20–40 principal investigators – have to specify how the projects are interrelated and how together they will build added value. SWEET also funds portfolios of interrelated projects, structured so that they benefit from each other. The systemic nature of the challenges addressed in SWEET requires fairly large consortia of research and implementation partners, whose work programmes are structured into research projects to be manageable. Biodiversa+ actively encourages synergies among its flagship programmes, each of which tackles a particular biodiversity issue. Similarly, projects proposed under the Innosuisse Flagship Initiative are composed of three to eight sub-projects that are the components needed for systemic innovation.⁶
- **Encourage independently approved projects to seek links with other projects.** This approach provides the flexibility needed in transdisciplinary research, which may encounter changes in focus, especially in early phases. NRPs fund individual research projects within a given topic. This can lead to collaboration and linking of projects. Annual meetings of all funded projects are useful for uncovering and identifying links and potential synergies.
- **Ask individual projects to locate their contributions within a systemic framework developed for the programme.** This may include identifying which domains (and therefore also which related disciplines, sectors, or knowledge fields) are connected with each other in what way and at

⁴ The Wyss Academy for Nature at the University of Bern, a newly founded institution in the Swiss academic landscape, was set up to test and evaluate such collaborations, with the mission to co-design new ways of reconciling nature and people.

⁵ For an overview of mission-oriented research and innovation in Switzerland cf. Swiss Science Council SSC (2023). Mission-oriented Research and Innovation in Switzerland. SSC Report 1/2023

⁶ Systemic innovation is a type of innovation where value can only be derived if it is synergistically integrated with other complementary innovations, going beyond the boundaries of a single organization. Systemic innovation requires multiple innovations to be coordinated. Consequently, the different contributory innovations and organizations are organized together into a whole system, where the overall success of the emergent innovation cannot be attributed to just one sub-innovation or participating organization.

which points in time. This creates awareness of concrete interdependencies that require joint action with researchers or stakeholders from other fields, and provides an overall orientation for jointly moving towards a common sustainability goal or vision (Deutsch et al., 2021). A funding programme that did this is WINGs, which developed a Theory of Change (cf. 2.3.1) at programme level for this purpose.

- **Require project scientists to invest time in integrative work at the programme level.** Projects can for example be asked to

appoint one or several integration specialists who have the task to integrate knowledge, ideas, and perspectives. They would seek links to other funded projects within a programme, in order to actively align project contents with each other and with the overall aim of the programme. This is ideally done throughout the research phase. In its latest call, SWEET asks funded consortia to appoint an ‘integration expert’, who should be well-versed in inter-and transdisciplinary research.

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2.2 Ensuring societal pertinence

Sustainability problems are societal problems. To understand their nature and complexity, investigators must put themselves in the shoes of societal actors, including diverse stakeholders and non-academic experts. For this reason, it is important for researchers to listen to and collaborate with non-academic experts and stakeholders from business, policy, and society in general. If the questions to be studied are very clear and specific, the exchange may be limited to some feedback on the research questions or discussion of preliminary results. If the topic is not well understood or the research questions are broader, closer stakeholder involvement may be needed throughout the research. Rather than relying on short-term, project-based collaborations, there are considerable benefits in establishing longer-term alliances with non-academic partners. This chapter lists some of the ways in which lighthouse programmes can encourage projects to address complex societal problems in close collaboration with these partners.

2.2.1 Familiarizing oneself with societal contexts, dynamics, and needs

Before proposing a new research or innovation project, researchers must familiarize themselves with the history and social context of a sustainability problem. This means they must identify the issues that remain disputed or unresolved and the remedies that may have been proposed, and understand the perspectives of different actors. This preliminary phase is essential to identify the relevant experts, actors, and stakeholders; to specify a society's knowledge needs; and to ensure that the research is pertinent to political, economic, and societal processes (Wuelser et al., 2012).

Design options

- **Ask applicants to specify how they propose to develop the best possible understanding of societal dynamics.** Information about societal debates, needs, political processes, and business activities will be essential for framing re-

search questions that are salient to the needs of stakeholders and decision-makers.

- **Ask applicants to frame research questions jointly with relevant non-academic stakeholders.** The choice of actors and stakeholders varies according to the problem, but could include representatives from policymaking, business, NGOs, grassroots communities, and, in some cases, indigenous or traditional societies. In the SOR4D programme, project consortia are required to develop their project jointly with non-academic actors, as a means of increasing the societal impact of research. Both the Volkswagen Foundation and the CRAs of the Belmont Forum place special emphasis on understanding and utilizing non-scientific perspectives and knowledge, including those of traditional societies. For example, applicants to the Volkswagen Foundation Societal Transformations scheme are asked to identify 'day-after-tomorrow' issues together with a range of stakeholders. And Innosuisse's Innovation Booster requires the collaboration with key stakeholders including potential users and civil society to identify relevant challenges (i.e. challenges relevant for the stakeholders' communities and more generally, for the Swiss economy and society). In order to identify new solutions for improving the lives of poor people, ETH4D aims to combine technical innovation with a profound understanding of people's behaviour and their environments.
- **(\$)** **Support an extended pre-proposal development phase.** Researchers need time and resources to familiarize themselves with societal dynamics, identify possible collaboration partners, and frame research questions. To ensure that proposals were based on a sound understanding of the social context, the SDU Programme (Akademien der Wissenschaften Schweiz, 2017) provided substantial funding (up to CHF 200,000 per project) for developing inter- and transdisciplinary research proposals. SOR4D's preparatory grants allow consortia to convene in a preparatory meeting to jointly prepare the full project proposals. And the Belmont Forum CRAs include a preparatory and capacity building phase of up to 6 months before the pre-proposal deadline. Applicants do not receive

funding for this phase but can benefit from a range of networking opportunities and capacity building workshops.

2.2.2 Building alliances with policy, society, and economy

Building and maintaining contacts and collaborations with academic and non-academic partners can be difficult for various reasons. One challenge is to select the most appropriate partners for a particular project. Important questions to ask when choosing partners include: who has the most relevant (academic and non-academic) expertise on the issue? What is at stake, and for whom (interests)? And who has the power to implement change (Wuelser et al., 2012)? It is also necessary to consider the collaborative competencies of both academic and non-academic stakeholders (Nurius and Kemp, 2019), as well as their motivations for participating.

It can be difficult to achieve a productive debate in a group with diverse technical expertise, different professional languages, and often different ways of sense-making (what scholars describe as ‘thought styles’ [Pohl, 2011]). The knowledge and expertise of non-academic stakeholders may include not only precise technical information, such as might be available from a government office or an engineering firm, but also less formalized experiential and traditional knowledge held for example by local communities. Overcoming such differences and building trust takes time and requires regular, positive interactions. Furthermore, the roles of the actors involved in a project need to be jointly clarified. They may be part of the project lead, and they may be involved in a form of collectively doing research (i.e. knowledge co-production, cf. Box 3). Contact and engagement intensity may differ in different stages of research projects. And a final practical problem is the cost of participation, both in time and financially. Many potential participants, especially private individuals and small businesses, may simply be unable to participate unless the programme can compensate them in some way.

Design options

– **Ask applicants to organize collaboration with non-academic stakeholders as part of project preparation** (see also 2.2.1). This encourages reflection on who is relevant and includes deciding who to involve and how. NRPs require research projects to identify key stakeholders and implementation partners, especially from the political and economic spheres, and to propose an implementation plan. At programme level, one option is to set up a sounding board composed of actors from practice. The LIRA 2030 programme trained its grantees in stakeholder

mapping and allowed up to 40% of project funds to be used for stakeholder engagement activities.

- **Ask projects to involve stakeholders in the research or innovation process.** Many programmes (e.g. the Belmont Forum’s CRAs, GCRF, FID) expect stakeholders to be actively involved in the research process and in implementation. The Global Fund asks projects for organizational structure charts⁷ reflecting the functioning of the collaboration in the project and validating the presence of the various partners. To strengthen stakeholder engagement, Biodiversa+ requires projects to establish an enlarged stakeholder board to comment on progress and results. Societal Transformations of Volkswagen Foundation requests not just participatory research, but also collaborative science communication. The SDG Labs organized by Future Earth consist of teams of researchers, community leaders, and entrepreneurs who come together to create social, ecological, or technological innovations for addressing the SDGs. The goal is to initiate transformative change by sowing seeds of innovation that can flourish, propagate, and serve as inspiration and a source of knowledge for broader-scale transformations. The GCRF programme encourages memorandums of understanding (MoUs) between funding programmes and international organizations to help in bridging the science-policy divide.
- **Require projects to work with a non-academic co-lead.** In SOR4D consortia, researchers and development actors are expected to share responsibility for their projects. Similarly, the NRP 82 on Biodiversity and Ecosystem Services requires that responsibility for the research is shared between science and practice. In SWEET, work package leaders can be actors from either science or practice, though the overall consortium coordinator must be an employee of an academic institution. Apart from this restriction, consortia are free to build governance structures that suit their needs, for example, by establishing mixed boards with an advisory or decision-making function.
- **Ⓢ Provide funding to support participation of non-academic stakeholders.** Many potential partners – for example from NGOs, small businesses, and the global South – may only be able to participate in a research project if they receive financial compensation for their time. SWEET allows such funding for non-academic project partners. The SNSF generally does so, providing the purpose of the project is non-commercial. The Belmont Forum provides funding to stakeholders in their CRAs, sometimes via subcontracts. Lighthouse programmes could require projects to obtain matching funds from

⁷ theglobalfund.org/en/staff/organizational-structure

partners in cases where they were likely to profit from the research.

- **Encourage proposals that incorporate multiple scientific perspectives and involve researchers from diverse scientific fields.** This approach emphasizes the importance of scholars from the humanities and cultural sciences in shaping the research design, as exemplified by the Volkswagen Foundation. Placing these scholars at the centre of the research process can strengthen interdisciplinary work.

2.2.3 Planning for the unexpected

By definition, research and innovation are uncertain processes, with unexpected events or results often necessitating changes to a project. Such unexpected events are especially likely in sustainability research on societal processes involving many actors. For example, discus-

sions with stakeholders during the research or innovation process may lead to a new understanding of the nature of the problem to be solved and new stakeholders to be involved. Alternatively, it may be necessary to reframe a project because of unpredicted events (e.g. a pandemic) or rapidly changing social, economic, or technological circumstances. This kind of uncertainty means that funding programmes must be open to changes in research activities, approaches, and even goals. Consulted experts recommend retaining up to 20% of a programme's budget for that purpose. This money can be used for reacting to unpredicted events and for seizing unexpected opportunities. The emergent nature of transdisciplinary approaches also requires that funders are prepared to accept unconventional kinds of outputs and outcomes.

Design options

- **Allow projects to adapt research partnerships to changing circumstances.** The Innosuisse Flagship Initiative allows flexibility with respect to partners within its consortia. If

Useful examples: Swiss Energy Research for the Energy Transition (SWEET), SFOE

Purpose and goal

- SWEET is geared towards the goals of Switzerland's Energy Strategy 2050 and Long-Term Climate Strategy.
- The programme aims to foster cooperation among research institutions; the private sector; professional associations; federal, cantonal, and communal authorities; and NGOs.
- Special attention is paid to linking research and implementation

Description

SWEET (Swiss Energy Research for the Energy Transition) is a funding programme of the Swiss Federal Office of Energy (SFOE). It runs from 2021 to 2032 and funds inter- and transdisciplinary consortia of research and implementation partners that collaborate on portfolios of interrelated projects for six to eight years. Consortia are led by a higher-education institution and must consist of partners from the ETH domain, universities, universities of applied sciences, and private-sector companies, which may be complemented by partners from professional associations; federal, cantonal, and communal authorities; and NGOs. Great importance is attached to including the social sciences and humanities to ensure that questions relating to issues such as social agency, perception, and acceptance, are considered from the outset. Depending on the topics, other federal offices are involved in the preparation of the calls for proposals and the monitoring of the consortia.

To accelerate the practical implementation, the project portfolios are expected to contain pilot and demonstration (P+D) projects, for which additional funding is available through the SFOE's P+D programme. The SFOE accompanies the consortia through yearly monitoring and requires that they consider knowledge and technology transfer (KTT) from the start. To give the work of the consortia a certain flexibility – e.g. to answer research questions that arose after the work began – supplementary funding can be requested from the SFOE.

Funding and organization

- Endowed with a total of CHF 148.3 million over 12 years.
- A total of 7 calls will support 11 consortia.
- Consortia receive CHF 8–18 million over six to eight years, depending on the call.
- Uses competitive calls for proposals and a two-stage evaluation process.
- Consortia need to be inter-/transdisciplinary.
- Funding for non-academic partners, including private sector, is available.

Distinctive features

Clear focus on contributing to goals of Switzerland's Energy Strategy 2050 and Long-Term Climate Strategy. Funding of inter-/transdisciplinary consortia of research and implementation partners over six to eight years.

Further information

bfe.admin.ch/bfe/en/home/research-and-cleantech/funding-program-sweet.html

necessary, partners may leave the consortium and new ones join. NCCRs similarly allow adaptations to research plans and consortia. Funded NCCRs have financial and organizational autonomy. The same applies to SWEET.

- **④ Provide funding that can be flexibly allocated.** The SWEET programme, for example, provides a supplementary budget to consortia if research shows that directions need to change or that new questions have arisen. In the SOR4D programme, part of the programme budget is reserved for communication activities and knowledge transfer, but the programme management can also use these funds to implement new ideas and activities. NCCRs are allowed full flexibility in the use of approved funds. NRPs use (financial) incentives, e.g. extra funds that can be provided for collaborative elements or platforms for generating community networks. In general, lighthouse programmes can allow projects to use part of their budget (e.g. 20%) flexibly to address unexpected issues.
- **Ask projects to describe how they will address the unexpected (both conceptually and practically).** Programmes could ask projects to reflect regularly on their activities and goals, with the possibility of changing direction if necessary. As a first step, teams could reflect on the type of unexpected action they can imagine (is it already known that such action might happen or is this an unknown unknown?). Such classification can help teams to already envision potential approaches and/or budget needed to cope with the unexpected. Continuous incorporation of learnings into the programme features and activities is key.
- **④ Allow for multi-stage applications (e.g. separate funding for problem framing, research, and probing implementation).** The SPP Umwelt worked with three distinct phases, which allowed projects to adapt to changing circumstances. SWEET encompasses a two-stage evaluation process for consortia (pre-proposals, full proposals); plans for the full 6–8 years must be presented in both stages, though a detailed description of the proposed work is only required for the first 3 years. Some programmes allow follow-up proposals, which however can be very time-consuming for both the researcher and funder if they must be fully reviewed.
- **Encourage a reflective approach to research and innovation.** To ensure that research and innovation do not lose sight of the larger objectives, some programmes (e.g. Societal Transformations of Volkswagen Foundation, LIRA 2030) ask for a formalized process of (self-)reflection on the chosen approach and the roles of individual participants. One purpose of this reflection is to review assumed impact pathways, identify possible unintended effects, and amend action plans. Regular gatherings of

the project team can be used to review progress, refresh assumptions, reassess the intended impact, and draw lessons about the effectiveness of actions or interventions that have been implemented. To ensure and support such reflection, funding programmes can ask for accompanying research in different formats (with or without intervening in the projects) and duration (Defila and Di Giulio, 2018). They can furthermore provide reflective tools to support funded projects in reflecting on current collaboration and integration processes and in deriving lessons learned and insights for next steps (e.g. Deutsch and Hoffmann [2021]).

2.2.4 Building long-term transformative networks

A common shortcoming of transformative research and innovation is that, while meaningful for those directly involved, it may have little wider impact (Polk, 2014; Hoffmann et al., 2019). Embedding research and innovation in societal dynamics (2.2.1) may thus require investing in further and longer-term social interactions, networks, and partnerships. In sustainability science, a knowledge system is referred to as a ‘network of actors connected by social relationships, formal or informal, that dynamically combine knowing, doing, and learning to bring about specific actions for sustainable development’ (van Kerkhoff and Szlezák, 2010, p. 4603). A critical role of lighthouse programmes should be to support longer-term societal change by helping establish and maintain such knowledge systems.

Design options

- **④ Fund research and innovation over longer periods so that networks and long-term partnerships can be established.** The LIRA 2030 programme encouraged institutional commitments rather than individual ones, leading to partnerships and networks that sometimes lasted beyond the project period. Indeed, networking and collaboration were recognized as the most important outcomes of the LIRA 2030 programme. Volkswagen Foundation’s Societal Transformation projects last up to five years and SWEET funds consortia for six to eight years; Innosuisse Flagships are completely flexible with respect to the duration of projects. The 12-year period of the SPP Umwelt was seen as instrumental in its success in founding enduring institutional structures and networks. NCCRs have a duration of 12 years and aim at building up structures that in the longer run will be financed by academic institutions. In addition to such concepts, lighthouse programmes could also offer funding for continuing collaborations created during the project’s phase. It might also be important to support interdisciplinary and in-

Box 3: Knowledge co-production

Because transdisciplinary research is about tackling societal problems, it has a normative orientation towards the common good, rather than serving particular interests (Pohl and Hirsch Hadorn, 2007). For this reason, transdisciplinary research seeks to consider and integrate all perspectives relevant to an issue (cf. 2.2.1) through a process known as knowledge co-production (Polk, 2015). This is a mode of research in which people from outside the research and innovation community (actors and stakeholders) work together with researchers in a process of shared learning.

Knowledge co-production approaches are important in sustainability research and innovation for several reasons:

- they help ensure that the research questions are framed in a way that is relevant to societal needs
- they allow the research to benefit from the experience and expert knowledge of societal actors and stakeholders
- they help build confidence among societal actors and stakeholders that the proposed options for action are in their best interests
- they help ensure that the results are presented in a way that is directly useful to decision-makers.

ter-sectoral collaborations that were not fully developed during the main research phase.

- **Establish long-term research and innovation networks.** NCCRs are based at one or more home institutions and the creation of research networks is important for building bridges among scientists, the general public, and policymakers. Several NCCRs have created research centres that maintain the collaborations and continue the programmes' work after the funded period is over. IDRC works directly with researchers in developing regions through international offices in various countries. As such, IDRC focuses on supporting capacity building and enhancing institutions, recognizing that this is a crucial requirement to ensure that the knowledge generated from research projects has a significant impact and leads to meaningful positive changes in the targeted areas.
- **💰 Fund follow-up activities designed to maintain and strengthen social interactions, networks, and partnerships.** The SNSF recently tested the funding of Implementation Networks to maintain and expand communities and networks built around research in SNSF projects, to make use of knowledge generated in those projects, and to offer a space for researchers and non-academic actors to think about potential implementation (cf. 2.3.1). These networks serve to stimulate cooperation

There is no single form or intensity of knowledge co-production (Bandola-Gill et al., 2023). Depending on the problem and its context, it may be most important when framing research and innovation projects, or it may require close collaboration at all stages of the project. It may require just a few expert stakeholders, or it may benefit from larger networks and communities spanning different sectors or world regions.

Knowledge co-production can raise complex ethical considerations around responsibility, accountability, and power, which sometimes blur the lines between research, innovation, and practice. Its successful application, therefore, depends on building partnerships that are transparent and based on mutual trust and respect.

For all these reasons, knowledge co-production is something that needs to be carefully planned and monitored throughout the research process.

Sources and toolboxes that provide useful guidance on knowledge co-production are listed in Section 2.4.1.

and exchange among diverse actors and communities, thereby contributing to intensifying and speeding up the application of research results in the public sector, politics, the economy, and society at large. The SNSF 'Transformation accelerating grants (TAGs)' offered as part of the R4D and SOR4D programmes (cf. 2.3.3) are also aimed at strengthening and expanding networks and partnerships, since these are key for making use of the knowledge, tools, and technologies developed within projects.

- **Encourage other actors to take over networks that developed as part of the programme.** As a consequence of the SPP Umwelt, the Swiss Academy of Sciences established offices to serve and develop thematic communities (e.g. around climate and global change, biodiversity, genetic research) that had developed during the funding programme. These offices continue to connect researchers with actors from government, business, and civil society.
- **💰 Contribute to globally connected regional sustainability hubs.** Another option for lighthouse programmes is to take up the idea of 'Science Missions for Sustainability' promoted by the International Science Council (International Science Council, 2023a, 2023b) and invest in building up globally connected regional sustainability hubs. The agenda and priorities of these hubs, which would engage in science in the service of society,

would be determined by regional communities and stakeholder needs. Science communities would collaboratively design, produce, integrate, implement, and evaluate potential pathways to achieving sustainability outcomes. These hubs could radically increase regional capacity for understanding and addressing nexus issues.

– **Promote longer term networks among research funders.** The Belmont Forum is a good example of a long-lasting, international network of research funders and science councils united by a common goal, namely to enable transdisciplinary research aimed at understanding and mitigating global environmental change.

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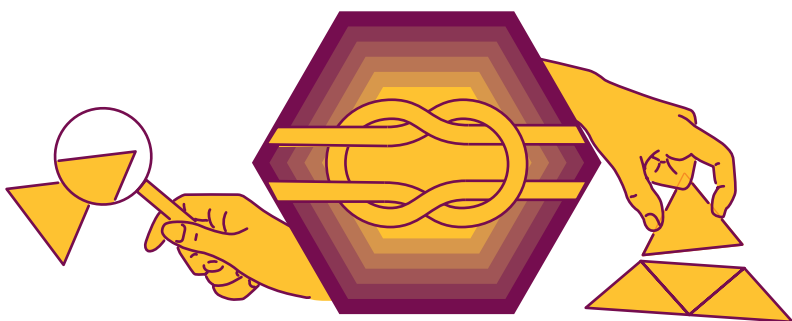
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2.3 Planning for impact

This chapter lists ways in which projects can link their work to implementation and choose effective approaches and output formats. One approach to specify possible impact pathways is Theory of Change (ToC), which is increasingly used in sustainability research and innovation to describe the causal relationships between a project and its intended effects (outputs, outcomes, and impacts), and to develop testable hypotheses about how and why change might happen (Belcher and Claus, 2020). In a complex social situation, the costs, benefits, and side-effects of particular actions may not be obvious and it will be necessary to test them in pilot settings.

2.3.1 Specifying impact pathways of generated knowledge

To increase implementation relevance, it is important to think from the beginning about the routes by which new knowledge could have a societal impact (Muhonen et al., 2020), the specific actions needed to ensure this impact, and the social or technical obstacles that may stand in the way. It is also important to distinguish between the direct effects of a research project and the indirect effects that depend on the decisions of actors unconnected with the project. For example, in an analysis of the impact of three NRPs in Switzerland, evaluators concluded that the main obstacle to applying research findings was a mixture of political resistance and lack of interest in the findings or even the topic. They went on to suggest that an effective impact pathway would require understanding and overcoming this lack of political interest. Thus, achieving impact might be possible by including in the project a wider range of fields and actor groups (Palavicino et al., 2023). A note of realism is necessary, however. While achieving impact is a desirable goal, it can never be guaranteed in an individual project: processes of social change are complex and influenced by constantly changing economic, technological, and environmental circumstances over which researchers have no control.

Design options

- **Ask applicants to elaborate on possible impact pathways for their proposed project.** Through its Societal Transformations profile area, the Volkswagen Foundation encourages researchers from diverse disciplines to use a ToC to contemplate how their research can be applied to effect positive changes in social structures. The LIRA 2030 programme organized a workshop on ToC to its grantees and asked all projects to conduct an annual self-reflection workshop to reflect on the validity of the project ToC developed and the adjustments required. In SOR4D, a ToC forms an explicit evaluation criterion. Projects are asked to explain how the results of a project could contribute to solving problems or provide concrete solutions in the context of Official Development Assistance (ODA) recipient countries. They need to propose how results could be validated and valorized in policy or practice and/or scaled up to other contexts.
- **Ask research and innovation projects to plan for developing knowledge in the form of specific transformation options (i.e. specific interventions, technological applications, or policies).** Transdisciplinary research can be a means to induce different types of transformation. Lighthouse programmes can ask teams to specify the type of transformation they envisage and to design the transdisciplinary approach accordingly (Palavicino et al., 2023).
- **Ask applicants to involve implementation partners in the design and execution of research.** Innosuisse Flagships, for example, are developed and executed by consortia that include at least two implementation partners. Similarly, the SWEET programme requires that at least two private-sector institutions be part of any research consortium.

2.3.2 Delivering options for action and promoting their adoption

Knowledge in the form of concrete options for action is useful to address case-based, specific problems. Such options for action can comprise technological and social in-

novations, development scenarios, policy and regulation proposals, suggestions for behavioural change, or business models. Research may therefore focus on relevant levers of change as described in the Global Sustainable Development Report (2023), including governance, economy and finance, individual and collective actions, science and technology, and capacity building.

The uptake of recommended options can be encouraged by ensuring they are presented in a form and language adapted to the main target group(s). In this connection, three forms of outputs are possible: information, tools,

Box 4: Real-world experiments

It is important to test new, concrete ideas about how to achieve sustainability in real-world settings. In recent years, several research approaches have been developed for proceeding from knowledge to action and thereby accelerating progress towards sustainability. These approaches include living labs, urban transition labs, transformation labs, and real-world laboratories (RWLs) (McCrory et al., 2020). Five constituting criteria for RWLs are (cf. Parodi et al. [2016], Wanner et al. [2018]):

1. Explicit normativity, with sustainable development as the guiding principle
2. A transdisciplinary approach aimed at building a bridge between science and society
3. A hybrid endeavour aimed at both societal transformation and scientific insights
4. Inclusion from the very beginning of stakeholders from different societal sectors
5. A long-term research setting that provides a framework and infrastructure for real-world experiments

In an RWL, experts of different disciplines and actors of diverse societal sectors jointly identify sustainability issues, and develop and implement concrete measures to address them. These measures (which could include social, economic, technical, legal, cultural, or other measures) are then tested in real-world experiments, to determine whether the theoretical ideas work in practice. Such ideas are necessarily based on simplifying assumptions about the complex real world, and the purpose of real-world experiments is to test whether these assumptions are realistic. If not, the proposed measures may either not work or have unexpected side-effects (Wagner and Grunwald, 2015).

Specific tips and success factors for RWLs can be found in Parodi et al. (2018, p. 179) and Bergmann et al. (2021, pp. 547–549). General success factors for demonstration and pilot projects, and insights into their role in societal transformations are provided by (Kristof, 2020).

and proposed changes in a system (Kaufmann-Hayoz et al., 2016). While there are many ways of sharing information (e.g. guidelines, handbooks, websites, etc.), tools designed to support concrete action (e.g. web-based analytical and visualization tools) usually require continuing scientific support and funds for their maintenance. Proposals for systemic change require the most follow-up work to have a chance of being taken up in practice.

Design options

- **Ask projects to specifically develop options for action.** Light-house programmes can support research projects by providing space for the development of specific innovations, such as through Social Innovation Labs, a short series of solution-focused workshops. Another option is to support innovation by dividing projects into stages. The French Fund for Innovation in Development (FID),⁸ for example, allocates separate funding for different project stages, including preparing the innovation, testing pilots, preparing for scale-up, scaling up, all the way to the transformation of public policy. The Innosuisse Flagship Initiative boosts systemic and transdisciplinary (social and technological) innovations that are central to Switzerland's economic and social challenges. The Innosuisse Innovation Boosters seek new ideas from researchers, aiming for radical solutions (known as the Challenge Stage of the programme).
- **Ask projects to develop outputs tailored for practice and policy-makers.** NRPs involve funded projects in a synthesis process to integrate their findings in an overarching context to generate knowledge that goes beyond the individual research results. Several research programmes encourage researchers to develop data platforms or information hubs. The FAIR (Findable, Accessible, Interoperable, Reusable) Guiding Principles for scientific data management and stewardship⁹ can help consortia to develop a data management strategy and improve the reuse of scholarly data. For example, in the Belmont Forum CRA 'Climate, Environment, and Health II', projects are expected to deliver innovative, cross-cutting data platforms that should be scalable, implementable, sustainable, and provide inclusive solutions for decision-makers.
- **Ask projects to provide systems for sharing and discussing results.** SWEET requires that a certain proportion of the project budget must be spent on knowledge and technology transfer (KTT) activities. Effective KTT is a demanding process that requires a high level of skill and experience, and it is therefore important for programmes to provide the necessary training. In NRPs

⁸ fundinnovation.dev/en/approach

⁹ go-fair.org/fair-principles

and SOR4D, budgets are provided for communication and dissemination activities. Projects are thus encouraged to think from the outset about how to communicate and disseminate their results to different audiences, and the dedicated funding (which cannot be used for research activities) supports them in this. Some NRPs bring together pairs of politicians and scientists to discuss scientific insights on issues of interest for policymaking.

- **Promote novel forms of discussion with a broader audience.** For example, through museum exhibitions, theatre performances, education centres (schools, universities), or civil society organizations.

2.3.3 Testing and validating transformation in pilot settings

Depending on complexities, it may be necessary to test potential options for action in pilot settings (e.g. real-world laboratories, cf. Box 4). These are useful where change processes need to be co-developed with practitioners;

cannot be fully planned, controlled, or anticipated and thus require exploration and probing; or may have too many unpredictable outcomes (Kristof, 2021). It is unrealistic to expect decision-makers to apply new solutions, however promising they may appear in theory, without evidence that they will work in practice. Private sector developers are understandably cautious about making large investments in new technologies, for example for power generation or space heating, that have not already proved to be reliable and cost effective. For these reasons, pilot and demonstration research involving stakeholders from outside the research community is crucial. It provides valuable insights into how new solutions will work in practice and what unforeseen side-effects, both positive and negative, might occur.

Establishing a pilot or demonstration project can be a challenging process. It usually requires a non-academic partner, for example a local authority or business, that is prepared to make a significant financial and time investment and also carry the risk if the project is unsuccessful. Such projects require strong relationships of trust and transparency between academic and non-academic partners. Researchers need to specify and be aware of

Useful examples: Societal Transformations, Volkswagen Foundation

Purpose and goal

- To create framework conditions for transformation processes and encourage researchers to think about the transfer of their research into social structures.
- To identify 'day-after-tomorrow' issues by integrating non-academic stakeholders.

Description

The Volkswagen Foundation is a private, non-profit organization that promotes science and technology in research and higher education. Its 'Societal Transformations' profile area supports research aimed at expanding knowledge about processes of societal transformation and developing possible courses of action together with stakeholders in civil society. It encourages cross-border and multi-perspective approaches and aims to open up new ways of contributing towards shaping societal transformations. And it encourages researchers to develop projects that are risky and 'surprising' with regard to its research questions and its research design. In addition, it offers experimental spaces for new methods such as explorative learning, creative research, and artistic research/artistic dialogues.

Funding and organization

- Funding is granted for a maximum duration of five years, with EUR 100,000–500,000 granted per project.

- Funds can also be used to support non-academic and international partners.
- Scholars from the humanities and cultural sciences are expected to play a central role in the research design.
- Integration of different scientific and non-scientific perspectives is one of the criteria for Volkswagen Foundation projects.
- The Foundation provides additional funds for unusual communication strategies that emerge during the project.
- Additional funds can be requested for the preparation and storage of research data (Open Science).
- Criteria for project selection include not only the planned approach, but also mechanisms to reflect on the roles of the participants.

Distinctive feature

Experts from non-academic fields form a part of the (non-permanent) review panel, ensuring that the proposals adequately address societally-relevant issues.

Further information

volkswagenstiftung.de/en/profile/profile-area-societal-transformations

their role in such collaborative processes within pilot settings. In addition, research in and on pilot settings often requires special methods to study processes of societal transformation.

Design options

- **💰 Support real-world experiments and demonstrator projects.** The new NRP 81 on Future Baukultur calls for living lab approaches. SWEET consortia are expected to define pilot and demonstration projects (P&D) that complement their research and innovation project portfolios. Depending on the topic of the call, SWEET requires consortia to use living labs. The FID enables the testing of several innovations to identify those that are most promising in the specific context and scale, with a focus on solving problems in low- and middle-income countries. With a focus on technology transfer, some NCCRs use virtual reality labs as experimental spaces. For instance the NCCR Automation provides examples of how this funding instrument works with real-world labs.
- **Offer experimental spaces for exploring new approaches.** The Volkswagen Foundation supports explorative learning, creative research, artistic dialogues, and experiments. The Innosuisse Innovation Booster includes an Idea Stage in which the desirability, viability, and feasibility of proposed ideas are tested.
- **💰 Support project follow-up activities that build on research outcomes.** The SNSF r4d programme offered ‘Transformation accelerating grants (TAGs)’ that allowed teams of researchers and non-academic stakeholders to make use of the knowledge, tools, and technologies developed within r4d research projects through translation and implementation initiatives. The follow-up programme SOR4D continues this instrument, offering projects the chance to extend their work into a 4th year in the form of a TAG.
- **💰 Fund research implementation networks.** Funded networks, which need to be composed of academic and non-academic actors, are intended to make research results more accessible and usable for society. The SNSF is currently testing its Implementation Networks, a new funding scheme for this purpose.

2.3.4 Exploring new pathways to impact

It is still common to think that research products are transferred to society in a few, mostly linear ways. These include technology transfer, knowledge brokerage through science–policy interfaces, and information campaigns directed towards the public (e.g. science exhibitions, public lectures, popular articles). If societal transformation is to

occur, it will be important to develop new pathways to impact that reach a larger audience and support multiplication and scale-up. These could include formal or informal exchanges, exhibitions, or social gatherings like the Swiss *apéros*, art or theatre-based interactions, or policy briefs. They could bring together students or established researchers with teenagers or elderly people from rural or urban areas, or with elected decision-makers at the communal, regional, national, or international level. They could bring together people who are already convinced about the importance of sustainable development with others who are indifferent or even reject the idea. They could aim at an open exchange for the sake of exchange, the joint definition of problems or goals, or the joint experimentation with ways forward. They could foster new encounters among different fields of knowledge, the humanities, or the arts. Indeed, social sciences, the humanities, and the arts have already been very active in creating new pathways to impact (Muhonen et al., 2020).¹⁰

Design options

- **Ask projects to assess impacts through interactive formats.** Programmes could ask research projects to include interactions (e.g. science-policy dialogue formats, real-world experiments, art-based interaction with the wider public, citizen science approaches) to test research impacts and develop successful approaches further. Such interactions could also be used to ask stakeholders what types of output would be most useful. Projects could also be asked to document productive interactions as a means to account for social impact and new impact pathways. This could be done through narratives or other methods (e.g. photo voice). Those interactions could then be shared in a repository as means to encourage new transformations in the programme. Interactions can be direct or indirect (Spaapen and van Drooge, 2011).¹¹
- **Ask projects to explore new pathways to impact.** The German instrument DATIpilot is an interesting example: it aims at supporting and learning for innovation and transfer and is an experimental space of the newly founded German agency for transfer and innovation¹² (DATI). It funds projects in two categories that it calls innovation sprints and innovation communities.

¹⁰ In the EU CORDIS database, there are several examples of how these interactions have led to successful practices in future research.

¹¹ The SIAMPI project offered a classification that is currently used in funding schemes in the Netherlands: eur.nl/en/research/research-services/societal-impact-evaluation/impact-evaluation-toolbox/productive-interactionssiampi

¹² bmbf.de/bmbf/sharedocs/bekanntmachungen/de/2023/07/2023-07-12-Bekanntmachung-DATIpilot.html

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2.4 Programme-level support for sustainability projects

A lighthouse programme is composed of individual research or innovation projects, each focused on a particular sustainability question or problem. An important responsibility of the programme as a whole is to provide a supportive research and innovation environment for these projects and the researchers who work on them. Here, we describe some of the ways in which programmes can support component projects, increase their societal impact, and respond to changing research and innovation needs.

2.4.1 Facilitating collaboration and knowledge co-production

Sustainability research uses a variety of transdisciplinary methods to enable the co-production of knowledge with stakeholders (Box 3). While some scientists have been trained in these methods (Bammer et al., 2020; Hoffmann et al., 2022), academics from disciplinary backgrounds usually have little experience of them. To interact effectively with stakeholders, it is important that researchers in lighthouse programmes develop a high level of competence in these methods.

Design options

- **④ Train researchers in transdisciplinary methods and knowledge co-production.** In their annual research fora, the LIRA 2030 programme organized courses for PIs on transdisciplinary theory, methods, and tools. These aimed to provide the researchers with competences including managerial and facilitation skills, sensitivity to political issues, managing tensions and reputational risks, and working with diverse stakeholders from villagers to government ministers. The capacity-building activities included presentations by experts as well as coaching and self-reflection workshops; they were carefully phased, starting with skills needed for research design (e.g. methods for co-designing research questions), followed by those needed to perform the re-

search (e.g. stakeholder engagement methods), and finally skills for writing up and communicating results (International Science Council, 2023).

- **④ Engage experts to facilitate interaction processes.** Projects that lack experience in transdisciplinary approaches may benefit from expert support provided by the programme. Such facilitation can be offered in the form of workshops for PIs, for example. Or it can be offered to funded projects so that they can use it whenever needed, e.g. to train researchers or to manage critical phases of the project, such as the co-design of research questions with stakeholders. For instance, a workshop on how to render research societally relevant, based on a specific tool comprising ten reflective steps (Pohl et al., 2017), was organized for researchers in the Joint Initiatives of the ETH Domain programme. Experts can also help in integrating knowledge, ideas, and perspectives across different projects (cf. 2.1.2).
- **④ Provide funding to support transdisciplinary collaboration, especially at critical stages in the research.** The SDU Programme (Akademien der Wissenschaften Schweiz, 2017) provided funding specifically for preparing developing inter- transdisciplinary research proposals (up to CHF 200,000 per project) (cf. 2.2.1). Similarly, the Austrian funding scheme #ConnectingMinds awarded projects that had passed the preselection stage EUR 10,000 for problem framing and preparation of the final proposal. The NRP 82 on Biodiversity and Ecosystem Services calls for preparatory grants in order to finalize the mixed project teams (actors from science and practice), ensuring shared responsibility and co-design of the full proposal. In addition, all NRPs offer funds to research projects for implementation activities.
- **Make use of toolkits and heuristic frameworks designed to support collaborative research.** The Network for Transdisciplinary Research of the Swiss Academies of Arts and Sciences offers a web portal¹³ providing methods and tools for co-producing knowledge that can systematically be searched by key issues or by research phases.

¹³ transdisciplinarity.ch/toolbox

The Shape-ID toolkit¹⁴ offers tools for different users, including funders and researchers. A number of publications (e.g. Collaboration and Team Science: A Field Guide [Bennett et al., 2010], BiodivERsA's Stakeholder Engagement Handbook [Durham et al., 2014]) provide valuable advice on how to build and manage interdisciplinary research teams. There are also publications providing heuristic frameworks for critical phases in transdisciplinary research, such as joint problem framing (see Pearce & Ejderyan, 2020).

- **Organize events designed to connect with stakeholders and learn from previous projects.** The Horizon Europe framework programme offers an annual meeting where researchers can meet stakeholders and partners of previous projects and learn from their experiences. To foster collaboration, LIRA 2030 provided an annual research forum and cross-project collaborative grants. ICT Agri-Food organizes boot camps for young researchers where they meet potential partners, develop project ideas, and receive training and guidance. NRP programme events facilitate interdisciplinary scientific exchange aligned with the programme goals. NRPs also organize specific stakeholder workshops to promote discussions between science and practice. Many programmes (e.g. ETH4D, the Belmont Forum, the Flagship Initiative, and Biodiversa+) host 'matchmaking events' at which researchers can meet with potential cooperation partners.
- **Support collaborative research by joining forces with other donors.** It may be useful for actors, organizations, and donors from different sectors to join forces and pool resources in a joint funding instrument aimed at impact-oriented sustainability research and innovation. Another form of pooling financial resources within lighthouse programmes is to require projects to seek matching funds from other interested groups. Such collaborations can potentially reduce duplication and costs and increase societal impact.
- **Collect examples of best practice in co-production from different projects.** These can serve as inspiration for research teams as they design their own projects. One valuable source of such examples is QRiH (Quality and Relevance in the Humanities), which was originally designed as a tool to support writing research evaluations in the humanities¹⁵ (cf. 3.3).

2.4.2 Making knowledge accessible

It is important that knowledge generated by transdisciplinary research is made available in forms that are useful for decision-making. Many stakeholders are unlikely to read research results published in peer-reviewed academic journals but do make regular use of the internet. For this reason, online information hubs may be the best way to present research findings at the programme level (cf. 2.3.2), especially if they include analytical tools that allow users to visualize data, produce different types of summaries, and express their own comments and preferences on particular options. These information hubs may also allow members of the public to participate in the research process by submitting data or images (e.g. citizen science or crowd-sourced science) or their own design ideas (citizen design science).

Programmes have an important role to play in supporting effective knowledge transfer. Not only can they provide researchers with training in science communication, but they can also ensure that this type of work is suitably recognized and rewarded.

Design options

- **④ Develop and maintain information hubs that provide open access to research results, information, and analytical tools.** Several programmes maintain information hubs where articles, videos, policy briefs, and other communication products are published (e.g. the Knowledge for Development platform¹⁶ and IDRC Digital Library). ICT Agri-Food uses online platforms called 'Knowledge Incubators' to foster knowledge exchange and innovation. It also organizes events at which researchers and stakeholders explore ways to make project results widely accessible. NCCRs publish newsletters and maintain websites that contain information aimed at the general public as well as quizzes and games, etc. NRPs disseminate results on websites, via newsletters, press releases, and press conferences. Many NRPs produce videos, podcasts, policy briefs, and other products tailored to specific target groups.
- **Develop policies aimed at improving data accessibility.** Many sustainability research programmes, such as the Belmont Forum CRAs, require that the data be made freely available (i.e. open access). For maximum usability, however, other conditions must also be met, such as the data being discoverable through catalogues and search engines, easy to download, well-supported by meta-data, comprehensible even to a non-specialist, and stored in trustworthy repositories. Useful advice for developing a data management strategy is given in the FAIR (Findable, Accessible, Interoperable, Reusable)

¹⁴ shapeidtoolkit.eu

¹⁵ qrih.nl/en/16-english/about-qrih/249-background-of-qrih

¹⁶ k4d.ch

ble) guiding principles for scientific data management and stewardship (cf. 2.3.2).

- **④ Financially support researchers in the preparation and storage of research data (Open Science).** The Volkswagen Foundation Societal Transformations programme launched a separate call for this issue and provides up to EUR 100,000 per application for projects that have been supported by the Foundation.
- **④ Work with professional knowledge brokers to prepare research syntheses.** Policy briefs are an excellent tool for consolidating relevant scientific evidence and aligning it with significant policies. To ensure that these products adequately address societal concerns, it may be helpful to engage professional knowledge brokers to manage the dialogue between researchers and stakeholders on the research findings. For example, in the Biodiversa+ programme, knowledge brokers acted as ‘interpreters/intermediaries’ in conveying essential research findings to decision-makers. This programme also created animated videos that could be used to communicate the results to both the scientific commu-

nity and a wider audience. For their part, NRPs have a mandate to address overarching questions that cannot be answered on the basis of individual project results. This has resulted in one of their major achievements: the production of target group specific programme syntheses that present the scientific results of individual projects and integrate them into an overarching context. A programme synthesis generates added value and offers more than the sum of the individual results: it creates knowledge that goes beyond the insights provided by individual projects.

- **④ Provide training and guidelines for science communication.** Programmes can support researchers by providing examples of good practice in science communication. For examples, for the WINGS programme, Eawag compiled a brief Science Communication Toolkit (Deutsch and Hoffmann, 2023). Similarly, the LIRA 2030 programme helped researchers develop and disseminate engaging stories about their work in a blog and video format and also present their research in the media. The SNSF offers media training for researchers. NRPs mandate ex-

Useful examples: Flagship Initiative, Innosuisse

Purpose and goal

- To strengthen the competitiveness of the Swiss economy and/or contribute to the well-being of society by increasing efficiencies, reducing costs, or resolving socially relevant challenges in the public interest.
- To bring about desirable systemic change through the combined effects of the individual innovations.

Description

The Flagship Initiative is a funding programme of the Swiss Innovation Agency, Innosuisse. Innosuisse defines broad topics for research (‘Flagships’) and issues calls for proposals. Flagships are composed of interdependent and interrelated subprojects, in which partners from academia and industry across different disciplines work together.

Criteria for evaluating proposals include: Will the implementation of the research results on the market have a positive influence on the competitive situation of the implementation partner(s)? Will successful implementation lead to a positive impact on the future well-being of the country, e.g. by reducing poverty, increasing the quality of life, improving the quality of education, reducing injustice, or increasing biodiversity?

Funding and organization

- No limits are set regarding the duration or budget of a Flagship.

- A Flagship consists of three to eight closely linked and interdependent subprojects. A consortium consists of at least three research partners (of which at least one is a University of Applied Sciences), and at least two implementation partners.
- Flagships are flexible with respect to partners; as long as the original objectives are not negatively affected, new partners may join a consortium and partners may withdraw.
- The programme funds cover the wage costs of the research partner. The implementation partners are required to contribute to the total costs of the Flagship with own work and services, which must at least correspond to 40–60% of the overall project costs.
- An online ‘Matchmaking Platform’ supports applicants in finding suitable partners for their consortium.

Distinctive feature

Flagships aim to advance systemic innovation via the combined effects of individual innovations generated by the interrelated and interdependent subprojects.

Further information

innosuisse.ch/inno/en/home/promotion-of-national-projects/flagship-initiative.html

Useful examples: Leading Integrated Research for Agenda 2030 in Africa (LIRA 2030), ISC and NASAC

Purpose and goal

- To address complex sustainability challenges across African cities by increasing the production of high-quality, solutions-oriented scientific knowledge on sustainable urban development by early career scientists in Africa.
- To strengthen the capacity of African scientists in inter- and transdisciplinary research, i.e. in knowledge co-production together with local authorities, industry, communities, and government representatives.
- To increase institutional recognition and financial support for transdisciplinary research in Africa (and globally) by holding strategic meetings with science funding agencies, science decision-makers, and scientific institutions.

Description

Launched in 2016, LIRA 2030 was a six-year research funding programme implemented by the International Science Council (ISC), in partnership with the Network of African Science Academies (NASAC). It was funded primarily by the Swedish International Development Cooperation Agency (Sida). With a focus on rethinking urban futures in Africa, it funded two-year collaborative research projects led by African early-career scientists. Project consortia were expected to involve different scientific disciplines (at least one social and one natural scientist) and develop actionable, context-specific solutions with policy and society.

Funding

- With a total budget of ~5 million Euros, LIRA 2030 funded 28 collaborative research projects of up to EUR 90,000 each over

two years. The funded projects resulted from three calls and covered 22 countries and 38 cities across Africa.

- A two-step selection process was applied. Between pre-proposal and full proposal development, a five-day training in transdisciplinary research was offered to improve quality of full proposals and develop understanding of transdisciplinary research.
- Proposals were evaluated not only with respect to the academic outputs, but also whether the research process encouraged partnership building and fostered the science-policy-society interface.
- Up to 40% of project funding was allocated to knowledge co-design, co-production, and translation into policy and practice.

Distinctive feature

In addition to research funding, the LIRA programme delivered various capacity-building activities to early career scientists. It provided peer-learning, networking, and community-building opportunities as well as the possibilities to contribute to national, regional, and global international policy processes.

Further information

International Science Council/Network of African Science Academies. 2023. Leading Integrated Research for Agenda 2030 in Africa (LIRA 2030 AFRICA); Key achievements and learnings (2016–2021). International Science Council, Paris, France. DOI: 10.24948/2023.04

perts who support researchers in science communication and dissemination.

- **Nominate researchers to present their findings at international policy processes.** Programmes should seek opportunities to highlight their research at important policy events such as meetings of COP and IPCC, as was done in the LIRA 2030 programme.

2.4.3 Providing a forum for dialogue and debate on issues of sustainability

Lighthouse programmes should develop a dialogue on sustainable development with both the general public and with political and business leaders. These discussions are valuable, not only for creating awareness about sustainability problems and their potential solutions, but also for helping researchers better understand societal aspects of the problems they study (cf. 2.2.1). The exchanges can take many forms, including different kinds of meetings, focus groups, and blogs.

Design options

- **Establish formats for discussing specific questions with political and business leaders.** These meetings may serve to discuss emerging issues, the relevance of research outcomes for policy and practice, and areas for potential collaboration. They are valuable opportunities for researchers to meet influential stakeholders and also as ‘reality checks’ of whether their proposed research is relevant and their recommendations realistic and implementable. There are many examples of such dialogues with decision-makers, including the GCRF’s High-level Policy Dialogues and the Science and Policy Dialogues organized by CIFOR.¹⁷ Building networks which are based on a stakeholder analysis is an important part of NRP’s knowledge and technology transfer (KTT) concept. Often NRPs offer dialogue platforms to discuss specific questions with politicians and other decision-makers.
- **Establish a platform for discussing sustainability issues with the broader public.** There are many examples of such platforms, including the Sustainability Science Forum¹⁸ of the Swiss Academy of Sciences and ‘Forum für Wissen’ of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). The LIRA 2030 programme organized an annual research forum, which brought together researchers, urban experts, and representatives from global research initiatives with the aim of fostering community building and peer learning (Patel et al., 2022). NCCRs establish direct contact with the public through events such as ‘Science Info Day’ or camps for primary and secondary school students.
- **💰 Provide training for researchers in science–policy–practice dialogue.** For example, Biodiversa+ organizes capacity-building activities on topics that include stakeholder engagement and science–policy interfacing, science communication, citizen science, open science, and data management.

2.4.4 Tracking changing research needs, including rapidly emerging issues

Needs for sustainability research are changing continuously as pressures on social systems and the environment increase and as political, economic, and technological conditions change. Many research needs emerge gradually and can be anticipated from long-term trends and through horizon scanning exercises. Others arise suddenly, such as those caused by extreme weather events, disease outbreaks, or financial collapse.

To ensure that lighthouse programmes address the most important and relevant research questions, it is important for them to track changing research needs and adapt their activities accordingly. Programmes need to develop pragmatic strategies so that they can address new research opportunities, without prejudicing important long-term research.

Design options

- **Call for projects on a recurring basis so that newly emerging themes can be included.** This is done by SWEET in the context of energy research, while Biodiversa+ launches annual calls on a variety of pressing issues. The GCRF Emergency Response Fund allows researchers to apply for additional funding to rapidly adapt existing projects, as well as providing new grants to respond to emerging research questions. The Innosuisse Innovation Boosters support ways to meet major challenges by creating an environment to foster science-based and sustainable radical innovation.
- **Allow for projects to adapt as research needs change or new issues emerge, providing extra funding if necessary.** SWEET consortia operate for far longer than the roughly two years it takes to prepare them (from initial discussions on which topic to pick to the funding decision). It therefore selects topics that are likely to still be relevant 8–10 years later and also allows for them to adapt to changing circumstances.

¹⁷ cifor.org/tradehub/2022/09/19/gcrf-trade-hub-high-level-policy-dialogue-on-palm-oil-and-environmental-sustainability-facing-food-climate-and-energy-crises

¹⁸ sustainability.scnat.ch/en/id/Pd3fK?embed=UDMDq

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Useful examples: Solution-oriented Research for Development Programme (SOR4D), SDC and SNSF

Purpose and goal

To produce better knowledge, solutions, and innovation through needs-driven, transdisciplinary research that advances sustainable development and reduces poverty in the least developed, low-income, and lower middle-income countries.

Description:

The Solution-oriented Research for Development (SOR4D) programme is a joint funding instrument of the Swiss Agency for Development and Cooperation (SDC) and the Swiss National Science Foundation (SNSF) and operates from 2022 to 2027. It builds on experiences and lessons learnt from previous joint programmes (e.g. the Swiss Programme for Research on Global Issues for Development, also known as the r4d programme). The programme prescribes a transdisciplinary set-up, where researchers and development actors from the global South and Switzerland jointly generate solution-oriented knowledge in their respective geographical contexts and test and disseminate their research results with potential for innovation (pilot testing, valorization). The SOR4D programme recognizes a historical North–South imbalance in research for development. It thus encourages fair sharing of responsibilities and working conditions in consortia as a small contribution to redressing it.

Funding and organization

- With an overall budget of CHF 19.3 million, SOR4D funds 16 transdisciplinary research projects with around CHF 1 million per project for a duration of four years (three years for

research and one year for application and dissemination in the form of a Transformation accelerating grant, TAG).

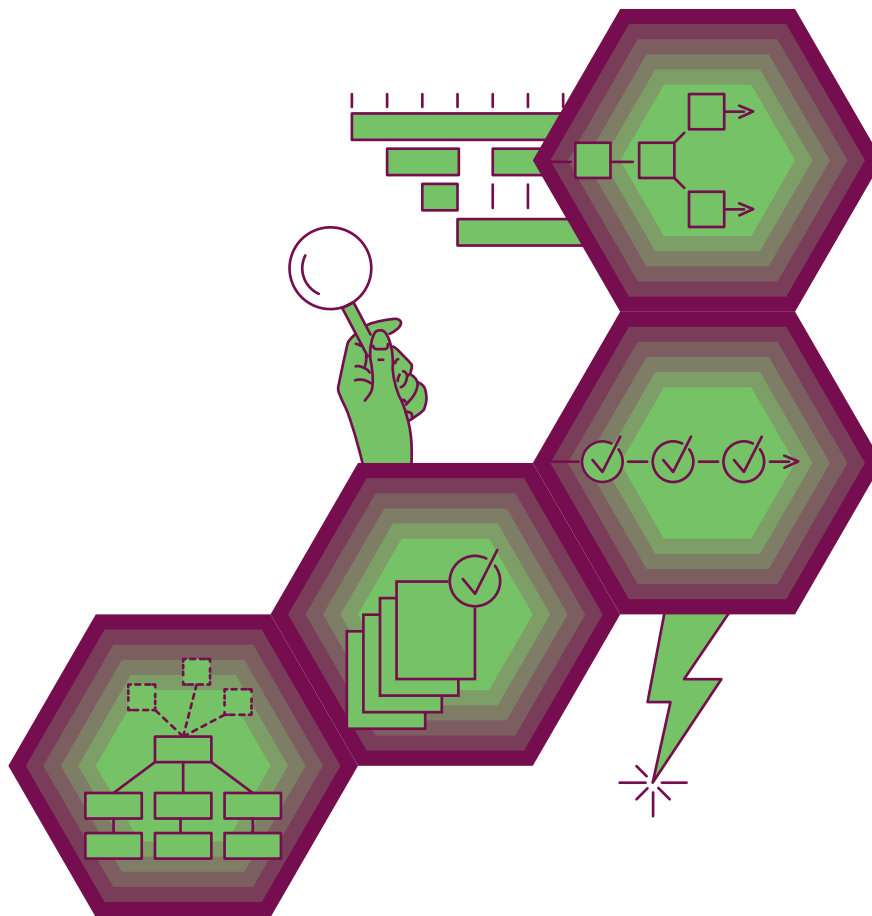
- Two-stage selection procedure (pre-proposals followed by full proposals). Projects invited to submit a full proposal can make use of a preparatory grant to organize a consortium meeting and develop their collaboration.
- A mixed review panel, composed of scientific and development experts from both global North and South. Scientific quality and relevance for development are of equal importance for projects funded in the SOR4D programme.
- 50% of the project budget must be spent in the partner country/countries, at least 20% must be allocated to development actors, and at least 10% must be spent on communication and dissemination activities to enable interaction and knowledge uptake.
- The SOR4D programme management takes an active role in monitoring projects and in supporting the community through workshops, trainings, and other events.

Distinctive feature

Development actors are part of the project consortium and thus share responsibility for the project alongside the research partners.

Further information

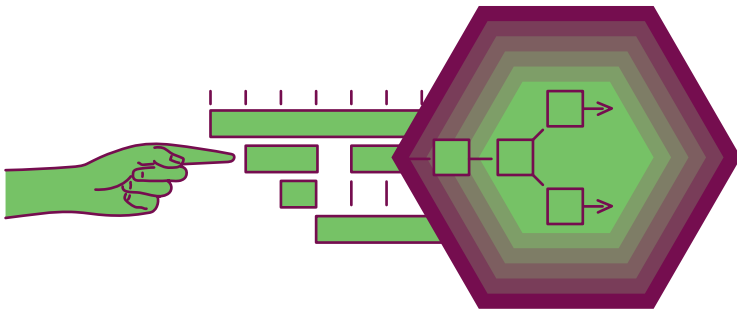
sor4d.ch



3 Programme development, governance, and impact evaluation

This chapter discusses the development and management of lighthouse programmes and proposes ways to make them effective in supporting sustainability transformations. It puts a special focus on issues relevant in the preparatory stage of programme development (3.1) and

highlights aspects around programme leadership, especially its composition (3.2). It also makes recommendations directed towards funding agencies for assessing proposals (3.3) and formatively evaluating actual programme outcomes and impact (3.4).

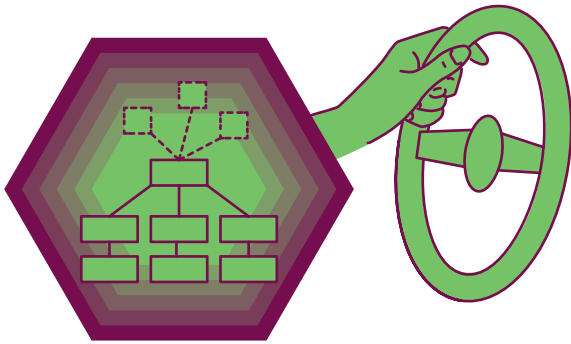


3.1 Redefining programme development

The process of developing a large sustainability research and innovation funding programme begins long before the programme is launched and involves many steps. These may include: studying problem perspectives and societal dynamics (cf. 2.2.1), gaining financing partners, obtaining institutional and policy support, mapping stakeholders and their interests, building alliances, developing impact hypotheses, and planning knowledge synthesis and dissemination. Mechanisms must be set up for formatively evaluating the actual programme outcomes and impact (cf. 3.4). Experiences with SWEET indicate that this preparatory phase can easily take two years, which also means that funding and other resources must be available to support the process of developing lighthouse programmes. Indeed, experience shows that the demands of developing a large programme funding sustainability research are generally underestimated (cf. SCCER evaluation report [Innosuisse, 2021]).

Design options

- **Use a Theory of Change approach to develop impact hypotheses at a programme level** (ToC, cf. 2.3.1). Several programmes have found ToC useful for visioning, planning communication, monitoring, evaluating, and learning at the programme level (Deutsch et al., 2021).
- **Involve experts from science and practice in developing and designing the calls for projects.** ICT Agri-Food, for example, offers a joint online workshop bringing together funding organizations and experts to adapt the format of a call.
- **Develop programme topics and foci through an iterative process.** NRPs develop scientific knowledge in support of solving current social and economic challenges. The process of selecting the topics for new NRPs involves a public and open call, followed by feasibility studies on promising topics, development of programme concepts, and drafting of call documents. In this process, the scope, goal, and research modules of the programme are designed in an iterative process with expert groups, the National Research Council of the SNSF, and the federal administration. The Federal Council takes the final decision and entrusts the SNSF with the implementation of the NRP.



3.2 Expanding programme leadership

Sustainability transformations involve numerous actors and stakeholders and often require globally concerted efforts to deal appropriately with spillover effects. Research and innovation funding programmes therefore need to ensure connectivity not only across diverse academic disciplines and fields of professional practice, but also across administrative, political, and national boundaries. In addition, they need to consider how these linkages can be maintained from the earliest planning stages of a programme to the post-research phase (something that is rarely considered in most funding programmes). Pursuing a respective overall strategy and focus requires an expanded programme leadership.

The complexity of sustainability research and innovation requires that leaders of a lighthouse programme consider interdisciplinarity, practice orientation, and spatial interconnections to form a balanced view of research needs and opportunities. This means that they must be familiar, not only with the state of disciplinary, interdisciplinary, and transdisciplinary research, but also with relevant developments in policy and practice. Given the emphasis upon societal processes, it is increasingly recognized that the arts, humanities, and social sciences should be more strongly represented in the leadership of sustainability research programmes.¹⁹

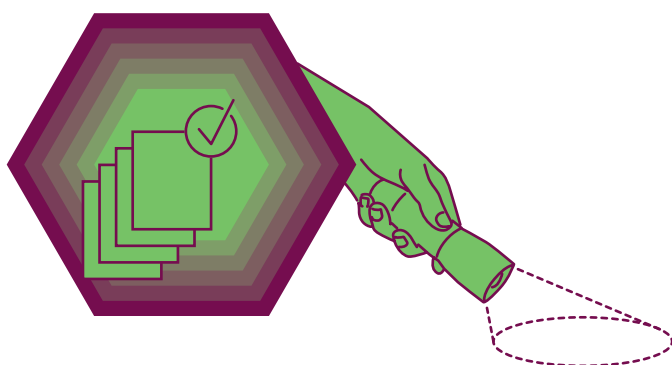
Design options

– **Involve key actors from practice in strategic programme bodies and/or build a joint programme management office.** A possible model is the enlarged stakeholder board of Biodiversa+. Others are the external advisory board of ETH4D and the review panel of SOR4D, which include researchers and practitioners from both the global North and South. NRPs have steering committees composed of experts from science from Switzerland and abroad – from different disciplines, with different research approaches (particularly use-inspired and applied sci-

ence), and from industry. Delegates of the National Research Council, representatives from the federal administration, knowledge and technology transfer (KTT) experts, and programme managers complement the steering committee in their advisory capacity. For larger inter- or transdisciplinary consortia, management support at the top programme level seems indispensable.

- **Participate in multinational research consortia as a means of promoting international collaboration.** Depending on the scope of the programme, consortium partners might include science funding agencies, foundations, government departments, businesses, and international development agencies. Ensuring regional representation in the leadership can also be very important in terms of increasing the relevance of the programme. These partners would jointly specify the terms of the research and award the programme. The r4d and SOR4D programmes are both partnerships between the SDC (government body) and the SNSF (funding agency), bringing diverse competencies to the table. The Belmont Forum CRAs represent an example of a funding scheme that fosters collaboration between funders internationally.
- **Allow for flexibility with respect to changes in programme leadership composition.** With changing circumstances and growing knowledge, changes not only in project and programme goals (cf. 2.2.3 and 2.4.4) but also in programme leadership might be useful.
- **Expand lighthouse programme leadership by including PIs of funded projects.** Lighthouse programme leadership can also be expanded by involving the PIs of individual funded projects in steering bodies. This would strengthen the coherence between projects and ensure that they build and use synergies to serve the overall programme goal.

¹⁹ The SHAPE-ID website collects some interesting and successful funding examples of this: shapeidtoolkit.eu/case-studies



3.3 Redesigning proposal assessment

According to Pohl et al. (2011), the evaluation process for sustainability-oriented research proposals differs from that for conventional research in four key ways: a) composition of the panel making the funding decisions, b) choice of reviewers, c) design of the review process, and d) questions for reviewers to consider. Important questions regarding the framing of the research should include its practical relevance in addressing sustainability goals and the feasibility of impact pathways (cf. 2.3). It is also important to assess the quality of productive interactions between science and practice that may arise from the proposed research (DORA declaration, Muhoenen et al. [2020]). Questions regarding the organization and management of a project should include the degree of inter- and transdisciplinary integration; mechanisms for self-reflection and adaptation; problem-solving competences; and management, social, and leadership skills.

Design options

- **Include representatives from different fields of science and practice in both the panel and the reviewers.** This is done in Belmont Forum CRA expert panels and also by the Volkswagen Foundation. The LIRA 2030 programme engaged reviewers from different disciplines and areas of professional practice to review each proposal. During the selection process, the LIRA 2030 programme focused on the quality of the proposals rather than the academic track record of the proposers. Importance was given not only to the scientific academic outputs but also to activities directed towards partnership building, the science–policy interface, and capacity building. A practical problem encountered by the LIRA 2030 programme was a lack of reviewers with experience in assessing transdisciplinary research. It may therefore be necessary to actively build a community of reviewers with transdisciplinary skills.
- **Ensure a suitable balance of disciplinary, interdisciplinary, and transdisciplinary expertise in both the call and the selection process.** In the Austrian funding programme #Connect-

ingMinds, for instance, it was mainly the transdisciplinarity experts who defined the evaluation of proposals; only at a later stage of the selection process were the proposals' disciplinary quality checked.

- **Involve applicants in selecting reviewers and determining evaluation criteria** (Klein, 2008; Huutoniemi et al., 2010).
- **Allow applicants to respond to the external expert reviews, so that panels can evaluate proposals based on both the expert reviews and the rebuttals.** Following a review of the NCCR selection process (see Langfeldt and Brorstad Borlaug [2016]), rebuttal letters were implemented at full proposal stage. Rebuttals can improve the quality of the review process by giving applicants an opportunity to address reviewer bias, clarify misunderstandings, and correct errors. In a two-step selection process, the LIRA 2030 programme provided expert comments to pre-selected proposals and the applicants were able to address those comments in the full proposals.
- **Use criteria designed to assess programme integration and co-production.** These are important criteria used by the Belmont Forum in assessing CRAs. The SOR4D programme includes eight evaluation criteria, in which scientific quality and relevance for development are of equal importance. Proposals have to demonstrate awareness for gender, intersectionality, and social inclusion and how these will be ensured throughout the research process. Transdisciplinary approaches and innovation potential can be among programme-specific criteria of NRPs, while impact, application, and implementation are usually among the main assessment criteria. Other criteria that have been proposed include collaboration readiness of teams (Hall et al., 2008; Hall et al., 2019), complementarity of team members, and intrinsic motivation (i.e. beyond receiving funding). While the complementarity of team members can be assessed in the written proposal, willingness to collaborate and intrinsic motivation can be more easily assessed through an interview.

- **Build awareness among evaluation committees of the need for research and innovation on sustainable development to deal with norms and values** and build capacities to evaluate such normatively-charged research.
- **Be fair to all applicants when assessing proposals from multinational consortia.** In assessing contributions from the global South, for example, more emphasis should be paid to the concept and content of a proposal than to formal aspects such as the quality of the English. This was done by the Belmont Forum in their CRA ‘Climate, Environment, and Health II’.

Box 5: Societal transformation

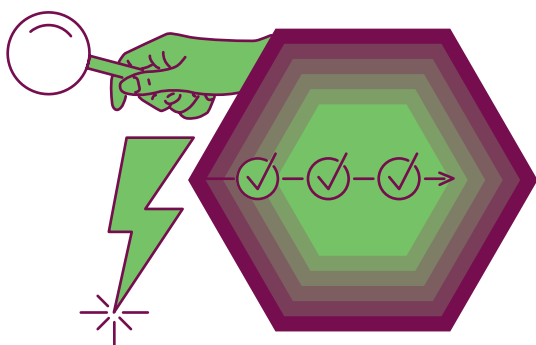
For societies to become more sustainable, profound changes will be needed. These changes will affect individual behaviour, political processes, and business models; they will impact every aspect of our lives, including patterns of consumption, how we produce energy and food, how we design and build our houses and towns, and our travel behaviour. Change of this magnitude is what is meant by societal transformation, which is variously characterized as being systemic, structural, radical, revolutionary, and disruptive (International Science Council, 2021). It requires new knowledge and new ways of thinking, for example, to transform commodity industries into circular economic systems. Many modes of doing research have been proposed to produce the knowledge needed to manage rapid change, including mission-oriented research, convergence research, transformation research, and transformative research. Here we focus upon the last two, which have especial relevance for sustainability.

Transformation research is descriptive-analytical. It examines the conditions under which transformations take place, which mechanisms and actors play a role, and which factors promote or hinder change. It focuses on how a system is structured

and functions (‘systems knowledge’), it documents prevailing goals (‘target knowledge’), and by analysing transformation processes, it contributes to the know-how of how future desirable states can be achieved (‘transformation knowledge’). These three types of knowledge are all needed to support progress towards solving problems (ProClim, 1997).

The term transformative research is used in two different but related ways. The first describes research that aims to overturn an existing paradigm and replace it with another. This meaning is captured in the US National Science Foundation’s definition of transformative research as ‘research that has the capacity to revolutionize existing fields, create new sub-fields, cause paradigm shifts, support discovery, and lead to radically new technologies.’ The second usage emphasizes the participation of the researcher, together with other social actors, in the change process, which leads to both personal and societal transformation.

See here for an overview of research on sustainability transformations and the development of the respective research fields in Switzerland: naturalsciences.ch/id/MIRbN



3.4 Integrating formative impact evaluation

Like any large research programme, lighthouse programmes should be subject to periodic evaluations. In principle, these would assess the contribution of the research to achieving societal goals, such as promoting positive changes and improving policy and decision-making. However, this may be impossible for various reasons. These include the fact that programmes address complex systemic processes, that any impacts may only become manifest slowly, and that many other circumstances – social, economic, and technological – may change at the same time. For this reason, evaluations at the programme level will usually have to focus on the more immediate outcomes of the research, including not only tangible research products but also the programme’s success in stimulating public awareness and debate. How these outcomes can be identified is itself a topic that requires more research.

In the context of lighthouse programmes, formative evaluation implies a process of continuous dialogue aimed at improving impact and more closely linking programme and project levels because of the explorative character of research and innovation for sustainable development. An important management function of programmes is thus to formatively evaluate the component projects using easily accessible diagnostics, to the benefit of both the project and the programme as a whole.

Design options

- **Be explicit about what ‘impact’ means in a particular programme.** Impact is a ‘fuzzy’ term that needs to be defined precisely in a particular context. Programmes can help by providing researchers with examples of what they understand by impact and how it may unfold. A heuristic for capturing the different effects of transdisciplinary research is provided by Schäfer et al. (2021), while Pärli et al. (2022) discuss how project effects may differ in the global North and South.
- **Undertake formative evaluations at the programme level.** Belcher & Hughes (2021) advocate a multifaceted, theory-based approach to evaluating the impact of integrated problem-oriented research programmes that includes testing the programme’s ‘Theory of Change’ (ToC, cf. 2.3.1) by assessing its anticipated and effective influence on policy, institutions, and practice.
- **Encourage impact evaluation at the project level.** There are various ways in which projects could evaluate the societal impact of research. One is to perform ex-ante co-design of impact evaluation. This involves developing a rational basis for anticipating the impacts of the research in collaboration with stakeholders (Kny et al., 2023), and tracking and modifying this as knowledge increases. Laursen et al (2022) advocates for different evaluation pathways depending on the problem and transformation envisioned in the proposal. In the Netherlands, the QriH²⁰ was an evaluation system implemented to allow for narratives to be included in the assessment of research collaboration within the humanities, i.e. their ‘productive interactions’ in research. The new SNSF CV²¹ also allows for this, which means that other types of impact are already being included in research evaluation.

²⁰ qrih.nl/en/16-english/about-qrih/249-background-of-qrih

²¹ snf.ch/en/gKcnwW6aEft4bMPF/page/your-curriculum-vitae-all-about-the-cv-format

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Useful examples: Collaborative Research Actions (CRAs), Belmont Forum

Purpose and goal

To support international transdisciplinary research that provides knowledge for understanding, mitigating, and adapting to global environmental change.

Description

The Belmont Forum is a partnership of funding organizations, international science councils, and regional consortia committed to the advancement of transdisciplinary science for environmental change and sustainability. Members propose thematic funding calls, so-called Collaborative Research Actions (CRAs), that correspond to their national research agendas. These CRAs can vary in scope and scale. Since its establishment, the Forum has successfully led 23 calls for proposals, committing over EUR 250 million, supporting 165 projects, including more than 1,000 scientists and stakeholders, and representing over 90 countries. Themes addressed by CRAs have included Coastal Vulnerability; Food Security and Land Use Change; Transformations to Sustainability; and Climate, Environment, and Health. New themes are co-developed through a scoping process with subject matter experts and funding agencies, including Belmont Forum members and interested supporting organizations. Each project proposal submitted to a specific CRA must be co-developed by natural scientists, social scientists, and stakeholders from at least three countries, supported by three funding organizations participating in the CRA.

Funding

- Available funds per CRA vary greatly, between EUR 1.3 million to EUR 27 million. Individual project budgets range from EUR 250,000 to EUR 3 million.

- Research consortia should be transdisciplinary and use participatory co-design, co-development, and co-implementation approaches.
- To promote more team building and collaborators, a two-step selection process can be applied (pre- and full proposals), which may span over six months. Guidance and training are offered to applicants during the proposal writing phase, e.g. scientific outreach, transdisciplinary methods, and data policy and management.
- Incubator workshops are organized as networking activities to connect researchers and stakeholders interested in submitting project proposals to a CRA.
- CRA proposals are not only evaluated according to scientific excellence, but also on how well the project is co-produced and according to the degree of integration that is achieved across the project consortium.
- Expert panels reviewing proposals include scientists and practitioners.

Distinctive feature

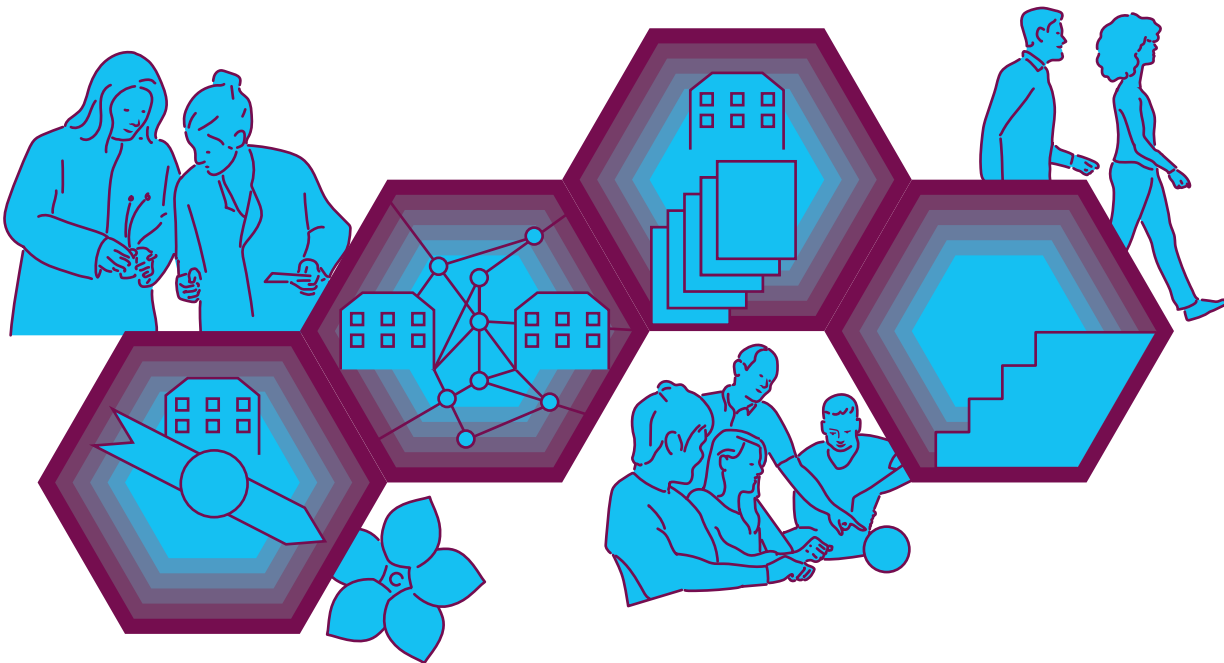
CRAs are jointly developed in a partnership between several Belmont Forum members (funding bodies or science councils from different countries) that also contribute to the call with their own funding.

Further information

belmontforum.org/cras

For future calls

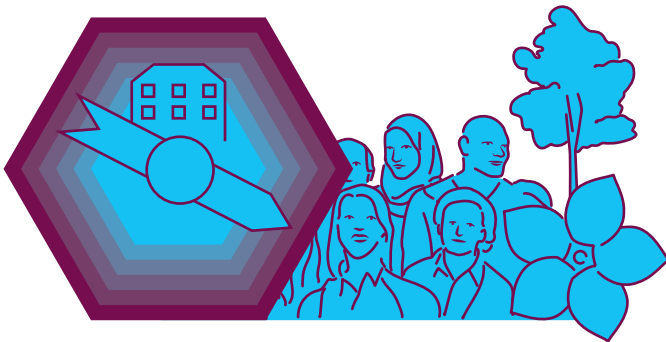
belmontforum.org/cras-in-scoping



4 Implications for research institutions

Fostering impact-oriented research in support of sustainability transformations offers specific opportunities for public and private academic research institutions (universities, universities of applied sciences, etc.). This chapter focuses on how research institutions can strengthen impact-oriented sustainability research and the role that lighthouse programmes can play in this development. It

presents options for making sustainable development an institutional priority (4.1) and for fostering cross-cutting research structures that support systemic and interdisciplinary work. It also makes recommendations for building capacity for transdisciplinary sustainability research and innovation (4.3) and for improving respective career opportunities (4.4).

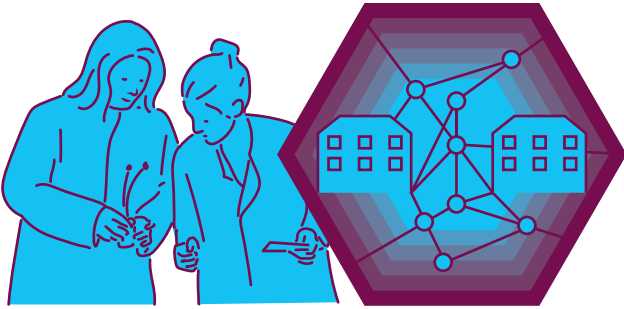


4.1 Making sustainable development an institutional priority

Contributing to sustainable development should ideally be a core value and common goal for academic institutions (Vogt and Weber, 2020), given the responsibility of science in society. Such ‘whole-institution approaches’ entail rethinking the curriculum, research priorities, campus operations, organizational culture, student participation, leadership and management, and community relationships. Strategically considering sustainable development also implies promoting sustainable and responsible research practices and making sustainability assessment an element of research evaluation. Much more prominence needs to be given to ethics and societal values in academic discourse. By linking research, teaching, and practice on campus, universities can become a beacon of sustainability for society as a whole (O’Donoghue et al., 2018; Vogt and Weber, 2020).

Design options

- **Make contributions to sustainable development explicit.** Research institutions can do this, for example, by developing Theories of Change (ToC, cf. 2.3.1) towards sustainable development and strengthening their capacity to support impact-oriented research for sustainability.
- **Include sustainable development in all curricula.** This is already done in some institutions of higher education, such as the University of Bern. There are many ways that universities could support education on sustainability, including using living laboratories as teaching settings (cf. 4.3).
- **Promote debate about ethical and normative dimensions of research and innovation.** Universities and research institutions have an immense impact on society through the knowledge and new technologies they develop. It is important, therefore, that they encourage active discussion within the research community about ethical and normative issues related to their research (Box 2).



4.2 Fostering cross-cutting structures

Because sustainability issues have many interrelated aspects, they can rarely be answered satisfactorily by one discipline alone. Many universities have experimented with novel structures to promote and foster continuity of interdisciplinary and transdisciplinary collaboration across organizational boundaries such as institutes, departments, and faculties. Among other activities, such institutions stimulate interdisciplinary research partnerships, provide funds for collaborative research, provide research and training in transdisciplinary methods, develop long-term partnerships with societal actors, and serve as a forum for dialogue with policymakers.

In developing new cross-cutting structures, it is important that these have sufficient resources and convening power within the university to achieve their objectives. All too often, new centres are launched with minimal funding and they find themselves unable to prevail in a system dominated by powerful departments and faculties. The public and explicit support for new cross-cutting structures from the university leadership is an important step in the right direction.

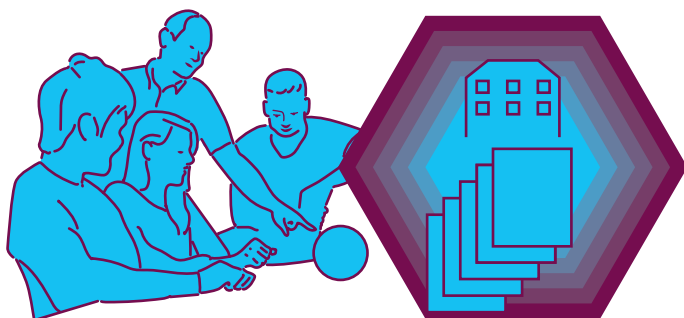
Design options

- **Establish cross-cutting structures for sustainability research and innovation.** The Stockholm Resilience Centre²² or the German Institute of Development and Sustainability (IDOS)²³ are inspiring examples of cross-cutting centres. The NCCRs provide several examples of new research centres that were established as part of a research programme. The Centre for Development and Environment of the University of Bern is an example of an interdisciplinary research centre established following an NCCR – the NCCR North-South. Other examples of institutionalizing interdisciplinarity and transdisciplinarity are given by Vienni Baptista and Klein (2022).
- **Establish new research facilities to support inter- and transdisciplinary research.** The Department of Environmental Systems Science at the ETH Zurich established the Td-Lab, a place where students, teachers, researchers, and other societal actors collaboratively define and tackle the complexities of sustainable development.²⁴ Many NCCRs created various types of physical and virtual infrastructure that universities continue to use.
- **Create positions that bridge different institutes, faculties, and departments.** Particularly relevant are appointments in domains so broad as to encompass the physical and social sciences as well as the humanities. Examples of such bridging disciplines are geography and anthropology (Youngblood, 2007), but also sustainability science or ecological economics.

²² stockholmresilience.org

²³ idos-research.de/en

²⁴ tdlab.usys.ethz.ch



4.3 Building capacity

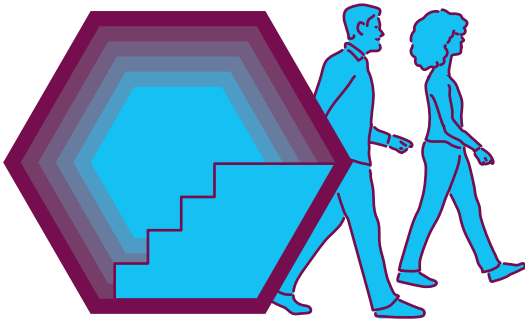
New forms of teaching, including competence-based study programmes and continuing education, are needed to build capacity for transdisciplinary sustainability research and innovation. Such research requires the ability to understand problems from the perspective of different actors and disciplines, as well as highly developed team and communication skills. It is also important to grasp the complexity of policymaking and the challenges of finding an optimal balance among many competing interests. Effective ways of developing these skills include case studies in which groups of students analyse complex, real-world problems and develop solutions in partnership with relevant stakeholders.

Design options

- **Develop transdisciplinary training at research institutions.** Institutions should promote sustainable development and transdisciplinarity in graduate programmes, as does the International Graduate School North-South (IGS), a spinoff from the NCCR North-South. The LIRA 2030 programme developed various training formats, some of which were later adopted by research institutions. The ETH Zurich offers inter- and transdisciplinary education as part of their MSc programme in environmental sciences, in a course called ‘Integration in Science, Policy and Practice: Inter- and Transdisciplinary Concepts, Methods, Tools’,²⁵ to provide students with necessary subject-, method-specific, as well as social and personal competences to analyse complex societal problems and generate promising solutions in an integrative way. The course Tackling Environmental Problems works with real case studies to teach problem solving approaches.²⁶
- **Monitor training formats developed by partners and stakeholders.** A repository of such formats is useful to avoid replicating the same content and format each time.

²⁵ vz.ethz.ch/Vorlesungsverzeichnis/lerneinheit.view?lerneinheitId=170665&semkez=2023S&lang=en

²⁶ tdlab.usys.ethz.ch/teaching/upl.html



4.4 Developing careers

There is an urgent need to improve career opportunities for those who engage in sustainability research. This will require new criteria for promotion and new career structures. The DORA declaration criticized the emphasis on peer-reviewed publications in promotion, arguing that more weight should be given to the overall quality of research output, as well as to criteria such as cooperation with stakeholder groups and science outreach. However, these new criteria are rarely considered as alternatives to an excellent academic publication record, but as additional demands, thereby increasing the pressure upon young researchers.

Design options

- **Recognize excellence in sustainability research by promotion.** Institutions should recommend researchers for promotion based on their achievements in transdisciplinary work. For example, they could promote scientists based on a strong record in managing transdisciplinary collaborations or non-traditional forms of knowledge transfer.
- **Lobby for novel forms of academic careers.** Institutions could actively develop career opportunities for sustainability researchers by creating positions such as ‘integration experts’ or ‘professors of practice’ and establish appropriate performance criteria. In this way, research institutions could benefit from outstanding individuals who have pursued most of their career in industry or public administration.
- **Ensure equal opportunities of employment.** This is a recognized responsibility for universities, but it becomes especially important in sustainability research and innovation, given its focus on societal problems. While most efforts have been devoted to promoting gender equality, such as providing financial support for childcare to facilitate research careers for both women and men, progress is also being made in other areas. For instance, the NCCR RNA & Disease has introduced supportive measures such as lab assistance before and during maternity leave, which has been adopted at the Department of Biology of ETH Zurich.
- **Promote or join communities of practice for developing career opportunities in sustainability science.** One example is the ITD Alliance Working Group on Integration Experts and Expertise,²⁷ which aims to develop the academic careers of integration experts and to strengthen integration across disciplines and between science, policy, and practice.
- **Develop leadership skills of early career researchers.** Institutions can also work closely with the Swiss Young Academies to foster the active participation and support of junior researchers and stakeholders interested in sustainability-oriented research. Mentorship programmes and associations, such as the World Young Academy, should also be part of the network of lighthouse programmes seeking to expand the competences in younger generations involved in co-production processes.

²⁷ itd-alliance.org/integration-experts

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Authors



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Peter Edwards

Until his retirement in 2017, Peter Edwards was Professor of Plant Ecology at ETH Zurich. While at ETH he served as Chair of the Department of Environmental Systems Science and subsequently Director of the Singapore-ETH Centre. He was also a member of the Executive Board of the Alliance for Global Sustainability, a research partnership of several leading universities. For the past five years, Peter has chaired the SCNAT Sustainability Research Initiative.

Who are we?

The **Swiss Academies of Arts and Sciences** are an association of the Swiss Academy of Sciences (SCNAT), the Swiss Academy of Humanities and Social Sciences (SAHS), the Swiss Academy of Medical Sciences (SAMS), the Swiss Academy of Engineering Sciences (SATW) and the Swiss Young Academy (SYA). They further comprise the two centres of excellence TA-SWISS (Foundation for Technology Assessment) and Science et Cité, as well as other scientific networks. The Swiss Academies of Arts and Sciences network the sciences regionally, nationally and internationally. They represent scientific communities on a disciplinary and interdisciplinary basis and independently of institutions and subjects. Their network is geared to the long term and committed to scientific excellence. They advise politics and society on knowledge-based and socially-relevant issues.

SCNAT – network of knowledge for the benefit of society

The **Swiss Academy of Sciences (SCNAT)** and its network of 35 000 experts works at regional, national and international level for the future of science and society. It strengthens the awareness for the sciences as a central pillar of cultural and economic development. The breadth of its support makes it a representative partner for politics. The SCNAT links the sciences, provides expertise, promotes the dialogue between science and society, identifies and evaluates scientific developments and lays the foundation for the next generation of natural scientists. It is part of the association of the Swiss Academies of Arts and Sciences.

With the **Sustainability Research Initiative (SRI)**, the Swiss Academy of Sciences, together with its sister institutions, promotes research on sustainable development and the 2030 Agenda. A special focus lies on inter- and transdisciplinary collaboration to jointly handle societal issues of higher priority in overarching consortia. The SRI is led by the SCNAT Steering Committee Sustainability Research.

The Sustainability Research Initiative represents Future Earth in Switzerland.

