73 NRP

Sustainable Economy
National Research Programme

Overview of the State of Research in NRP 73

A well-designed political framework and consumption and production patterns for a sustainable economy.

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

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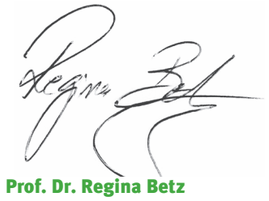
NRP 73
Swiss National Science Foundation (SNSF)
Wildhainweg 3
P.O. Box CH–3001 Berne
T +41 (0)31 308 22 22
E nrp73@snf.ch
W www.nrp73.ch

Preface

The transition to a sustainable economy requires a long-term perspective as it will affect the welfare of both present and future generations. Beyond the current urgency surrounding the COVID-19 pandemic, a shift towards a smarter and more prudent society, which is less vulnerable and more resistant to risks, is necessary. This reality is intrinsic to the transition to a sustainable economy. Policies are required, which balance costs and benefits in the long run and are based on principles of fairness and equity. Knowledge gaps remain in our understanding of the gains and drawbacks of such a transition. Closing some of these gaps is the main purpose of the National Research Programme "Sustainable Economy: Resource-Friendly, Future-Oriented, Innovative" (NRP 73). By creating new knowledge, NRP 73 may support Switzerland for future challenges.

Science can provide tools and recommendations that assist policy makers and private industry with their decision-making. Through its research, NRP 73 provides research findings that benefit the environment, the private sector and society as a whole. To be credible and relevant, the new knowledge must be collected, analysed and discussed with stakeholders.

This report provides a first overview of the state of research in NRP 73 at the midway point. The report has been organised so that chapters can be read independently. All statements made in this report are based on the research outcomes provided by the different research projects. A list of relevant publications can be found in the references section.



Prof. Dr. Regina Betz
Co-President of NRP 73

Prof. Dr. Gunter Stephan
Co-President of NRP 73

Back row from L.T.R:
Susanne Blank
Prof. emeritus Anne Petitpierre-Sauvain
Dr Barbara Dubach
Prof. Dr Katharina Michaelowa

Middle row from L.T.R.:
Prof. Dr Helga Weisz
Prof. Dr Regina Betz
Prof. Dr Gunter Stephan
Prof. Dr Alison Anderson

First row from L.T.R:
Dr Michael Obersteiner
Dr Pascal Walther
Prof. Dr Roberto Zoboli

Absent:
Prof. Dr Andrea Baranzini

1. Introduction

> Research needs to deliver solutions that decouple economic growth and prosperity from resource consumption.
>
> **Ruedi Noser,** Member of the Council of States

Transitioning towards a Sustainable Economy

NRP 73 aims at generating scientific knowledge about a sustainable economy that uses natural resources sparingly, creates welfare and increases the competitiveness of the Swiss economy.

With a well-designed political framework including economic incentives and through sustainable consumption and production, the transition to a sustainable economy can be achieved while improving people's welfare.

Objectives and Relevance of NRP 73

NRP 73 takes account of environmental, economic and social aspects and examines natural resources across all stages of the value chain. Its objectives are to:

- Acquire scientific knowledge to better understand and facilitate a sustainable economy;
- Identify opportunities and risks against the backdrop of a globally connected Swiss economy;
- Understand the dependencies and vulnerabilities resulting from the chosen measures and instruments;
- Identify priority areas for the future and propose specific areas for implementation.

NRP 73 funds "use-inspired basic research" and coordinates research through systematic monitoring and knowledge exchange.

This report aims to:

- Inform the private sector, associations, politicians as well as authorities and public administrations about the state of research of NRP 73;
- Present initial scientific achievements and explain the scope of the four new projects;
- Show the relevance and potential impacts of preliminary research findings;
- Highlight resulting opportunities and challenges of a sustainable economy and practical implications in the thematic fields of NRP 73.

A more comprehensive, integrated and target group tailored communication of the findings will be implemented in the synthesis phase, starting at the end of 2020.

Facts and Figures about NRP 73

At the core of NRP 73 are the 29 research projects made up from a diverse consortia featuring 66 project leaders, 30 postdocs, 45 doctoral students, 39 further employees from a range of disciplines and research institutions all over Switzerland, supported by 60 private and 50 non-academic partners.

The Sustainable Development Goals and NRP 73

Given the current overuse of natural resources meeting the 2030 deadline set by the United Nations to achieve the Sustainable Development Goals (SDGs) requires creativity and innovation.

The ambition of NRP 73 is to contribute to the achievement of the SDGs. For example, many of the 29 projects address a number of these goals such as:

- SDG 9 Industry, Innovation & Infrastructure;
- SDG 11 Sustainable Cities & Communities;
- SDG 12 Responsible Consumption & Production;
- SDG 13 Climate Action;
- SDG 15 Life on Land.

The transition towards a sustainable economy will create winners and losers and might entail adverse short-term effects on growth and employment. More broadly, potential trade-offs between different SDGs will have to be considered.

Sustainable Development Goals

2. Scientific achievements

> Whether a country benefits or loses from a transitioning towards a sustainable economy will largely depend on the occupational structure of the country.
>
> **Niggli and Rutzer,** researchers from the project Green labour market effects

2.1 Sustainable Finance and Governance

Legal and social conditions in the financial sector, the labour market and acceptance of policy measures are interrelated.

Sustainable finance aims at encouraging firms to invest into projects, which are environmentally friendly and improve society's overall welfare. Deeper knowledge of the relevant skills, the necessary changes in governance and the interrelation between government-led measures and private initiatives is needed to harness such finance.

Technological change, especially towards clean technologies, is a cornerstone for the transition to a sustainable economy. This requires significant investments and a skilled workforce. The latter challenges the education sector. Since investment decisions are driven by trust and the perception of risks and uncertainties, policy-makers can set adequate signals for supporting the engagement of investors.

Sustainable Finance

The research projects related to sustainable finance are addressing the impact of investment decisions on the transition to a sustainable economy.

The project Sustainable finance confirms that companies which are issuing "green" or "sustainable" bonds, i.e. fixed-income securities issued to raise capital for financing their projects based on the requirements of environmental, social and governance (ESG) management, attract investors who show concern for these issues. So far, they perform rather better in financial terms than more traditional ones. Their success increases the effect of incentive taxation pursuing similar goals.

In turn, this improves the positive effects expected from sustainability policies, such as an increase in general social welfare.

Furthermore, the Swiss economy has the opportunity to play a major role in the international transition towards sustainable finance. The high number of cash rich investment funds and institutional investors, as well as Microfinance Investment Vehicles and Impact Funds, supports this thesis. According to a feasibility study performed in this project, a Swiss Social Stock Exchange (SWISOX), where financial instruments geared towards supporting a sustainable economy are traded, could be an innovative instrument to promote sustainable finance (see Figure 1).

The project Financing clean tech uses text-mining techniques to build historical indices of environmental regulations on the basis of articles on environmental and climate policy found in newspapers. It shows that due to the sector's large dependency on public support, announcements about environmental policies affect investors' expectations about the profitability of investing. And thus, any uncertainties about environmental policy are particularly harmful to clean tech investments.

Governance

The projects related to governance look at how challenges in the labour market can affect the path towards a sustainable economy, and also the impact of voluntary corporate environmental initiatives.

Preliminary results of the project Green labour market effects show that a significant proportion of the Swiss workforce already has the necessary skills required for the transition towards a sustainable economy. These skills largely overlap with the so-called "STEM skills" (Science, Technology, Engineering and Mathematics). Soft skills, such as "entrepreneurial spririt" are also important. Making the Swiss economy more sustainable creates challenges for firms and decision-makers in the Swiss education and training system.

The project Voluntary corporate environmental initiatives shows that there is strong public support for strict government regulation with regard to environmental and social due diligence. This is to be compared with private sector self-regulation. It is frequently regarded as a preferred way by companies of decreasing adverse environmental and social impacts of economic activity. However, voluntary measures by corporate actors can decrease public support for government-led environmental policies. Citizens' regulatory preferences are generally affected by their perception of government-private sector relations.

Opportunities and Challenges

Sustainable finance provides an important contribution in the transformation of economies. It stimulates and motivates the replacement of existing production systems for cleaner ones. However, one major challenge is that the financial industry needs more trust and empirical evidence about the benefits of sustainable finance products to convince investors.

To meet the requirements of a more sustainable economy, firms and decision-makers in the Swiss education and training system will face new challenges. This creates winners and losers across the workforce. Thus, there is an urgent need to adapt existing training and education programmes.

The individual reaction to government or private sector measures may vary. Those who perceive the relationship between the private sector and the government as synergistic are more likely to support private sector self-regulation while not opposing government intervention, whereas those who perceive the relationship as antagonistic are more likely to support either private sector self-regulation or government regulation.

Relevance and Impact

Sustainable finance is a kind of cooperative self-regulation as it transfers regulatory power in parts from governmental institutions to private actors. Nonetheless, governmental activities and public policy which would monitor corporate activity and enforce transparency can mobilise sustainable finance as they can create an atmosphere of trust and reliability. Preliminary evidence on a more general approach indicates that strict public policy frameworks to "coregulate" by the state and by the financial sector garner support. On the basis of this preliminary evidence, there is a potential to create stable public policies to improve the effectiveness of private sector efforts.

Further research, in particularly with regard to legal issues is carried out by two additional projects: Legal framework for a resource-efficient circular economy and Sustainable trade relations for diversified food systems.

Figure 1: Schematic illustration of the Swiss Social Stock Exchange (SWISOX)

A study carried out in the project Sustainable finance gives evidence for the feasibility of the Swiss Social Stock Exchange (SWISOX). Companies that combine a social or ecological purpose with the pursuit of financial success could one day be listed on the SWISOX.

> Don't put off until tomorrow what you can do today. **Benjamin J. Franklin**

2.2 Cities and Mobility

The transport and housing sectors in Switzerland play a crucial role in meeting the greenhouse gas (GHG) emission reduction target of the Swiss Federal Council by 2050.

Addressing decarbonisation of the transport and housing sectors requires drastic measures including a focus on lifestyle change supported by policy instruments.

The transport and housing sectors in Switzerland account for approximately 60% of CO2 emissions (BFS, 2018). A Material Flow Analysis (MFA) of the project Post-fossil cities demonstrates that current policies for the residential buidling sector (see Figure 2) are not sufficient to comply with the Swiss Federal Council's target to achieve carbon neutrality by 2050. In order to compare mitigation options, decision-makers need to be able to visualise the trade-offs and synergies between actors. The novel simulation game developed in this project allows policy makers to engage in priority setting, and to understand the impacts of specific interventions, timings and delays.

In relation to transport, computable general equilibrium (CGE) and stock-flow transport modelling undertaken in the project Decarbonisation of the transport sector suggest that improvements in technology, e.g. change of fuel mix, reduced energy consumption per vehicle, shifts in fleet mix, and efficiency gains such as increased load factors, will not be enough to reach carbon neutrality. Instead, a modal shift is needed, which includes regulatory measures and behavioural shifts towards alternative forms of transport. Importantly, this model is the first to consider the lifetime impact of the existing car fleet until the last car exits the system.

Opportunities and Challenges

Cities present a number of opportunities for the transition towards a sustainable economy and the development of sustainable circularity strategies (see chapter 2.3 Circular Economy, Buildings and Construction). These include new infrastructures to support a greater shift towards car-pooling, use of public transport, and smaller living space per person. The Swiss economy could benefit by developing new products and services for the transport industry. Through the simulation game participants can understand the trade-offs and synergies faced by key players and gain vital insight into the underlying energy and material flows, and related systemic effects.

Key challenges concern behavioural issues (see chapter 2.5 Sustainable Behaviour), feasibility of institutional measures, aligning conflicting goals, managing rebound effects, and finding a common language. For example, measures need to be introduced to bring about shifts in habitual travel behaviour including the use of alternative forms of transport and a CO2 levy on residential buildings.

Relevance and Impact

NRP 73 provides interactive tools to explore pathways to a more sustainable future through the consideration of various scenarios. These have strong policy relevance and direct attention to the importance of reflecting on process and learning in transforming to a more sustainable economy.

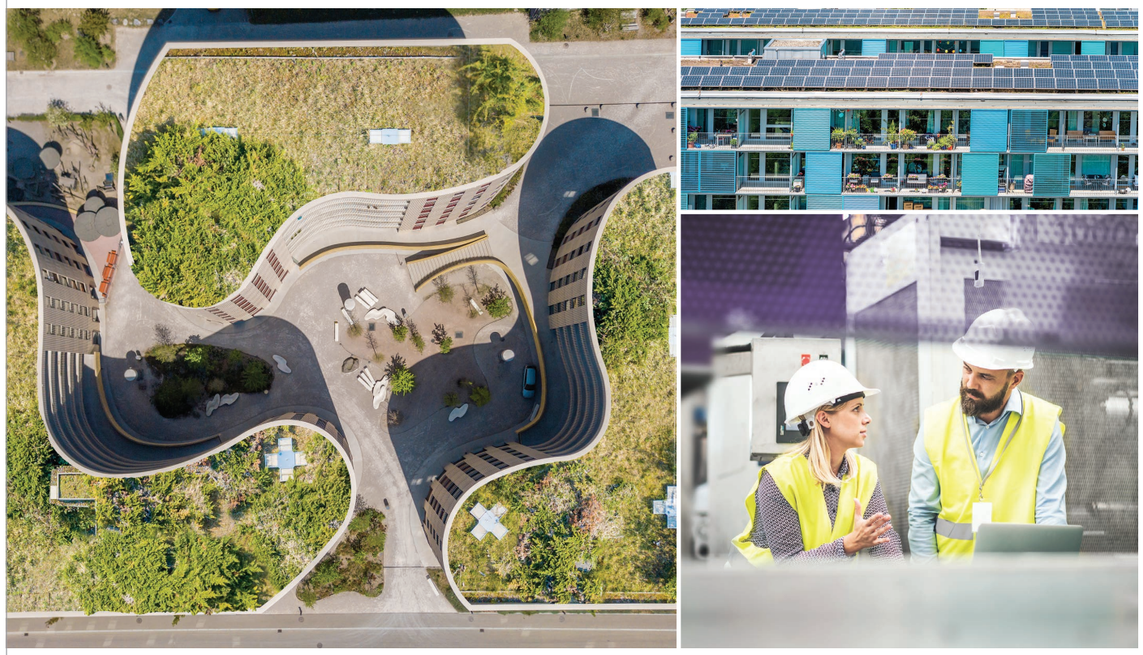


Figure 2: Actions and lifestyle changes to meet the 2050 targets.

A Material Flow Analysis (MFA) carried out by the project Post-fossil cities for the Swiss residential building stock confirms that a combination of measures such as a CO2 levy, building programmes and lifestyle changes are needed in order to achieve carbon neutrality by 2050.

MFA reveals that we need the following actions to meet the 2050 targets:

1. Construction of nearly zero-energy buildings starting today.
2. Increase of renovation rate from 1% to 3%.
3. Renovation of buildings to the lowest technically possible energy demand.
4. Faster replacement of fossil-fuelled heating, leading to a complete fossil-free energy system in 2050.

Possible lifestyle changes include:

1. Lower floor area per capita (from 47 to 41 m2/cap).
2. Construction dominated by multi-family houses.
3. Reduction of heated area by avoiding heating areas beyond the living space (e.g. staircases, basements, attics).
4. Indoor temperatures of maximum 20°C.

> Cooperating with other enterprises delivers sustainable solutions that far exceed the efforts of working independently.
>
> **Anonymous industry partner**

2.3 Circular Economy, Buildings and Construction

The circular economy must pursue broad sustainability objectives, where environmental, social and economic aspects are equally important.

Several projects provide relevant findings for the circular economy in Switzerland. They generate new knowledge on the material basis and the industrial dimensions of the associated circular value chains, from plastics to industrial waste.

Buildings are a core part of people's every-day life and an essential element of a sustainable economy. The building and construction sectors have a pivotal role in the system of material flows. While the increase of circularity and material efficiency in these sectors is expected to deliver positive environmental effects, the process must also be directed towards achieving sustainable economic and social outcomes. This integrated view of sustainability must apply to other sectors as well, such as circularity strategies in water and health services.

Preliminary results of the projects reveal open issues in circular business strategies and public policies that can be addressed by developing innovative knowledge tools.

In the project Towards a sustainable circular economy environmental indicators for circular value chains in Switzerland have been developed. Life Cycle Assessment (LCA) measures of the environmental value retained through reuse, remanufacturing, repairing or recycling have been undertaken. Monetary values generated through increasing circularity will be quantified for insulating materials and packaging. The case study on thermal insulation materials in residential buildings in Switzerland identified possibilities for closing resource loops. A dynamic Material Flow Analysis (MFA) for these materials predicts a recycling rate of 10% in 2055 in a business-as-usual scenario, whereas improved deconstruction practices and contaminants removal would lead to a recycling rate of 62% and to a reduced climate impact of 30% (see Figure 3). Another focus area is the plastic packaging value chain in Switzerland, including its international links. The mechanisms for reconfiguring this value chain are currently being investigated.

The project Co-evolution of business strategies and resource policies in the building industry combines system dynamic modelling with an integrated assessment of environmental and economic impacts related to business strategies in the construction material sector. The transdisciplinary research approach is based on close collaboration with partners in industry and public policy using the method group-model-building. Both system dynamic and assessment models are based on MFA at different scales, e.g. company and region. First results show that different policies in waste/resource-management and settlement development have a strong effect on decision-making in the construction materials and building industries. Yet, some incentives are contradictory and encourage an inefficient use of natural resources.

The potential for circularity in the housing sector has been studied through integrated modelling of tenants' behaviour, housing markets, and environmental pressures in the project Ecological footprint in the housing sector. The preferences of tenants can have various, sometimes negative repercussions on the implementation of sustainable housing strategies. The housing environmental footprint cannot be treated in a standalone fashion, and both owners' strategies and people's freedom of choice must be considered in sustainable housing strategies.

Hospitals are sustainable if their negative impacts on the environment, society and the economy are reduced, and if the benefits are optimised over the entire life cycle. The project Resource efficiency in Swiss hospitals conducted a comprehensive assessment of indicators of material and energy use in partner hospitals. In order to gather representative data on resource consumption in the Swiss hospital sector, a nationwide survey was carried out and has identified areas for improving the sustainability of Swiss hospital management. These include, for example, the supply of energy, catering and medical products, more efficient logistics, and innovations like Smart Labels, which can monitor the temperature of heat-sensitive drugs throughout the supply chain.

The relevance of small-scale modular technologies for sustainable urban water management is assessed in the project Challenges of modular water infrastructure systems. Recent global industry dynamics, potential lead markets and new governance models may support these new systems. New cost-benefit analysis methods are developed for comparing alternative implementation strategies that consider the balance of environmental and social benefits as well as economic feasibility. The challenges and opportunities of these new options for Swiss urban water management are explored through extensive interaction with regulators and providers of urban water management services.

The project Laboratory for circular economy defined circular economy in an interdisciplinary effort as an "economic system that produces goods and services within a framework of physical and environmental constraints, and necessary to achieve the basic conditions for the well-being and health of human society". To capture the environmental and economic opportunity of circularity, business models will have to change. Thirty-eight "Circular Patterns" have been identified and categorised that enable companies to build sustainable circular solutions. With the help of an original "Circular Canvas" methodology different business model ideas can be combined into a circular ecosystem, thus enhancing understanding and feasibility for companies.

The projects highlight that a number of "circularity ideas" emerge in Switzerland, and that these ideas aspire to become new products, processes and businesses. Attempts to be the "first mover" have to face both the barriers to innovation, such as the delays in adapting regulation to circularity, and the need to redesign the business models following a circularity approach. Alongside with the reduction of policy and regulation uncertainties, a structured interaction between research and stakeholders from industry, policy, and society can reduce risks for circular businesses.

Another general result across the different projects is that circularity does not necessarily mean sustainability. Circularity strategies must demonstrate that their environmental and socio-economic implications are sustainable, and must enable freedom of choice to people and an equal distribution of benefits.

Opportunities and Challenges

A number of challenges to sustainable circularity emerge, in particular in the construction and buildings sectors' value chains, which mobilise a huge mass of materials and are critical to a sustainable economy.

For the construction sector, in many Swiss regions current prices for gravel are low, which economically displaces aggregates from construction waste. Regulatory barriers for secondary materials work in the same direction of preventing the closing of the loop. Therefore, reducing the ecological impact of gravels and concrete seems to depend, among others, on the responsible management of primary raw materials and land conservation policies.

For the Swiss building sector, the need to provide housing for an ever-growing population requires accommodating changes in lifestyles and increasing environmental demands. However, tenants' preferences are powerful, and understanding these preferences is a condition for designing dwellings that combine market potential and sustainability.

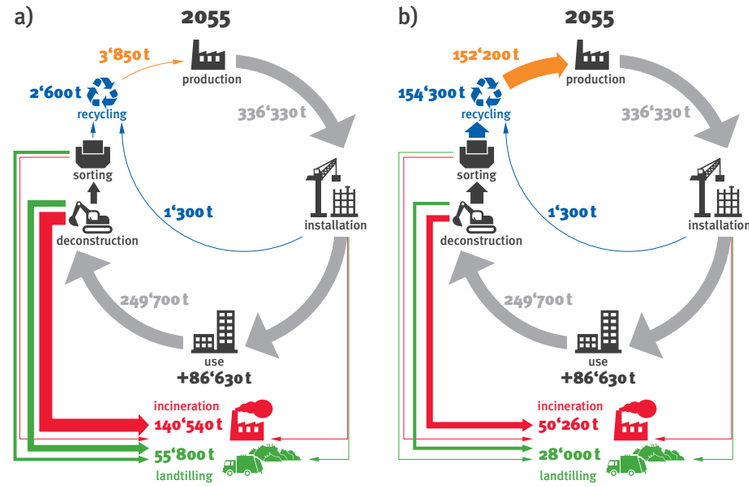
Relevance and Impact

In most of the projects the usual boundaries across disciplines and between science and practice have been broken in order to deliver more advanced solutions and practical tools. In some cases, the results are new with regard to a specific application, in other cases methodologies are new, for example, regarding modelling combinations. New datasets and information bases have been, and are being, produced to become available to a range of users.

The projects involve industrial partners that actively contribute to research. An extensive number of workshops and discussions have been carried out by the projects and revealed high degrees of involvement by these partners.

Figure 3: Two scenarios for insulating materials and recycling rates in 2055

The project Towards a sustainable circular economy shows insulation material flows in 2055 (a) for the baseline scenario and (b) for the increased recycling scenario.



> Measuring and monitoring both material consumption and its environmental impacts is key for the successful transition to sustainable supply chains.
>
> **Anonymous expert**

2.4 Supply Chains

Sustainable supply chains minimise negative environmental and social impacts and the risk of supply disruptions.

Federal policy, public procurers, companies and industries face different challenges and different opportunities to improve the sustainability of their supply chains.

With an imports to GDP ratio of 54% in 2018, the Swiss economy is highly dependent on global markets. However, knowledge of sustainability implications and the risks inherent in Switzerland's global supply chain is lacking and incomplete. Improving the sustainability of Swiss supply chains requires focusing on different data needs, sustainability standards, risks assessment approaches of various private and public actors and tackling potentially conflicting legal constrains. In NRP 73 some of these issues are addressed.

The environmental impacts of Switzerland's global supply chain are among the largest worldwide, when measured on a per capita basis.

Federal policy needs comprehensive, aggregated and periodically updated data of Switzerland's global supply network to evaluate its inherent risks and its environmental and social impacts. The project **Open assessment of the Swiss economy and society** starts from the recognition that in existing databases (ecoinvent, Exiobase & Social Hotspots Database), Swiss global supply chains are incompletely represented and inconsistent data dominate. With the help of complementary data sets, critical reflection and modern computational methods, data resolution and completeness will be improved and data uncertainties reduced.

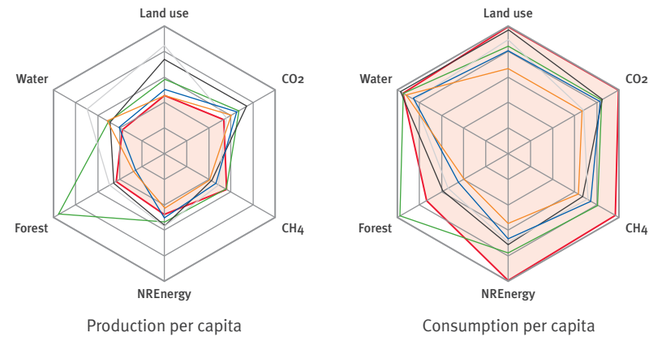
Another angle is to focus on selected supply chains. This allows us to identify specific, quantitative and qualitative socio-economic conditions that determine sustainability outcomes. The project **Enhancing supply chain sustainability** focuses on cocoa farms supplying two Swiss chocolate companies. The first results, based on LCAs and original data collection from 200 cocoa farms, show large differences among individual farms regarding biodiversity impacts, child labour, and gender inequality among otherwise similar supply chain actors. A core finding is that transparency among value chain actors is a key factor for improving sustainability among smallholder farmers, and for facilitating long-term relationships along the value chain. Such long-term relationships are a prerequisite for targeted investments into capacity building for effectively addressing social and environmental challenges.

Switzerland spends 40 billion Swiss Francs on public procurement per year, which amounts to 8.5% of final consumption. The project **Sustainable public procurement** asks how public procurement in Switzerland is regulated, which incentives and disincentives are created by current regulations, and how they should be changed to incentivise sustainable public procurement. The project found that the level of detail concerning how sustainability is integrated in public procurement tenders, particularly in the European Union, is not well aligned to the procurement volume, the characteristics of the procured products and the decision-making culture in Switzerland. The list of sustainability indicators, currently used in EU public procurement, is too long and bureaucratic and is not recommended as a benchmark for Switzerland. Voluntary standard ISO 20400 works well but is rather gegeneric on sustainability. Therefore, the project team proposes a short list of 10 topical sustainability indicators with specific subindicators and a decision tree for choosing an appropriate level of detail in sustainable public procurement tenders leaving freedom and responsibility also with the public buyers on a case-by-case basis.

The project **Switzerland's sustainability footprint** shows that GHG emissions associated with the global supply chains of Swiss consumption, the so-called consumption-based emissions, are among the largest in the world, when measured on a per capita basis and by far exceed emissions from the Swiss territory, called production-based emissions (see Figure 4). The same applies to other environmental footprints of Swiss final consumption, such as land use or water use footprints. For CH_4 and CO_2 the effect of economic growth is larger for consumption-based emissions than for production-based emission. A number of Swiss firms apply private sustainability standards to mitigate their environmental impacts but their number and design vary significantly across industries. Many sustainability standards, especially in the agricultural and cosmetic sectors, give priority to domestic products, leading to potential conflicts with trade law.

Figure 4: Switzerland's environmental footprint

The Project **Switzerland's sustainability footprint** shows a big difference between per capita production- and consumption-based environmental footprints for Switzerland. This is due to high import footprints relative to low footprints of territorial production.



Scales (maximum value):
Land use – 9t (crops, crop residues, grazing volume), **Water –** 2100m³ (usage in agriculture & livestock), **Forest –** 2.1m³ (industrial & fuel wood, including tropical wood), **Non-renewable Energy –** 8.8t oil equivalent (energy except solar, wind, and hydro), **CH_4 –** 3t CO_2 equivalent global warming potential, **CO_2 –** 13t

Opportunities and challenges
New computational methods hold great promise for a reliable and comprehensive assessment of the risks and sustainability impacts of Swiss global supply chains. Joint projects with researchers provide opportunities for Swiss companies to investigate the sustainability outcomes of their suppliers in sufficient detail and rigor and to incorporate supply chain sustainability into their business models. Public buyers and their regulators will benefit from clear guidance about how to navigate in a complex regulatory landscape and how to modify regulations towards better sustainability outcomes. Challenges arise from the huge complexity of global supply chains, their environmental and social impacts, existing regulations and how to achieve decoupling between economic growth and environmental impacts. Investments in social capital, transparency, and the right balance between standardisation and flexibility and a coherent legal framework are key leverage points to cope with these challenges.

Relevance and Impact
In the past decades many high-income countries, including Switzerland, outsourced production capacities to countries with lower wages and less environmental and social protection standards. The risks of this approach are starkly illustrated in the COVID-19 pandemic where health systems have run out of essential protective equipment and medical devices, prices are exploding and politicians consider forcing national companies to produce desperately needed medical goods. The results of these projects will help Swiss policy and Swiss companies to include global supply chains in their reporting systems, to regularly monitor their risks and sustainability impacts, and to address legal and economic challenges.

> Receiving information on my electricity consumption on a very regular basis and being able to see how far I was from achieving my goal, was very helpful and made me think about electricity usage behaviour.
>
> **Anonymous tenant of a participating household**

2.5 Sustainable Behaviour

Corporate and individual behaviour is key in the transition towards a sustainable economy.

Public policies and technological advances are important factors for moving towards sustainability. But their success will depend on corporate and individual behaviour as they will determine whether or not the economy follows a sustainable path.

Sometimes, environmentally friendly products or technologies are not consumed or adopted, even if financially viable. In other cases, the benefits for the efficient use of natural resources are drastically lower than expected, due to rebound effects. Occasionally, environmental policies are ineffective or cause unintended negative impacts due to unexpected behavioural patterns. NRP 73 projects analyse the determinants of corporate and individual behaviour to understand how it can be orientated towards a sustainable economy.

People's environmental identity determines their behaviour, and sustainable decisions in one domain do not negatively spill-over to others. Behavioural nudges also affect business decisions.

The sustainable behaviour of both people and companies are analysed in five interrelated research projects - three of which have delivered preliminary results. The main aim of the project **The influence of environmental identities** is to analyse what constitutes an environmental identity and how this identity can be activated to promote sustainable behaviour. Preliminary results indicate, at least in the short term, that messages highlighting the consequences of personal decisions on the environment have a greater impact on sustainable behaviour than on personal values. In other words, irrespective of a person's environmental stance, reminding them of their connection to nature is likely to have an effect on their sustainability behaviour.

While this first project concentrates on the determinants of a given individual decision, the project **Sustainable consumer behaviour** assesses whether behavioural changes in one domain have positive or negative impacts on the behaviour in other domains. Preliminary results indicate that spill-over effects are not negative and may rather go in a positive direction, e.g. saving electricity consumption may lead, for instance, to water conservation (see Figure 5). There seem to be clusters of environmental behaviour that are more closely linked than others. Saving electricity and conserving water are, for example, more closely related than saving electricity and recycling materials. The effectiveness of policy interventions to foster sustainable behaviour seems to depend essentially on direct effects without causing undesired side effects.

Do behavioural mechanisms that induce individuals to use fewer natural resources also promote environmentally-friendly business decisions? The project **Nudging SMEs** uses behavioural experiments to study business decisions and to test how nudging can be applied to steer company behaviour. Preliminary results show that nudges in the form of pro-environmental and financial appeals seem to work with small and medium sized enterprises (SMEs). Providing information about environmentally well-performing competitors to which companies can compare themselves is effective for motivating sustainable behaviour. However, even small efforts or costs prevent SMEs from implementing measures that increase sustainability. If employees are involved in sustainability activities this may positively spill-over in subsequent decisions and in non-professional activities, which would confirm the preliminary results about no significant negative spill-over effect.

Preliminary results of the research projects show that policy measures may impact the behaviour of people and companies directly, triggering a more sustainable resource use. More sustainable behaviour in one domain will not negatively spill-over to other domains. Policy measures should however be carefully designed, especially since companies seem to be sensitive even to small additional costs, and households may compensate technological advances through behavioural changes.

Two additional projects will extend the analysis on motivations and barriers of consumers' sustainable behaviour. The project **Rebound effects of the sharing economy** estimates the net environmental effects of peer-to-peer sharing activities and tests measures to maximise positive effects while addressing rebound effects. Similarly, consumers' decisions to adopt lifetime extending behaviours of smartphones, tablets and laptop computers are analysed in the project **Extending the lifespan of mobile devices**.

Opportunities and Challenges

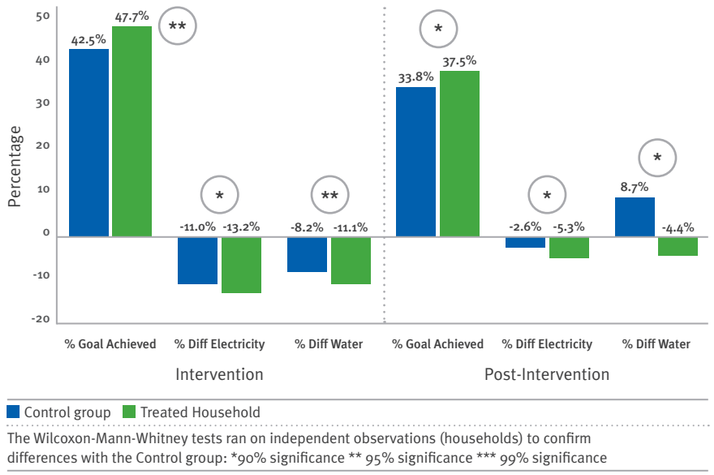
The challenges are the limited influence of consumer behaviour as well as the fact that mostly short-term effects could be measured so far, while the long-term effects still have to be quantified. Opportunities arise from the fact that interventions making households behave in a more sustainable way seem to work efficiently without negative spill-overs. The insight, that nudges can be integrated in business models to prevent rebound effects, is another opportunity.

Relevance and Impact

Preliminary results indicate that voluntary approaches have the potential to complement more traditional command-and-control policies and public interventions based on economic instruments, such as environmental taxes. Sustainable behaviours can be enhanced by acting on people's environmental mind-sets with short-term interventions like public and commercial messages, or on their environmental identities through long-term approaches, such as educational programmes. No significant negative spill-over effects are observed. Therefore, the costs of targeted public interventions to enhance sustainability in one area will not be augmented through effects that counterbalance the respective effects in other areas. In the same vein, behavioural economic nudges may be used to foster sustainable behaviour by SMEs, in particular those that convey information about reference points.

Figure 5: No negative spill-over effects from electricity consumption reduction on water consumptiont

The project **Sustainable consumer behaviour** ran a field experiment giving households incentives to reduce electricity consumption. Treated households (green bars) reduced their electricity consumption more than households who did not commit to an electricity saving goal (control group, blue bars).



The Wilcoxon-Mann-Whitney tests ran on independent observations (households) to confirm differences with the Control group: *90% significance ** 95% significance *** 99% significance

> The analysis underscores the need to consider multiple indicators while assessing dietary sustainability.
>
> **Canxi Chen,** researcher of the project Impacts of Swiss food consumption and trade.

2.6 Agriculture, Nutrition and Forestry

An ecosystem transformation towards sustainability requires integrating the consumers of such services with the collective actions of producers.

The agriculture and forestry sectors produce goods and services to cover society's needs. At the same time, the food system causes damage to natural resources, the environment and society.

Actions and behaviour in and by Switzerland are required to support the transition to sustainable land use. Potential synergies and trade-offs need to be identified and considered by farmers, foresters, the food industry and policy-makers. NRP 73 develops scientific evidence with novel data, methods and evidence from pilot projects to assess these synergies and trade-offs and to explore the development of sustainable agricultural and forestry solutions.

A common feature of the projects is that they operate in a transdisciplinary mode of co-production with relevant stakeholder groups. This ensures a robust set of tools for supporting sustainable land use.

The project **Interaction of economy and ecology in Swiss farms** has uncovered large variability in environmental and economic performance across Swiss farms. This indicates that there is still untapped potential by farms to improve performance if best practices are adopted. In order to evaluate product group level performance of multiple input-outputs production systems, eco-efficiency at product group level is measured by relating the output to environmental impact indicators. Synergies as well as trade-offs between the environmental and economic performance are observed. Eco-efficiency can differ between the product groups on a specific farm as well as between farms.

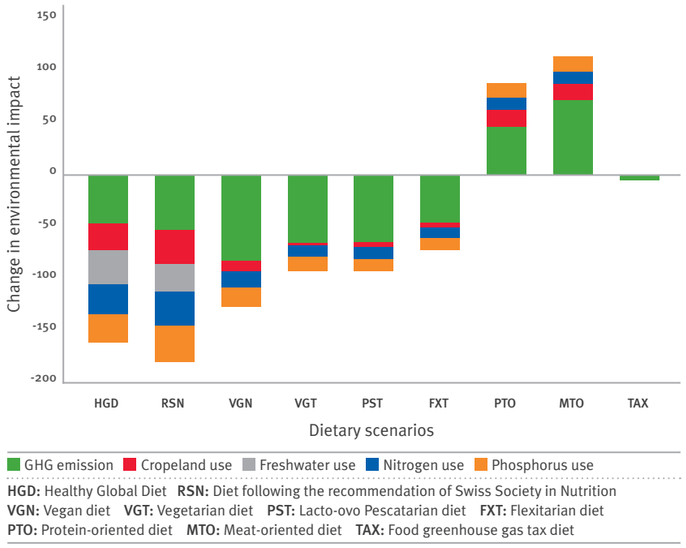
The project **Digital innovations for sustainable agriculture** combines experimental and economic analysis to explore how agriculture's environmental footprint can be reduced. High spatially and temporally resolved observations are needed to adapt fertilizer management for improved climate smart agricultural outcomes. Economic analysis finds that information from drone based observing systems can help reduce the use of fertilizers. However, the value of information is rather small for an individual Swiss farmer under current conditions. Thus, the efficacy and efficiency of policies for precision farming in Switzerland will depend on how farmers collaborate in the use of new technologies and how contractors will enter the market and support farmers to capture the relatively small benefit. This might raise concerns about market power and data ownership.

The project **Impacts of Swiss food consumption and trade** has developed a new framework, using LCA, by combining a multi-indicator-based environmental and ecosystem impact assessment with a nutritional quality and affordability assessment. Knowledge about the Swiss food system and nutritional outcomes provides a new, clearer and "fairer" sustainability analysis. Results indicate that a diet according to the recommendations of the "Swiss Society for Nutrition" would lead to a 36% improvement in the environmental performance, a 33% cost reduction and a 2.7% increase in health outcomes (see Figure 6). Achieving a sustainable diet entails a high reduction in the intake of meat and vegetable oils and a moderate reduction in cereals, roots and fish products, while at the same time an increased intake of legumes, nuts, seeds, fruits and vegetables.

Global trends and regional changes provoke challenges in the sustainable provision of ecosystem services in Swiss forests. The **Ecosystem services in forests** project adapts existing forest models to come up with a range of associated sustainable forest management options. Indicative results show that Swiss forests are highly sensitive to climate change. In particular, spruce stands outside its natural habitat will have to be converted to more "heat-adapted" forests. Indicators for timber supply are tracked as well as diverse ecosystem services such as carbon sequestration, protection, and biodiversity are quantified. The models are designed to operate as a support tool for decision-making and will be iteratively tested with stakeholders. In this way ecosystem service provisioning strategies can be tested ex-ante on a regional up to the national scale.

Figure 6: Dietary change scenarios and implications for food sustainability

The project **Impacts of Swiss food consumption and trade** analysed the environmental footprints of nine alternative diets relative to the current diet. Shifting from our current diet to the RSN diet will lead to the maximum reduction in footprints, ~36% on average across five domains.



HGD: Healthy Global Diet **RSN:** Diet following the recommendation of Swiss Society in Nutrition
VGN: Vegan diet **VGT:** Vegetarian diet **PST:** Lacto-ovo Pescatarian diet **FXT:** Flexitarian diet
PTO: Protein-oriented diet **MTO:** Meat-oriented diet **TAX:** Food greenhouse gas tax diet

The project **Insurance value of forest ecosystems** investigates how hazard prevention can be improved by sustainable forest management practices and made financially viable through an innovative insurance solution. The project was able to define a set of forest management options to reduce gravitational hazards to lower-lying economic assets. The validity of hazard reduction was demonstrated both by a dedicated rockfall simulation model and real-life experiments. The economic component of the project indicates a willingness of households to compensate forest owners for additional forest management efforts that are geared toward the reduction of avalanches and rock fall risk. The potential success factors to develop an operational business model together with practitioners are under investigation and promising institutional frameworks have been identified partially based on the empirical learnings.

The project **Trade-offs in forests** has developed a more general framework to examine conflicts. It takes the example of forest clearing for creating infrastructures for a sustainable economy in Switzerland. At this stage the project has collected information from regions looking at legal frameworks and uncovering existing conflicts of interest. Preliminary results indicate that the transition to a more sustainable economy in Switzerland has led to small but steady increases of forest clearances in the plateau and Alps regions driven by renewable energy and public transport infrastructures. The project has started to elaborate pathways for conflict resolution. First results point to the issue of ownership structure in a wider economic context. This in turn might help open windows of opportunity for property rights-based instruments.

A sustainability transformation requires a diversity of approaches that are tailored to the socio-economic context, the diverse environmental conditions and cultural differences. The set of projects allows inference from locally adapted learning experiments to behaviour of larger populations. Achieving sustainability in the context of the Swiss land use system entails behavioural changes that are scalable to critical masses for a broader transformation to happen. The data and tools developed under the NRP 73 are perfectly suited to accompany such a transformation.

Opportunities and challenges

A shifting preference in society, the emergence of new technologies together with a fast-changing natural environment presents many opportunities for science to provide evidence-based impetus to societal changes. However, issues around potential misuse of farm level data as well as legal frameworks to use new technologies may serve as barriers. Scientific evidence based on new data sources might also suffer from lacking acceptance, but at the same time allow for more integrated policies governing natural resource management, supply chain management and consumer behaviour. The projects support awareness raising and quantification of benefits from nature-based solutions both in monetary terms as well as reverence of nature's priceless contribution to people.

Relevance and Impact

The projects generate new knowledge and evidence to help mainstream locally adapted ecosystem services solutions for private and public decision-making. The notion of consistent local or national contributions to the SDGs appears important in the context of agriculture, nutrition and forestry. Decision-making for managing natural resources, be it a forest, an agricultural field, a farm, or a consumer choice, involves balancing trade-offs between different ecosystem services. To this end the projects present a what-if-scenario for land management decisions to be made today while benefits and risks will arise much later. The projects have and will generate evidence for industry to tailor their products, help improve the efficacy and precision of policy instruments as well as to understand and quantify variability of eco-efficiency.

Contribution of NRP 73 to the agricultural policy from 2022 onwards (AP 22+)

How can environmentally friendly production be strengthened while securing the future of farmers?

NRP 73 is expected to contribute to the efficient achievement of these two objectives of AP22+. What new technologies will play a role, which will not, and what policy measures will help to achieve these objectives? The focus lies on the more efficient use of nitrogen and pesticides as well as the reduction of greenhouse gas emissions.

In addition, indications are expected as to which farms perform particularly well from an economic and ecological perspective, what the success factors are and how they can be improved. This will help to draw conclusions for the implementation of AP22+.

3. Practical Relevance of NRP 73

3.1 Building Bridges Between Research and the Private Sector

Innovations for a sustainable economy often require systemic change affecting entire industries.

The NRP 73 projects acknowledge this and are building bridges between research and industry. This chapter provides some examples of the collaborations between research projects and the private sector.

More than 11 industry sectors and 60 companies are involved in the programme. Several research projects are assessing the impact of new technologies or building new business models for eco-design, recycling, recovery and circular economy. At the company level, this requires numerous and specific adjustments of business practices.

The following examples highlight existing collaborations:

- The project **Towards a sustainable circular economy** collaborates with companies from the insulation sector to determine the potential of closed-loop systems for insulation materials and to reduce the indirect energy demand of conventional and energy efficient buildings.
- The project **Sustainable finance** developed a feasibility study to create a full-fledged Swiss Social Stock Exchange (SWISOX), dedicated to sustainable businesses.
- The project **Sustainable consumer behaviour** is developing a strategy together with one of the big Swiss real estate companies to reduce the CO_2 emissions from their buildings through behavioural interventions instead of building investments.
- In collaboration with famers, farming associations and public administrations the project **Digital innovations for sustainable agriculture** shows that precision agriculture and other "smart farming technologies" have the potential to make agricultural production more efficient.
- In the project **Co-evolution of business strategies and resource policies in the building industry** data is collected in case study analysis with seven different companies producing sand, gravel, cement, concrete and services in logistics, construction and waste management.
- The project **Insurance value of forest ecosystems** investigates how hazard prevention can be improved by sustainable forest management practices and be financially made viable through innovative private insurance solutions.

To ensure success, the scalability of such innovations is key. As we mostly talk about conceptual inventions, scaling must be done through locally accepted organisations. A specific NRP 73 synthesis process and co-creation labs will offer the opportunity to bring together researchers and practitioners to exploit these potentials.

3.2 Interdisciplinarity and Collaborations Are Key for Knowledge Transfer

Interdisciplinarity and collaborations with non-academic partners are key for knowledge transfer and a successful implementation of NRP 73 findings.

To date a significant amount of knowledge transfer initiatives and collaborations with stakeholders have taken place. In addition, the recognition and engagement shown by private and public actors reveals the potential of NRP 73.

With the advancement of NRP 73, an increasing number of communication and knowledge transfer activities have been implemented, ranging from scientific articles and information on project specific websites to presentations and dialogues at public and stakeholder events.

Figure 7: Knowledge transfer output

Output can be summarised as follows:

- **55** scientific articles
- **47** articles in newspapers, magazines or periodicals
- **189** presentations or attendances at academic conferences, workshops or university lectures
- **153** public or stakeholder events
- **23** projects have strong partnerships with non-academic actors, and the majority of the projects have collaborations with stakeholders
- **10** projects have a project-specific advisory board
- several thematic workshops at the programme level

Stakeholder Expectations

To ensure meaningful impact and contributions to a systematic transition of the Swiss society and economy, the expectations of stakeholders were considered from the beginning of NRP 73.

The Steering Committee and the project teams are committed to an analysis of the present economic mainstream, innovative new ideas and best practice as well as pertinent scientific publications, contributions at scientific events, and career advancement opportunities for young researchers.

The Sounding Board and project partners expect to learn more about system boundaries, pain points as well as new scientific insights and innovative thinking to implement a sustainable economy in Switzerland. According to these actors, this can best be achieved with practical and applicable research findings, an optimal mix of policy instruments and economic incentives as well as specific activities for the different target groups. While this overview of the state of research of NRP 73 addresses all stakeholders, leading up to the programme synthesis target group tailored knowledge transfer activities will be developed.

4. Summary and Outlook

The transition towards a sustainable economy can only be achieved by focusing on new business models in key sectors, innovative sustainable finance as well as behavioural changes around consumption.

NRP 73 generates scientific knowledge for the transition towards a sustainable economy, discovers untapped resource efficiency potential and will contribute to a broad range of SDGs. The envisaged synthesis process will generate added value that goes beyond the insights provided by individual projects.

The NRP 73 projects are providing new measurement and assessment tools to guide circularity strategies in different value chains, and to develop new business models that close material loops and thus improve resource efficiency. For example, in the **building and construction sector,** the recycling rate can be increased from 10% to over 60% for insulating material due to improved deconstruction practices and contaminant removal. Furthermore, additional potential was identified in concrete production by substituting raw materials for the clinker production with construction and demolition waste.

In the **agricultural sector,** new combinations of methods revealed that there are significant efficiency potentials between different product groups, e.g. between red meat and chickpeas to provide protein. While the project findings show that digital innovations such as drones and sensors for precision agriculture will only provide small benefits from savings in fertilizer costs for individual farmers, the developed new contract forms in this project will help to overcome this obstacle.

Given the strong **financial sector** there is a role for Switzerland in financing sustainable finance initiatives. An innovative proposal in this context is the Swiss Social Stock Exchange (SwiSOX), developed by one of the projects. Since the Swiss **labour force** has the skills which are typically required in green occupations, Switzerland seems to be well equipped with the necessary financial and human capital resources for the transition to a more sustainable economy. Furthermore, GHG emissions associated with the global supply chains of Swiss consumption are among the largest in the world, when measured on a per capita basis. Attempts by Swiss private and public actors towards more sustainable supply chains are diverse and differ substantially across industry and at the federal, cantonal or municipal level.

But the transition to a sustainable economy cannot be achieved by focusing only on the finance and the production side. Equally important is the consumption side, especially **people's behaviour.** Encouragingly, the research projects did not find negative spill-over effects in environmentally-friendly behaviour. Interventions to reduce, for example, household's electricity usage or hot water consumption prove to be effective without undesired side effects. However, simulations and models predict that technology improvements and efficiency gains are not enough for Switzerland to achieve carbon neutrality by 2050.

More changes are necessary in the **transport and building sector** such as shifts in travel behaviour and reduced living space. Since this involves people's attitudes and preferences, households must be involved as key allies of the transition. In addition, it seems that even small efforts or costs prevent SMEs from implementing measures that increase sustainability.

Finally, in order to get companies or individuals to behave more sustainably and to tap into the potentials of circularity, repairing and changing habits, government interventions will need to be carefully designed and smartly implemented. Considering that circularity does not necessarily mean sustainability, new insights are needed to ensure a green economy. There are still relevant barriers, including regulatory barriers and potential rebound effects, to increase circularity in different value chains. These are being analysed by several new projects.

To identify areas and options for action, co-creation labs will bring together researchers, partners from practice and public administration to be part of the synthesis process. This will also facilitate the integration of results into an overarching context and the formulation of concrete recommendations. In addition, the researchers already have and will continue to collect large volumes of data. During the synthesis, NRP 73 will compile and compare this data to ensure quality and to make it easily accessible to relevant users. Last but not least, in order to provide the target groups with direct access to the findings, conclusions and recommendations, the products of the programme synthesis will be presented via a web portal.

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Concept and Editorial Work
Prof. Dr Regina Betz, Zurich University of Applied Sciences
Dr Barbara Dubach, engageability, Zurich
Dr Pascal Walther, Swiss National Science Foundation, Berne

Proofreading
Jonathan Ballantine (English), Madrid

Design
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