

Priority Themes for Swiss Sustainability Research



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Priority Themes for Swiss Sustainability Research

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 identifies our country's most urgent research needs.

> sustainabledevelopment.un.org

> eda.admin.ch/agenda2030/en/home/agenda-2030/die-17-ziele-fuer-eine-nachhaltige-entwicklung.html



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*‘We are not only responsible for what we do,
but also for what we do not do.’
Jean-Baptiste Poquelin, Molière (1622–1673)*

Foreword

We are proud to introduce this timely white paper on priority themes for sustainability research. This document not only attempts a careful comparative analysis of present challenges, but also provides an outlook for our society and particularly the role of science in helping to achieve the UN Sustainable Development Goals (SDGs) at the national and global levels. The themes presented in the following chapters encompass crises, resilience, and transformation processes – that can also be seen as evolution. Crises have been a hallmark of life since time immemorial. They can take a variety of forms, but are generally seen as destructive. The ability to survive crises is often referred to as resilience, i.e. ‘the capacity of a strained body to recover its original shape and size’. However, surviving crises is not merely a matter of returning to the *statu quo ante*. It involves evolution, often nurtured by unpredictable choices. Life on Earth was originally confronted with choosing between oxygen and sulphur as the best electron acceptors. This led to seemingly incompatible aerobic and anaerobic forms of life, which eventually became mutually dependent in sustaining our planet’s biodiversity.

Surviving crises may result from random mutations and Darwinist selection, or from complex behavioural adaptations. Great Britain’s shift to coal energy in the 18th century – following massive deforestation – resulted in new impacts on health and the environment, including the well-known case study of colour changes to the birch moth. At the same time, the increased use of horses for transportation predicted big cities to be soon blanketed with several inches of manure. Electric tramways were introduced in response, but were soon overtaken by emerging petrol lobbies, which fed the wealth-generating but also harmful and imperialistic industrial boom of the 20th century. One outcome of this was virtually unlimited access to energy.

Since then, industrial societies have conducted the most uncontrolled anthropogenic experiment ever, spewing tens of millions of years’ worth of underground-accumulated carbon into the atmosphere in less than a century. Scientists issued warnings about the risks of carbon pollution and climate change for over 40 years, until the United Nations finally launched the 2030 Agenda for Sustainable Development in 2015, endorsed by numerous countries including Switzerland.

At first glance, solving such problems using science and technology might appear relatively straightforward. In reality, the issues are exceedingly complex. They involve each of us as individuals and our societies as a whole.

They demand reconsideration of basic values, visions, hopes, disruptive models of behaviour, solidarity, finance, economy, and socio-political implementation. Taken together, it makes for an unprecedentedly challenging task.

Per capita, Switzerland still uses more than five times its share of ecological space and resources in terms of pollution and consumption. At the same time, it is a wealthy country with excellent science traditions and an exemplary direct democracy. It needs to become a better example to the world.

The present white paper addresses these issues and specifically the challenges and the role of science. The report tackles six key themes that were conceived, written, and edited by interdisciplinary expert groups, to whom we would like to express our sincere thanks.

Finally, the present white paper recommends an initial set of priority themes for Swiss sustainability science, as well as ways of substantially increasing our science capacity. It represents an agora gathering of not only academics, but of all relevant stakeholders and social partners – including decision-makers and citizens – in hopes of solving complex sustainability challenges. It does so respecting local Swiss realities, but with no shortage of national- and global-level ambition to make sustainability possible.

We wish you stimulating reading and look forward to your reactions and feedback.

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Bern, October 2020

Executive Summary

Our world faces great environmental and social challenges. Unsustainable patterns of production and consumption are causing loss of biodiversity, irreversible damage to soils, widespread environmental pollution, and a warming climate. At the same time, over one billion people live in extreme poverty, and growing inequality within and among countries is leading to political instability and large-scale migration.

The 2030 Agenda for Sustainable Development is a universal call to action to end poverty, protect the planet, and ensure that all people live in peace and prosperity by 2030. The 2030 Agenda sets out 17 Sustainable Development Goals (SDGs) that aim to balance the social, economic, and ecological aspects of sustainable development. It was adopted in 2015 by the member states of the United Nations (UN), including Switzerland. The UN has called upon the global academic community to undertake the research necessary to achieve these goals. Since all countries face different challenges, the question arises as to what Switzerland's most urgent research needs are with a view to meeting its commitments under the 2030 Agenda.

Against this background, the Swiss Academies of Arts and Sciences has identified sustainable development as one of its strategic priorities. The Sustainability Research Initiative (SRI) was set up under the leadership of the Swiss Academy of Sciences (SCNAT) to promote research for sustainability in Switzerland. Important tasks for the SRI include expanding and strengthening the community of researchers working on sustainable development in Switzerland, identifying priority themes for sustainability research, and promoting funding opportunities.

The purpose of sustainability research is to support the process of societal transformation towards greater sustainability. For this, different kinds of knowledge are required: *systems knowledge* about the properties of the system in question; *target knowledge* about the sustainability targets that should be set; and *transformation knowledge* about how those targets can be achieved. Production of these types of knowledge may require researchers to work closely with relevant societal actors in a process called *transdisciplinary research or co-production of knowledge*.

In this white paper, the SRI proposes a set of priority themes for Swiss sustainability research. The themes were developed through intensive consultation over the course of 18 months with stakeholders from academia, government, NGOs, and the private sector. They are intended

to provide crucial knowledge needed for Switzerland to progress towards greater sustainability and to meet its international commitments such as the 2030 Agenda and the Paris Agreement on climate change. The following six priority themes were identified:

Food for people and planet. Current high-input and high-output food systems have many negative consequences for producers, consumers, and natural environments worldwide. Projections based on the increasing wealth of low- and middle-income countries suggest that meat consumption will continue to grow, which will only increase pressure on the environment. It remains unclear how to develop a sustainable food system that is beneficial to all actors and contributes to a global system capable of feeding 9–10 billion people by 2050.

Thriving spaces: sustainability and spatial development. Mobility, housing, and individual choices profoundly impact patterns of land use, both in Switzerland and abroad. The concept of thriving spaces relates to how we perceive, use, change, restore, and protect our spaces, and how lifestyle choices and economic activities can be reconciled as part of a sustainable whole. Changing course will require being inspired by the best examples of sustainable land use and developing a shared vision of the way forward.

Net-zero greenhouse gas emissions society. To achieve the very specific goal of reducing net greenhouse gas emissions to zero by 2050, many technical challenges and conflicts of interest must be overcome. How can a strategy be developed that is politically and socially acceptable? Research is needed to support societal efforts to rethink the links between energy use and human well-being.

Economic and financial systems for well-being. Our current economic system tolerates or even encourages highly unsustainable practices. Finance is increasingly disconnected from the real economy and the huge volumes of assets traded in uncontrolled, speculative and manipulated financial markets have contributed to economic and financial instability. The costs of resulting crises, overconsumption, pollution, resource depletion, and social inequalities are far too high, both for present and future generations. Our current economic paradigm must be transformed into one that serves sustainable development.

Shared values, visions, and pathways for sustainability. 'Sustainability', far from being an objectively defined concept, is underpinned by assumptions, discursive elements, val-

ues and paradigms, many of which are implicit and even contradictory. These need to be identified and debated so that we can develop a shared vision of a sustainable future and a strategy for achieving it. The scientific community can support this societal process with research that is collaborative and inclusive.

Dealing with synergies, trade-offs, and common threads. The all-encompassing ambition of sustainable development requires the pursuit of many important goals in parallel. This frequently involves co-benefits among some goals and trade-offs among others. Progress towards achieving the SDGs will require systemic research aimed at identifying, understanding, and prioritizing interactions among sustainability goals.

Enabling transdisciplinary sustainability research. The final chapter proposes ways for creating an enabling environment for transdisciplinary sustainability research. The proposals include: a) developing incentive systems that encourage researchers to get involved in such research and increase recognition for teamwork; b) strengthening science – policy dialogue; c) building partnerships with non-academic stakeholders; d) introducing training programmes to develop the skills needed for sustainability research; e) setting up novel institutional structures to foster collaboration across organizational boundaries; and f) strengthening funding opportunities and further developing evaluation procedures for transdisciplinary sustainability research.

Zusammenfassung

Unsere Welt steht vor grossen ökologischen und gesellschaftlichen Herausforderungen. Nicht nachhaltige Produktionsweisen und Konsumverhalten führen zu einem Verlust an biologischer Vielfalt, irreversiblen Bodenschäden, weitreichender Umweltverschmutzung und globaler Klimaerwärmung. Gleichzeitig leben über eine Milliarde Menschen in extremer Armut, und die wachsende Ungleichheit innerhalb und zwischen den Ländern führt zu politischer Instabilität und massiver Migration.

Die Agenda 2030 für nachhaltige Entwicklung ist ein universeller Aufruf zum Handeln, um die Armut zu bekämpfen, unseren Planeten zu schützen und sicherzustellen, dass alle Menschen bis 2030 in Frieden und Wohlstand leben. Die Agenda 2030 umfasst 17 Ziele für nachhaltige Entwicklung (Sustainable Development Goals, SDGs) zur Sicherstellung einer nachhaltigen Entwicklung auf ökonomischer, sozialer sowie ökologischer Ebene. Diese Agenda wurde 2015 von den Mitgliedstaaten der Vereinten Nationen (UNO), darunter die Schweiz, verabschiedet. Die UNO hat die globale akademische Gemeinschaft aufgefordert, die zur Erreichung dieser Ziele notwendigen Forschungsanstrengungen zu unternehmen. Da alle Länder vor unterschiedlichen Herausforderungen stehen, stellt sich die Frage, was der dringendste Forschungsbedarf der Schweiz im Hinblick auf die Erfüllung ihrer Verpflichtungen im Rahmen der Agenda 2030 ist.

Vor diesem Hintergrund haben die Akademien der Wissenschaften Schweiz die nachhaltige Entwicklung zu einer ihrer strategischen Prioritäten erklärt. Die Sustainability Research Initiative (SRI) wurde unter der Leitung der Akademie der Naturwissenschaften Schweiz (SCNAT) ins Leben gerufen, um die Forschung im Bereich der Nachhaltigkeit in der Schweiz zu fördern. Wichtige Aufgaben der Initiative für Nachhaltigkeitsforschung (SRI) sind der Ausbau und die Stärkung der Forschungsgemeinschaft, die sich in der Schweiz mit nachhaltiger Entwicklung befasst, die Identifizierung von vorrangigen Themen in der Nachhaltigkeitsforschung und die Anregung von Finanzierungsmöglichkeiten.

Ziel der Nachhaltigkeitsforschung ist es, den Prozess der gesellschaftlichen Transformation hin zu mehr Nachhaltigkeit zu unterstützen. Dazu sind verschiedene Arten von Wissen erforderlich: *Systemwissen* über die Eigenschaften des betreffenden Systems, *Zielwissen* über die Nachhaltigkeitsziele, die gesetzt werden sollten, und *Transformationswissen* darüber, wie diese Ziele erreicht werden können. Um solches Wissen zu erlangen, kann es erforder-

lich sein, dass die Forschenden eng mit den relevanten gesellschaftlichen Akteurinnen und Akteuren in einem Prozess zusammenarbeiten, der als *transdisziplinäre Forschung* oder *Ko-Produktion von Wissen* bezeichnet wird.

In diesem White Paper schlägt die SRI eine Reihe von Schwerpunktthemen für die Schweizer Nachhaltigkeitsforschung vor. Die Themen wurden in intensiver Konsultation über einen Zeitraum von 18 Monaten mit Interessenvertreterinnen und -vertretern aus Wissenschaft, Regierung, NGOs und dem privaten Sektor entwickelt. Die Bearbeitung dieser Forschungsthemen soll entscheidende Erkenntnisse liefern damit die Schweiz auf dem Weg zu mehr Nachhaltigkeit voranschreiten und ihre internationalen Verpflichtungen – allen voran jene im Rahmen der Agenda 2030 und des Pariser Klimaabkommens – erfüllen kann. Die sechs Schwerpunktthemen sind:

Umwelt- und sozialverträgliche Ernährungssysteme. Die derzeitigen Systeme zur Nahrungsmittelerzeugung – mit hohem Input und Output – haben rund um den Globus viele negative Folgen für Produzenten, Konsumierende und Umwelt. Projektionen zeigen, dass der Fleischkonsum aufgrund des zunehmenden Wohlstands von Ländern mit niedrigem und mittlerem Einkommen weiterhin wachsen wird. Es bleibt unklar, wie ein System zur nachhaltigen Erzeugung von Lebensmitteln entwickelt werden kann, das für alle Akteurinnen und Akteure von Nutzen ist und sich in ein globales System einfügt, das bis zum Jahr 2050 neun bis zehn Milliarden Menschen ernähren kann.

«Thriving Spaces»: Nachhaltigkeit und Raumentwicklung. Mobilität, Wohnen und individuelle Entscheidungen haben einen tiefgreifenden Einfluss auf die Landnutzung, sowohl in der Schweiz als auch in anderen Ländern. «Thriving Spaces» oder der Umgang mit unserem Raum beinhaltet die Art und Weise, wie wir unsere Räume wahrnehmen, nutzen, verändern, wiederherstellen und schützen und wie es uns gelingt, unsere Lebensstile und wirtschaftlichen Aktivitäten als Teil eines nachhaltigen Ganzen in Einklang zu bringen. Ein Kurswechsel erfordert die Entwicklung einer gemeinsamen Zukunftsvision und die Inspiration durch Erfolgsmodelle nachhaltiger Nutzung von Landressourcen.

Gesellschaft mit Netto-Null-Treibhausgasemissionen. Um das sehr konkrete Ziel zu erreichen, die Netto-Treibhausgasemissionen bis 2050 auf null zu reduzieren, müssen viele technische Herausforderungen und Interessenkonflikte überwunden werden. Wie kann eine Strategie entwickelt

werden, die politisch und gesellschaftlich akzeptiert wird? Forschung zur Unterstützung der gesellschaftlichen Bemühungen, die Zusammenhänge zwischen Energieverbrauch und menschlichem Wohlbefinden neu zu überdenken, ist notwendig.

Wirtschafts- und Finanzsysteme, die der nachhaltigen Entwicklung dienen. Unser derzeitiges Wirtschaftssystem toleriert oder unterstützt Praktiken, die in hohem Masse nicht nachhaltig sind. Das Finanzwesen ist zunehmend von der Realwirtschaft abgekoppelt, und der ungezügelter Handel auf den Finanzmärkten hat zur wirtschaftlichen und finanziellen Instabilität beigetragen. Die Kosten, die als Folge der daraus resultierenden Krisen, des übermässigen Konsums, der Umweltverschmutzung, der Ressourcenverknappung und der sozialen Ungleichheiten entstehen, sind viel zu hoch – sowohl für heutige als auch für zukünftige Generationen. Unser gegenwärtiges Wirtschaftsparadigma muss so umgestaltet werden, dass es der nachhaltigen Entwicklung dient.

Gemeinsame Werte, Visionen und Wege zur Nachhaltigkeit. «Nachhaltigkeit» ist keineswegs ein objektiv definiertes Konzept, sondern wird durch Annahmen, Diskurselemente, Werte und Paradigmen definiert, von denen viele implizit und sogar widersprüchlich sind. Diese müssen identifiziert und diskutiert werden, um eine gemeinsame Vision für eine nachhaltige Zukunft zu entwickeln – und einen gemeinsamen Weg, wie diese Zukunft erreicht werden kann. Die wissenschaftliche Gemeinschaft kann diesen gesellschaftlichen Prozess mit kollaborativer und integrativer Forschung unterstützen.

Umgang mit Synergien, Zielkonflikten und transversalen Fragen. Das übergeordnete Ziel einer nachhaltigen Entwicklung erfordert die gleichzeitige Verfolgung vieler wichtiger Ziele. Diese Ziele bieten häufig einen gemeinsamen Nutzen, können aber auch Zielkonflikte beinhalten. Um die Fortschritte bei der Verwirklichung der SDGs zu beschleunigen, ist es erforderlich, solche Beziehungsgeflechte besser zu verstehen. Eine systemische Forschung, die darauf abzielt, Wechselwirkungen zwischen den Nachhaltigkeitszielen zu identifizieren, zu verstehen und zu priorisieren, ist dringend erforderlich.

Förderung transdisziplinärer Nachhaltigkeitsforschung. Das Schlusskapitel zeigt Wege zur Stärkung eines förderlichen Umfelds für die transdisziplinäre Nachhaltigkeitsforschung auf. Die Vorschläge umfassen: a) die Entwicklung von Anreizsystemen, die die Anerkennung von Teamarbeit erhöhen und Forscherinnen und Forscher ermutigen, sich in der transdisziplinären Nachhaltigkeitsforschung zu engagieren; b) die Stärkung des wissenschaftspolitischen Dialogs; c) den Aufbau von Partnerschaften mit nicht-akademischen Akteuren; d) die Ausarbeitung von Ausbildungsprogrammen zur Entwicklung der für die Nachhaltigkeitsforschung erforderlichen Kompetenzen; e) die Schaffung neuartiger institutioneller Strukturen zur Förderung der Zusammenarbeit über Organisationsgrenzen hinweg; und f) die Stärkung von Finanzierungsmöglichkeiten und die Weiterentwicklung von Evaluationsansätzen für die transdisziplinäre Nachhaltigkeitsforschung.

Résumé

Notre monde est confronté à des défis environnementaux et sociaux majeurs. Les modes de production et de consommation non durables entraînent une perte de la biodiversité, des dégradations irréversibles des sols, une pollution environnementale généralisée et une augmentation des températures. Dans le même temps, plus d'un milliard de personnes vivent dans une pauvreté extrême, et les inégalités croissantes au sein des différents pays et entre ceux-ci entraînent une instabilité politique et des migrations à grande échelle.

L'Agenda 2030 pour le développement durable est un appel universel à l'action pour mettre fin à la pauvreté, protéger la planète et faire en sorte que tous les peuples vivent dans la paix et la prospérité d'ici à 2030. L'Agenda 2030 prévoit 17 objectifs de développement durable qui visent à équilibrer les aspects sociaux, économiques et écologiques du développement durable. Il a été adopté en 2015 par les États membres des Nations unies (ONU), dont la Suisse. L'ONU a fait appel à la communauté universitaire mondiale afin d'entreprendre les recherches nécessaires pour atteindre ces objectifs. Comme les pays sont souvent confrontés à des défis spécifiques, la question se pose de savoir quels sont les besoins les plus urgents de la Suisse en matière de recherche en vue de respecter ses engagements dans le cadre de l'Agenda 2030.

Dans ce contexte, les Académies suisses des sciences ont fait du développement durable l'une de leurs priorités stratégiques. L'initiative pour la recherche sur le développement durable a été mise en place sous la direction de l'Académie des sciences naturelles (SCNAT) pour promouvoir la recherche sur le développement durable en Suisse. Parmi les tâches importantes de l'initiative pour la recherche sur le développement durable figurent l'élargissement et le renforcement de la communauté des chercheurs travaillant sur le développement durable en Suisse, l'identification des thèmes prioritaires pour la recherche sur le développement durable et la promotion des possibilités de financement.

L'objectif de la recherche sur le développement durable est de soutenir le processus de transformation de la société vers plus de développement durable. Pour cela, différents types de connaissances sont nécessaires: des *connaissances des systèmes* sur les propriétés du système en question, des *connaissances des objectifs* qui devraient être fixés en matière de développement durable et des *connaissances de transformation* sur la façon dont ces objectifs peuvent être atteints. La production de ces types de

connaissances peut exiger des chercheuse et chercheurs qu'ils travaillent en étroite collaboration avec les actrices et acteurs sociaux concernés dans le cadre d'un processus appelé *recherche transdisciplinaire* ou *coproduction de connaissances*.

Dans ce livre blanc, l'initiative pour la recherche sur le développement durable propose une série de thèmes prioritaires pour la recherche suisse dans ce domaine. Les thèmes ont été développés grâce à une consultation intensive de 18 mois avec des parties prenantes du monde universitaire, du gouvernement, des ONG et du secteur privé. Ils visent à fournir les connaissances essentielles dont la Suisse a besoin pour progresser vers plus de développement durable et pour respecter ses engagements internationaux tels que l'Agenda 2030 et l'Accord de Paris sur le changement climatique. Les six thèmes prioritaires suivants ont été identifiés :

De la nourriture pour le genre humain et la planète. Les systèmes alimentaires actuels caractérisés par un niveau élevé d'intrants et de production ont de nombreuses conséquences négatives pour les producteurs, les consommatrices et consommateurs et les environnements naturels du monde entier. Les projections montrent que la consommation de viande va continuer à augmenter en fonction de la richesse croissante des pays à revenu faible et intermédiaire. On ne sait toujours pas comment développer un système alimentaire durable qui soit bénéfique à l'ensemble des acteurs et qui contribue à un système mondial capable de nourrir 9 à 10 milliards de personnes d'ici 2050.

Des espaces vitaux et prospères: un développement spatial durable. La mobilité, le logement et les choix individuels ont un impact profond sur les modes d'exploitation des sols, tant en Suisse qu'à l'étranger. La prospérité des espaces implique la manière dont nous percevons, exploitons, modifions, restaurons et protégeons nos espaces, et la manière dont nous parvenons à concilier nos choix de vie et nos activités économiques dans le cadre d'un ensemble durable. Pour changer de cap, il faudra développer une vision commune de la voie à suivre et se concentrer sur des exemples inspirants de la manière dont les ressources foncières peuvent être utilisées de manière durable.

Une société à zéro émission nette de gaz à effet de serre. Pour atteindre précisément l'objectif de réduction des émissions nettes de gaz à effet de serre à zéro d'ici 2050, de nombreux défis techniques et conflits d'intérêts doivent être surmontés. Comment développer une stratégie qui soit

politiquement et socialement acceptable? La recherche est nécessaire pour soutenir les efforts de la société visant à repenser les liens entre l'utilisation de l'énergie et le bien-être humain.

Des systèmes économiques et financiers pour le bien-être. Notre système économique actuel tolère ou même encourage des pratiques éminemment contraires à la durabilité. La finance est de plus en plus déconnectée de l'économie réelle et les énormes volumes d'actifs traités sur les marchés financiers en roue libre ont contribué à l'instabilité économique et financière. Les coûts des crises qui en résultent, de la surconsommation, de la pollution, de l'épuisement des ressources et des inégalités sociales sont beaucoup trop élevés, tant pour les générations actuelles que futures. Notre paradigme économique actuel doit être transformé de manière à servir au développement durable.

Des valeurs, visions et voies communes pour le développement durable. Le « développement durable », loin d'être un concept objectivement défini, est sous-tendu par des hypothèses, des éléments discursifs, des valeurs et des paradigmes, dont beaucoup sont implicites et même contradictoires. Il faut les identifier et en débattre afin de développer une vision commune d'un avenir durable ainsi que la manière de la réaliser. La communauté scientifique peut soutenir ce processus sociétal grâce à une recherche collaborative et inclusive.

Traiter les synergies, les compromis et les points communs. L'ambition globale du développement durable exige la poursuite simultanée de nombreux objectifs. Cela implique souvent des avantages connexes pour certains objectifs et des compromis pour d'autres. Ces interdépendances doivent être mieux comprises afin d'accélérer les progrès vers la réalisation des objectifs de développement durable. Il est urgent de mener des recherches systémiques visant à identifier, comprendre et hiérarchiser les interactions entre les objectifs de développement durable.

Promouvoir la recherche transdisciplinaire sur le développement durable. La recherche sur le développement durable nécessite un cadre favorable. Notre dernier chapitre propose des moyens de renforcer la capacité institutionnelle à entreprendre des recherches sur le développement durable. Les propositions comprennent : a) élaborer des systèmes d'incitation qui renforcent la reconnaissance du travail d'équipe et encouragent les chercheurs à s'engager dans la recherche transdisciplinaire sur le développement durable ; b) renforcer le dialogue entre les sciences et la politique ; c) établir des partenariats avec des parties prenantes non universitaires ; d) élaborer des programmes de formation destinés à développer les compétences nécessaires à la recherche sur le développement durable ; e) mettre en place de nouvelles structures institutionnelles pour favoriser la collaboration au-delà des frontières organisationnelles ; et f) renforcer les possibilités de financement et développer davantage les approches d'évaluation pour la recherche transdisciplinaire sur le développement durable.

Sintesi

Il nostro mondo si trova ad affrontare importanti sfide ambientali e sociali. I modelli di produzione e di consumo non sostenibili stanno causando perdita di biodiversità, danni irreversibili al suolo, inquinamento ambientale diffuso e riscaldamento climatico. Allo stesso tempo oltre un miliardo di persone vive in condizioni di estrema povertà e le crescenti disuguaglianze all'interno delle nazioni e tra di esse stanno portando a instabilità politica e a migrazioni su larga scala.

L'Agenda 2030 per uno sviluppo sostenibile è un appello universale a mobilitarsi per porre fine alla povertà, proteggere il pianeta e garantire che tutte le persone vivano in pace e prosperità entro il 2030. L'Agenda 2030 definisce 17 obiettivi di sviluppo sostenibile (OSS) che mirano a conciliare gli aspetti sociali, economici ed ecologici dello sviluppo sostenibile. È stata adottata nel 2015 dagli Stati membri delle Nazioni Unite (ONU), tra cui la Svizzera. L'ONU ha invitato la comunità accademica mondiale a intraprendere le ricerche necessarie per raggiungere tali obiettivi. Poiché tutti i paesi si trovano ad affrontare sfide diverse, si pone la questione di quali siano le esigenze di ricerca più urgenti per la Svizzera, al fine di rispettare gli impegni assunti nell'ambito dell'Agenda 2030.

In questo scenario, le Accademie svizzere delle scienze hanno indicato lo sviluppo sostenibile come una delle loro priorità strategiche. L'Iniziativa per la ricerca sulla sostenibilità (Sustainability Research Initiative, SRI) è stata istituita sotto la guida dell'Accademia svizzera di scienze naturali (SCNAT) per promuovere la ricerca per la sostenibilità in Svizzera. Tra i compiti essenziali della SRI rientrano l'ampliamento e il rafforzamento della comunità di ricercatori che si occupano di sviluppo sostenibile in Svizzera, l'individuazione di temi prioritari per la ricerca sulla sostenibilità e la promozione di opportunità di finanziamento.

Lo scopo della ricerca sulla sostenibilità è supportare il processo di trasformazione della società verso una maggiore sostenibilità. Per questo obiettivo sono necessari diversi tipi di sapere: *conoscenza dei sistemi*, ovvero delle proprietà del sistema in questione; *conoscenza degli obiettivi*, ovvero degli obiettivi che dovrebbero essere fissati in tema di sostenibilità; e *conoscenza della trasformazione*, ovvero come tali obiettivi possono essere raggiunti. La produzione di questi tipi di conoscenze può richiedere ai ricercatori di collaborare strettamente con gli attori sociali rilevanti in un processo chiamato *ricerca transdisciplinare* o *coproduzione di conoscenze*.

In questo libro bianco la SRI propone una serie di temi prioritari per la ricerca svizzera sulla sostenibilità. I temi sono stati sviluppati nel corso di un intenso processo di consultazione durato 18 mesi con gli stakeholder del mondo accademico, del governo, delle ONG e del settore privato. Mirano a fornire le conoscenze fondamentali affinché la Svizzera possa progredire verso una maggiore sostenibilità e rispettare i suoi impegni internazionali, come l'Agenda 2030 e l'Accordo di Parigi sui cambiamenti climatici. I sei temi prioritari individuati sono:

Cibo per le persone e per il pianeta. Gli attuali sistemi alimentari ad alto input e output hanno molte conseguenze negative per i produttori, le consumatrici e i consumatori e gli ambienti naturali in tutto il mondo. Dalle proiezioni emerge che il consumo di carne continuerà ad aumentare sulla base della crescente ricchezza dei paesi a basso e medio reddito. Non è ancora chiaro come sviluppare un sistema alimentare sostenibile che sia vantaggioso per tutti gli attori e contribuisca a un sistema globale in grado di nutrire 9–10 miliardi di persone entro il 2050.

Prosperità degli spazi: sostenibilità e sviluppo spaziale. La mobilità, l'abitare e le scelte individuali incidono profondamente sui modelli di utilizzo del territorio, sia in Svizzera che all'estero. La prosperità degli spazi comprende i modi in cui percepiamo, utilizziamo, cambiamo, ripristiniamo e proteggiamo i nostri spazi, e come riusciamo a conciliare le nostre scelte di vita e le attività economiche in quanto parte di un insieme sostenibile. Per cambiare rotta sarà necessario sviluppare una visione condivisa della strada da seguire e concentrarsi su esempi ispiratori di come le risorse del territorio possano essere utilizzate in modo sostenibile.

Società a zero emissioni nette di gas serra. Per raggiungere l'obiettivo molto specifico di ridurre a zero le emissioni nette di gas serra entro il 2050, è necessario superare molte sfide tecniche e conflitti di interesse. Come si può sviluppare una strategia politicamente e socialmente accettabile? Occorrono ricerche per sostenere gli sforzi della società volti a ripensare i legami tra lo sfruttamento dell'energia e il benessere umano.

Sistemi economici e finanziari per il benessere. Il nostro attuale sistema economico tollera o addirittura incoraggia pratiche altamente insostenibili. La finanza è sempre più scollegata dall'economia reale e le negoziazioni effettuate nei mercati finanziari hanno contribuito all'instabilità economica e finanziaria. Le crisi che ne derivano, il consumo

eccessivo, l'inquinamento, l'esaurimento delle risorse e le disuguaglianze sociali hanno costi troppo elevati, sia per le generazioni presenti che per quelle future. Il nostro attuale paradigma economico deve essere trasformato in un sistema al servizio dello sviluppo sostenibile.

Valori condivisi, visioni e percorsi per la sostenibilità. La «sostenibilità», lungi dall'essere un concetto definito con oggettività, si fonda su presupposti, elementi discorsivi, valori e paradigmi, molti dei quali sono impliciti e persino contraddittori. Questi fattori devono essere identificati e discussi in modo da sviluppare una visione condivisa del futuro sostenibile e delle modalità per realizzarlo. La comunità scientifica può sostenere questo processo sociale con la ricerca collaborativa e inclusiva.

Gestire le sinergie, i compromessi e i punti comuni. L'ambizione globale dello sviluppo sostenibile richiede di perseguire molti obiettivi ugualmente importanti allo stesso tempo. Ciò comporta spesso dei co-benefici per alcuni obiettivi e dei compromessi per altri. Per accelerare i progressi verso la realizzazione degli OSS, tali interdipendenze devono essere meglio comprese. È urgente una ricerca sistemica volta a identificare, comprendere e dare priorità alle interazioni tra gli obiettivi di sostenibilità.

Promuovere la ricerca transdisciplinare sulla sostenibilità. La ricerca sulla sostenibilità richiede un contesto favorevole. Il capitolo finale propone le modalità per rafforzare la capacità istituzionale di portare avanti la ricerca sulla sostenibilità. Le proposte comprendono: a) sviluppare sistemi di incentivazione che aumentino il riconoscimento del lavoro di squadra e incoraggino i ricercatori a impegnarsi nella ricerca transdisciplinare sulla sostenibilità; b) rafforzare il dialogo tra scienza e politica; c) costruire partenariati con stakeholder non accademici; d) sviluppare programmi di formazione che favoriscano l'acquisizione delle competenze necessarie per la ricerca sulla sostenibilità; e) creare nuove strutture istituzionali per promuovere la collaborazione oltre i confini organizzativi; e f) rafforzare le opportunità di finanziamento e sviluppare ulteriormente gli approcci di valutazione per la ricerca transdisciplinare sulla sostenibilità.

‘Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.’

(Brundtland Report, WCED, 1987)

1. Introduction

Peter Edwards (ETH Zurich), Gabriela Wuelser (SCNAT)

Framing Sustainability

Sustainability thinking is not new. The early Alpine communities in Switzerland, for example, evolved institutions and practices that enabled them to protect their productive base and persist, despite harsh environmental conditions. Indeed, much can be learned about sustainability from studying traditional institutions and practices such as those of the Swiss Alps. Elinor Ostrom’s seminal work on how resources held in common – such as forests, water, and fish stocks – can be co-operatively managed was inspired by her research in the Swiss community of Törbel in the canton of Valais.

As long as people obtained most of their resources locally, the problem of sustainability was largely a local problem. If a disaster occurred, it soon became evident. When the potato blight disease reached Switzerland, for example, many Alpine communities could no longer produce enough food to support their populations, which led to mass emigration. In contrast, many people in today’s globalized world enjoy a high standard of living because they draw upon resources from across the globe and benefit from cheap goods produced in low-wage countries. But this means that the links between overconsumption, environmental damage, and poverty become less obvious. People cannot see, for example, the carbon dioxide accumulating in the atmosphere or the inhumane conditions in textile factories of low-income countries. For such reasons, and because of the growing world population, sustainability has become a problem of global dimensions.

As an abstract concept, sustainability appears beguilingly simple; but in real-world contexts, it turns out to be extremely complex and multi-faceted. The definition given in the *Brundtland Report* (see above) is one of many, though certainly the best known and most broadly legitimized. Sustainable development is about the integrity of natural systems, which means ensuring that human activities do not cause harm to the climate or to ecosystem functioning. It is also about human development, which means ensuring that the resources needed for human well-being are distributed equitably, both within and across generations. And finally, the use of the word ‘development’ in the Brundtland definition is a reminder that billions of people across the world live in extreme poverty or face threats to life and limb, and that any efforts to restrain the use of resources must not be at the

expense of their legitimate aspirations for a decent life. Accordingly, these core objectives also form the basis of the 2030 Agenda.

An important feature of sustainable societies – one that is often overlooked – is the capacity to recover from extreme disruptions such as those caused by natural disasters, pandemics, or rapid technological change. This capacity, known as *resilience*, is sometimes treated as an aspect of sustainability, and other times as a separate and complementary concept. There is a growing consensus, however, that sustainability and resilience must be considered together, and any research programme concerned with the future well-being of human societies should cover both. Given the complexity of sustainability, we need simplifying concepts that help us understand and visualize what it means in practice. Three concepts that have proven very helpful in this respect are described in Box 1.1. For example, countries’ ecological footprints can be plotted against their performance according to the Human Development Index (see Fig. 1.1). Doing so reveals glaring differences between countries in terms of both ecological impact and human well-being. This diagram is one way to show what the goal of sustainable development should be: for all countries to occupy the lower right-hand quadrant, which represents high human development within the resource limits of the planet. At present, the high human development enjoyed in Switzerland clearly comes at the expense of future generations and compromises the integrity of natural systems globally.

The Sustainable Development Goals (SDGs)

The 2030 Agenda for Sustainable Development is a universal call to action to end poverty, protect the planet, and ensure that all people live in peace and prosperity by 2030. It was adopted by member states of the United Nations (UN), including Switzerland, in 2015. At the heart of the 2030 Agenda are 17 Sustainable Development Goals, or SDGs, which highlight the main challenges the world faces, including those of climate change, environmental degradation, poverty, armed conflicts, and inequality. Each SDG sets a number of specific targets that are to be achieved by 2030, with 169 targets in total.

The Federal Council uses the SDGs to define its policy priorities for implementing sustainable development in

its multiyear strategic plan. It has established a comprehensive system for monitoring sustainable development, currently with 73 indicators that are regularly updated. Since 2015, Switzerland's sustainability policies, both nationally and internationally, have been determined by the 2030 Agenda for Sustainable Development. With the *Voluntary National Report 2018*, the Federal Council conducted a first comprehensive baseline assessment of the implementation status at a federal level. A gap analysis indicated that among the chosen 85 indicators, 39 showed a positive trend, 12 showed no significant evolution, 14 showed a negative trend, while for 20 no assessment was possible.

On the positive side, Switzerland has already fulfilled several targets and is at an advanced stage in achieving others. For example, Switzerland is free from extreme poverty (target 1.1) and from hunger (target 2.1). Education (target 4.1) is free, compulsory, and of good quality. On the negative side, further efforts are needed in several other areas. Consumption of natural resources (SDG 12), for example, is increasing overall. Swiss consumption of resources obtained from within Switzerland is decreasing, but the use of resources from abroad is increasing in an unsustainable way.

The UN recognizes that the SDGs cannot be achieved on the basis of existing knowledge, and calls upon the global academic community to undertake the research needed to develop solutions. To this end, the Global Sustainable Development Report 2019, titled *The Future is Now: Science for Achieving Sustainable Development*, makes specific recommendations for the kind of problem-oriented research needed for transformation.

Science for sustainability

Scientific research has already contributed greatly to understanding the challenges of sustainability and to finding solutions. Thanks to research in the natural sciences, we have a detailed understanding, for example, of how human activities are causing climate change and a dramatic loss of biodiversity. Thanks to research in engineering, we have been able to improve the energy efficiency of buildings and to reduce the physical burdens of labour. Thanks to research in the social sciences, we understand what constitutes peaceful and inclusive societies, and how to foster social innovation. Thanks to research in economics and political sciences, we know – at least in principle – how to promote distributive justice and internalize environmental costs.

Two features characterize much of this research. First, most of it was disciplinary and conducted without much exchange between traditional academic departments. Sec-

Box 1.1 Influential concepts for understanding sustainability

Ecological footprint analysis uses an ecological accounting system to measure the quantity of nature, or effective land area, that individuals use or consume to meet their needs, recognizing that this land is dispersed across the world (global hectares: gha). The average ecological footprint of someone living in Switzerland, for example, is 6.3 gha, whereas the globally available land per person (biocapacity) is only 1.3 gha, meaning there is an overshoot in Switzerland of 5.0 gha per person. The global ecological footprint presently exceeds global biocapacity by a factor of 1.7, of which approximately 60% can be attributed to emissions from burning fossil fuels.

Planetary boundaries represent an attempt to define the 'safe operating space' for human activities at a global scale. First published in 2009 the method identifies thresholds for nine Earth-system processes which, if exceeded, could be disastrous for humanity. The nine processes are: climate change; the rate of biodiversity loss (terrestrial and marine); interference with nitrogen and phosphorus cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; change in land use; chemical pollution; and atmospheric aerosol loading. Of these, the boundaries of three systems (rate of biodiversity loss, climate change, and human interference with the nitrogen cycle) have already been exceeded.

Economic doughnut (Fig. 5.1) refers to a way of visualizing the problem of sustainability that combines the concept of planetary boundaries with a complementary concept of social boundaries. The hole in the doughnut represents the proportion of people that lack the essentials for human well-being, while the outer perimeter represents the planetary boundaries that must not be exceeded. According to this concept, an economy can only be defined as prosperous if it meets the 12 social goals without transgressing any of the nine planetary boundaries.

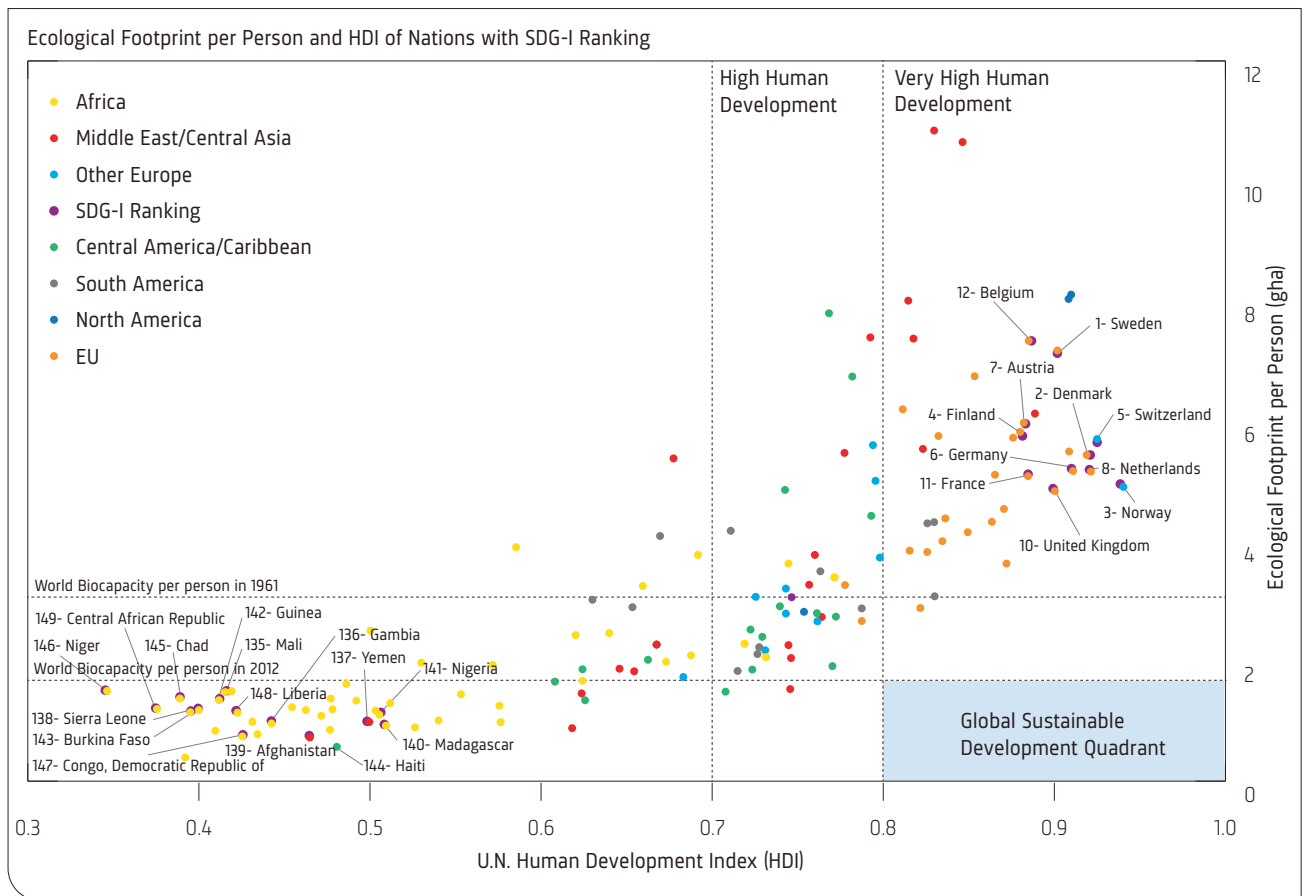


Figure 1.1: Ecological footprint per person and Human Development Index (HDI) by country indicate how close each country is to basic global sustainable development criteria. Each number indicates the country's ranking on the sustainable development goal (SDG) index. Source: Wackernagel M et al. (2017) Making the Sustainable Development Goals Consistent with Sustainability. *Front. Energy Res.* 5:18.

ond, with the exception of studies conducted in the long traditions of 'action research' and 'participatory research', the objects of inquiry were usually formulated solely by researchers, and any resulting new knowledge was made available to decision-makers primarily by means of academic publications and contract reports. These traditional ways of framing research and transferring knowledge will continue to be important, but other – multidirectional, multi-perspective, collaborative, and transformative – approaches will be at least equally important to help our societies tackle the most complex challenges of sustainable development.

Indeed, as early as 1997, members of the Swiss research community argued that several types of knowledge were needed by decision-makers. In *Visions by Swiss Researchers*, published by the Conference of the Swiss Scientific Academies (CASS), the authors recommended that science focus on providing three interrelated types of knowledge to the public debate: *systems knowledge*, about the properties of the system in question; *target knowledge*, about possible and desired targets to make the system

more sustainable; and *transformation knowledge*, about how those targets can be achieved.

Production of these different types of knowledge functions best when researchers collaborate across disciplines and work closely with relevant societal actors in a process called *transdisciplinary research* or *co-production of knowledge*. But such research poses significant practical challenges for researchers and research institutions, which may explain why it is not more common. For example, it is time-consuming and requires developing mutual understanding between different scientific cultures and ways of thinking. It also calls for managerial and communication skills that many university researchers may lack.

Sustainability research is also different because it raises normative questions – something that researchers often find difficult. They may, for example, need to specify a particular vision of sustainable development towards which their work is aimed. This does not mean that the role of the scientist is to prescribe what the 'right' vision should be, but rather that he or she is explicit about the

values and desired goals to which the work refers. In some contexts, researchers may set out a range of options and their likely consequences, without advocating one particular course of action. Or they may need to explain how particular solutions favour one group of actors at the expense of another. In such cases, sound reasoning and an ethical perspective are required to make clear which values are favoured, and why.

Since the CASS *Visions* paper was originally published, research on sustainable development has grown enormously. A recently published paper provides a useful synthesis of core topics requiring further research; these include: ‘to (a) measure sustainable development, (b) promote equity, (c) adapt to shocks and surprises, (d) transform the system into more sustainable development pathways, (e) link knowledge with action, and (f) devise governance arrangements that allow people to work together in exercising the other capacities.’¹

In conclusion, the academic community has a crucial role to play in providing the knowledge needed for societal transformation towards sustainability. While traditional modes of academic research will continue to be important, much more emphasis needs to be given to research that is transdisciplinary and problem-oriented. In addition to there being adequate funding and appropriate evaluation procedures, it is also important that academic institutions strengthen their capacity to undertake such research. Chapter 8 lists a first set of elements that should be considered in order to strengthen the enabling environment for transdisciplinary sustainability research.

Priority themes for sustainability research

The goal of the Sustainability Research Initiative (SRI) set up under the leadership of the Swiss Academy of Sciences (SCNAT) is to stimulate the research needed for Switzerland to progress towards greater sustainability and to meet its international commitments relating to the SDGs and the Paris Agreement. Rather than present a comprehensive research agenda for sustainability research, this white paper sets out six themes of special relevance to Switzerland (based upon criteria given in Box 1.2).

The priority themes were identified and developed through an extended participatory, bottom-up process. The first round of discussions was held in June 2019 with experts and board members from the six member institutions of the Swiss Academies. It was based on four (out of six) entry points to sustainable development, or fields of transformation, identified in the UN Global Sustainable Development Report 2019. These were: shifting towards

sustainable and just economies; building sustainable food systems and healthy nutrition patterns; promoting sustainable urban and peri-urban development; and achieving energy decarbonization and universal access to energy. The discussions focused on the potential contribution of science in these areas, and the opportunities for, and obstacles to, collaboration between traditionally separate academic fields of expertise.

Box 1.2. Criteria for priority themes in sustainability research

- Priority themes should address broad problems of sustainability requiring profound societal changes;
- The research should have implications for several SDGs, and thus be highly interdisciplinary or transdisciplinary;
- The primary purpose of the research should be to provide the knowledge needed for transformation, and should therefore focus on the social, political, economic, and technological levers of transformation, as described in the Global Sustainable Development Report 2019;
- Priority topics should not duplicate but ideally complement existing sustainability research in Switzerland;
- Research topics should concern issues for which Switzerland has a particular need or responsibility or impact, whether nationally or internationally.

The second step consisted of two one-day stakeholder workshops in Zurich and Lausanne in August 2019. In total, around 100 experts from science and practice identified key sustainability challenges from their perspectives, both as experts and as members of society. These workshops revealed a remarkable degree of consensus amongst participants as to the most important issues facing Switzerland. Based on these discussions and clustering of the many ‘burning issues’ identified, the project’s Steering Committee developed five thematic areas for detailed consideration.

The third step was to establish expert working groups for each of the thematic areas, composed of both experts from science and practice. Between April and June 2020, these groups defined the topics and developed the concept papers that form the main chapters of this white paper. This step was impacted by the COVID-19 pandemic, which pre-

¹ Clark and Harley, 2020 (p. 331)

cluded in-person workshops. Instead, the experts – many of whom had never met – had to collaborate exclusively using virtual interaction tools and platforms. The various chapters bear the names of the working group participants and, by doing so, illustrate the diversity of expertise and thinking styles involved in sustainability science.

The final thematic areas were:

- **Food for people and planet** – towards a sustainable food system for Switzerland
- **Thriving spaces: sustainability and spatial development**
- **Net-zero greenhouse gas emissions society** – how can Switzerland reduce net greenhouse gas emissions to zero by 2050?
- **Economic and financial systems for well-being** – towards an economic paradigm consistent with the goal of sustainable development
- **Shared values, visions, and pathways for sustainability** – how can societies develop shared values and visions that support change towards sustainability?

In addition to these five themes, a sixth group was convened to consider the interrelations and common threads among the thematic areas:

- **Dealing with synergies, trade-offs, and common threads**
 - understanding interrelations between sustainability goals as basis for policy alignment

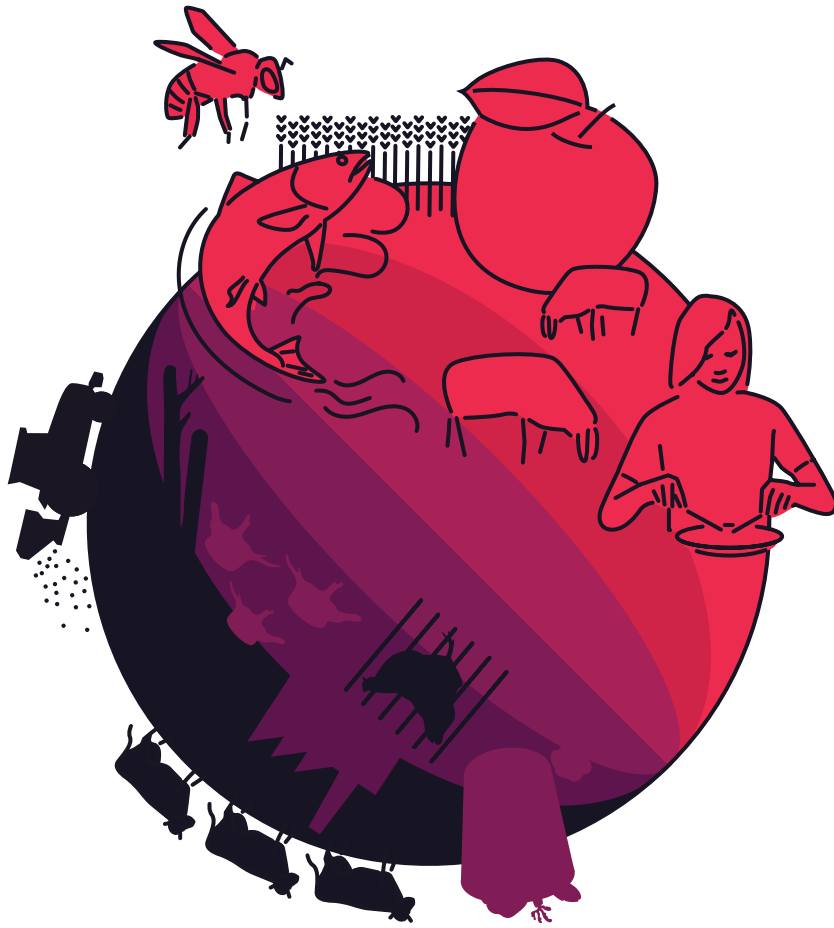
The working group chapters vary in style and scope, reflecting not only the differing state of knowledge in different areas, but also the bottom-up process by which they were developed. Some of the problems are well known and have already been broadly debated (e.g. Net-zero greenhouse gas emissions society). In other cases, the issues introduced have only been discussed at the margins and are just beginning to enter wider scientific debates (e.g. Economic and financial systems for well-being). Thus, the kind of research that is needed varies widely among the priority topics, from basic conceptual work to developing solutions that can be implemented immediately. In all cases, however, the proposed research is considered essential for Switzerland to meet its sustainability commitments.

In conclusion, sustainability represents 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 many ways, this will require a new relationship between the research community and other societal actors. The topics presented here represent just a first step in identifying the research needs for sustainable development in Switzerland. The discussions between the research community

and other societal actors must continue, and deepen, so that future actions towards sustainability are based upon the best possible knowledge.

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2. Food for People and Planet

Current high-input and high-output food systems have many negative consequences for producers, consumers, and natural environments worldwide. Projections based on the increasing wealth of low- and middle-income countries suggest that meat consumption will continue to grow, which will only increase pressure on the environment. It remains unclear how to develop a sustainable food system that is beneficial to all actors and contributes to a global system capable of feeding 9–10 billion people by 2050.

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Problem statement

Current high input and high output food systems have massively increased provisioning ecosystem services (mainly food, feed, fibre, fuel) worldwide, and so reduced the number of food insecure people. At the same time, however, these systems may harm the health of people and nature in ways that make them unsustainable and not regenerative. Agricultural production systems are not only a significant cause of climate change, but also strongly affected by it. Most of them contribute to soil degradation, inefficient nutrient use, eutrophication of water, and biodiversity loss. Pesticide use has unintended

effects on both terrestrial and aquatic ecosystems. Swiss agriculture, whether intensive or extensive, generates externalities around the world. This effect, also known as ‘telecoupling’, leads to social inequality and negative impacts on small-scale agriculture in the global South. All of these problems are compounded by high rates of food loss and waste.

Efforts to address the known weaknesses of modern food systems have spurred creativity and innovation. While some promising new solutions have been identified, food losses and environmental degradation continue. This is partly because of the sheer magnitude of the challenge:

Counteracting such negative impacts in a globalized world, irrespective of whether the causes are endogenous or exogenous (tsunamis, volcano eruptions, climate change, drought, pandemics, rural exodus, migration, and war), is highly complex. To date, the importance of *resilience* – the capacity to withstand and recover from extreme events of all kinds – has been underestimated in the context of food systems, but it will become a major dimension of sustainability going forward.

In recent decades, consumers in wealthy countries have benefitted from falling food prices relative to average income. Spending on food in Switzerland fell from 30% of household income in 1960 to only 6.4% in 2019. One consequence has been a decline in the perceived value of food, which has encouraged wastefulness. In parallel, strong global trends towards animal-derived and highly processed foods may contribute to chronic health problems such as obesity, diabetes, and heart disease. The connection between these personal and global scales is apparent when one reflects that meat consumption is projected to grow even further as wealth in low- and middle-income countries increases.

Many of the problems outlined here have been aggravated by national regulations and subsidies (e.g. dairy-sector subsidies) that were designed to protect and support domestic producers. These regulatory frameworks can be seen as collateral consequences of the increasing globalization of processing and trade. In the case of agriculture, the benefits of globalization are ambivalent, since most public goods are strictly local ones.

In conclusion, current agriculture is beset with numerous trade-offs, most of all between short-term productivity and the longer-term well-being of natural systems and future generations. There is consensus in the scientific community that human food security and well-being depend on the functioning and provision of non-commodity ecosystem services. Overcoming current problems has been complicated by inadequate economization and a lack of holistic approaches in policy, research, and administration.

In Switzerland, actors in the food chain have never developed a broadly based vision for sustainable and resilient food production, instead coming together only on specific topics such as the charters on the Swiss quality strategy or digitalization. One reason for this may be that the relevant knowledge has not been sufficiently disseminated to stakeholders. Nonetheless, these issues are well covered in the media and there are growing signs that our society is willing to adopt more sustainable patterns of production and consumption. It is thus all the more urgent to im-

prove understanding of the factors that promote or hinder the transformation of food systems.

Key unresolved questions

State-of-the-art achievements in Switzerland: Switzerland has a very complex system of legal regulations, state and private incentives, farmer initiatives, and competing trends among citizens and consumers. Initial questions thus centre on comparative analysis of current agricultural practices:

- How well do dominant agricultural systems (and associated technology) in Switzerland address sustainability, taking into account ecological, economic, and social dimensions as well as good governance of all actors?
- How well do these systems perform with respect to curbing biodiversity losses, addressing climate change, protecting and improving water use, as well as other impacts and externalities? How do the resulting public goods and transaction costs of different policy measures compare when applied to existing farm practices?

Developing a broad-based vision of future food systems in Switzerland: Despite many individual initiatives and concepts, Switzerland lacks a comprehensive vision for sustainable, resilient food systems that is valid across many actors and value chains.

- How would a broadly shared policy vision for the Swiss food system look, and how would it address the issues raised in the other chapters of the present research agenda?
- What are different scenarios for future food use and production in Switzerland, beyond earlier more global models?
- How much promise does a truly sustainable food production and consumption system have in Switzerland? How could such a system secure the livelihoods of the farming community?

Transformation of food policy in Switzerland and beyond: With the Millennium Ecosystem Assessment report of 2005, the IPCC Report on Climate Change and Agriculture of 2007, and the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) of 2008, the scientific world has laid essential foundations and generated a wealth of data for the renewal of agriculture and nutrition. Nevertheless, to date, the proposals for transformation remain contradictory and imprecise. The following questions arise:

- What are the exogenous drivers and endogenous incentives and nudges for change in agriculture and nutrition in Switzerland ('from pitchfork to table fork')? What potential role is there for harmonization of agricultural, agri-environmental, and food-related health policies?

What are the roles played by different stakeholders, information channels, and the responsiveness of information recipients (e.g. farmers, consumers, industry)? What is the potential of the Swiss regulatory framework in fostering a transition to sustainable food production and food consumption?

- What changes are needed in the international trade of agricultural goods (food, feed) to resolve the major contradictions between production conditions (e.g. animal welfare, social fairness, environmental conservation) at home and in countries exporting to Switzerland? How can the economic, social, and ecological externalities of Switzerland's food and feed imports be quantified and what kinds of mechanisms could be implemented to internalize them?
- What are the trade-offs and synergies between 'protectionism' and trade distortion, on the one hand, and global sustainability, on the other?

The role of science and technology: Arable farming was one of humanity's great cultural and technical achievements. Over the centuries, agricultural knowledge and technology has vastly improved. Beginning in the early 20th century, agricultural productivity finally grew faster than the human population. Scientific research played a crucial role in this unprecedented breakthrough. Today, the research community is challenged to find ways of producing even more food without exceeding planetary boundaries. Fundamental questions that must be answered include:

- How can or should scientific progress contribute to sustainable farming systems and nutrition in order to overcome or reduce the trade-offs described above?
- What are the best synergies between the following three technology or knowledge levels? Namely, (1) high-tech innovation, such as digitalization and novel breeding methods; (2) moderate or midlevel technology, such as farm and food technology in general or the development of biocontrol and botanicals in plant protection; and (3) practical knowledge/adoption (related to agronomy, site conditions, farmer community traditions, or consumer preferences) at all points along the value chain?
- What methodological advances in science are needed to facilitate completely viable, functioning sustainability solutions in agriculture and nutrition? What role could be played by development of methods for sustainability assessment and true cost accounting? How can researchers benefit from relevant examples of innovative research methods from other branches of science, such as swarm intelligence, post-disciplinarity, and design thinking?
- How can the active involvement of farmers, consumers, and citizens accelerate the adoption of scientific knowledge and the transformation towards sustainable and regenerative farming and food systems?

- Which methods of transformative learning, cooperation, and participation can be developed to deeply anchor sustainable agriculture and nutrition in our societies and make particular economic and social interests transparent?

Expected relevance for Switzerland and internationally

Though somewhat scattered, a wealth of knowledge exists on the techniques, economic and social impacts, and political and administrative implementation of sustainable farming. Many promising solutions are already known, but must be refined and complemented by ecological, social, and technological innovation for proper implementation. The research proposed here can foster systemic integration through the active participation of non-academic stakeholders. It can help to improve the coherence and consistency of Swiss agricultural, food, health, environmental, and trade policies. The current complex mix of private and governmental measures needs to be critically evaluated. New public steering measures, or refined existing measures, can benefit from scientific assessment and substantiation. Informed dialogue between producers, consumers, and citizens only grows in importance as the impacts of our food systems on the environment and society become increasingly visible. The interdependencies and interactions between people's nutritional behaviour and agricultural practices in Switzerland, on the one hand, and Switzerland's significant ecological and socio-economic footprint abroad, on the other hand, can no longer be ignored. Swiss agriculture policy can be better adapted to account for state-of-the-art knowledge of its national and international effects.

Links with the other thematic areas that need to be addressed

Use of land and water resources and the environmental externalities of food production may compete with or reinforce visions of *thriving spaces*. People's habits in terms of the kinds of food they consume – e.g. food produced by a nearby farmer who they know and visit – have implications for thriving spaces. The migration of farmers from rural regions and the urbanization of larger areas of Switzerland is underway. So far, there is no concept of thriving spaces for rural, peri-urban, and urban areas that includes food production. Since many areas of Switzerland are ecologically very sensitive and topographically challenging, automation may be needed to preserve these unique qualities. In remote rural areas, a labour-extensive and robot-intensive agriculture might be the future. Greater digitalization may also be a solution. In peri-urban and

urban areas, local agriculture might become more important, with pathways including urban gardeners and farmers, vertical farming, or the use of industrial wasteland and buildings for vegetable production. Food production might also become important for climate regulation in cities and for the psychological well-being of urban dwellers.

Given finite our land resources, trade-offs will likely be required between food production and consumption, on the one hand, and renewable biomass-based energy production needed to achieve *net zero greenhouse gas emissions*, on the other. Whether and to what degree land acts as a carbon sink will depend on factors including our nutritional behaviour, food waste, decisions about meat production, use of grasslands, and lifestyles (e.g. veganism). Last but not least, our food systems must be designed such that they supply us with enough protein and energy.

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3. Thriving Spaces: Sustainability and Spatial Development

Mobility, housing, and individual choices profoundly impact patterns of land use, both in Switzerland and abroad. The concept of thriving spaces relates to how we perceive, use, change, restore, and protect our spaces, and how lifestyle choices and economic activities can be reconciled as part of a sustainable whole. Changing course will require being inspired by the best examples of sustainable land use and developing a shared vision of the way forward.

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Problem statement

A society's use of space is shaped by lifestyles, by technology, and by the economy. Today, over three-quarters of the Earth's surface have been transformed by human activities, and this fraction will only increase as the global population grows by 28% until 2050. Already, 29% of land is degraded, representing a key cause of malnutrition, poverty, forced migration, and conflict for some 1.3–3.2 billion people. Urban sprawl, land degradation, and deforestation continue unabated, driven by livestock farming, raw material extraction, industrial development, and other important factors. With an ecological footprint of around five global hectares *per capita*, Switzerland contributes significantly to these worldwide trends.

Space in Switzerland is under intense pressure, fuelled by conflicting demands for infrastructure, transportation, housing, recreation and tourism, food production, and industry. Some 70–80% of the Swiss population now lives in cities, suburban, or peri-urban areas, which – together with connecting infrastructure – occupy a major fraction of the lowlands. This pressure upon space threatens Switzerland's landscape diversity and biodiversity, and the essential ecosystem services that these provide. It has been estimated that to prevent further loss of essential natural resources at least 30% of Switzerland's land area – encompassing all types of natural habitats – must be protected and used in ways that maintain or restore biodiversity.

Inspired by the 2030 Agenda, *thriving spaces* offers a vision of living environments that meet the resource needs of all people while maintaining the integrity of natural systems. Thriving spaces are places where both biodiversity and people flourish; they are carbon neutral, resilient, capable of regeneration and foster human well-being and social connections. It is a vision intended to show the kinds of adaptation that will be needed for everyone to lead a good life within the constraints of planetary boundaries. Making this vision a reality, however, will require radical changes not only in lifestyles and economic activities, but also in how people perceive and use space, both nationally and globally.

One major challenge will be to develop more holistic strategies for planning and managing the use of space. How we perceive, value, and use land are strongly influenced by our cultural, societal, and economic systems. Conversely, patterns of spatial development also influence social attitudes, lifestyles, and economic activities. These tight linkages mean that competing claims on space can only be resolved if we consider prevailing societal values, particularly relating to individual freedom and environmental concern. Such values, however, often vary widely between rural and urban areas, between economically thriving and marginalized areas, between social classes and between different generations. Progress towards greater sustainability, as envisioned in *thriving spaces*, can only occur if these differences in values, and the concerns and fears they engender, are taken into account in the planning process.

Another challenge is ensuring policy coherence. All too often, there is misalignment – even conflict – between sustainability goals and policies in different sectors such as transportation, agriculture, tourism, industry, and energy. For example, subsidies designed to support a particular goal in one sector often cause harm in another sector. Competing interests also manifest as political divides, which make it difficult to implement the kinds of comprehensive strategies needed for sustainability. Finally, global dynamics can interfere with, and even neutralize, the outcomes of policies developed at a local or national level. Real estate and property markets, for example, have been altered by the growing dominance of the financial sector (financialization), and remote investors may show little interest in incorporating local sustainability goals in their projects.

On the practical side, there are many things that can be done to make the vision of thriving spaces a reality, though research will be needed to determine the most effective options. For example, economic systems and business models need to be harmonized with the vision of sustainably thriving spaces. Opportunities include plan-

ning for carbon neutrality, adopting industrial ecology approaches, utilizing smart and digital technologies, and developing a circular economy based on reuse of natural resources. In many places, maintaining the essential services provided by natural systems, such as supporting biodiversity, providing food, and acting as a sink for CO₂, will require restoring degraded land and preventing further degradation. To realize these ideas, however, will require institutional arrangements that ensure close collaboration between stakeholders in urban planning, politics, NGOs, and academia.

Key unresolved questions

Envisioning thriving spaces: The concept of thriving spaces as presented here is very broad. The essential elements of this concept need to be fleshed out in greater detail to provide a basis for public debate, planning, and policy.

Key questions are:

- How do different actors – including citizens, planners, and policymakers – perceive the value of the space in which they live? What role does the aesthetic dimension play in this respect?
- How can we link spaces to well-being, and what are the meanings and narratives of well-being in the context of thriving spaces?
- What are joint visions of thriving spaces, and how do they address the concerns of sustainable development and the 2030 Agenda as well as the need to maintain natural diversity and associated natural resources?

Spatial development: In Switzerland, federal planning law is designed to encourage inward urban development, including better use of vacant land, higher densities, and the creation of attractive urban green and blue spaces. Yet the consumption of land via urban sprawl remains high (0.69 m² per second in Switzerland²), fuelling continued loss of green spaces and biodiversity. In particular, effective instruments are lacking that recognize and protect the quality of landscapes outside of settlement areas. In addition, spatial development also needs to tackle social divides, e.g. the consequences of gentrification. Overall, questions around social diversity, quality of life, sustainable habitats, and spatial development must be addressed.

This leads to the following questions:

- What are appropriate, socially inclusive strategies, concepts, and instruments to address densification and inward settlement development, protect and revalue un-

² www.bfs.admin.ch/bfs/fr/home/statistiques/espace-environnement/utilisation-couverture-sol/evolution.html

built areas, ensure adequate biodiversity, and safeguard essential ecosystem services?

- How can the quality of life in urban areas and other living environments be improved for everyone, in particular the socially disadvantaged?
- How can the instruments of spatial planning be put to work in the service of climate protection and adaptation to climate change?

Dealing with urban–rural divides and unequal opportunities:

Rapid demographic changes, such as those triggered by inward migration or industrial decline, can lead to economic disruption and social and political unrest. Recent research illustrates that linguistic divides are disappearing in Switzerland. However, the language-based *Röstigraben* is giving way to new regional divides between cities and agglomerations, on the one hand, and smaller rural communities, on the other. As a result, social inequalities between and within regions are rising. Overall, spatially manifested frictions, such as the urban–rural divide, have been increasing in recent years and need to be better understood. Differences in consciousness and other roots of the problem – often related to social, cultural, and economic opportunities (or lack thereof) – need to be addressed. We must particularly consider how global challenges such as mass migration and industrial restructuring are linked to these locally manifested political divides.

Key questions include:

- What are the drivers and social consequences of the urban–rural divide? What are the roles of globalization, digitalization, demographic changes, etc., and who are the ‘winners’ and ‘losers’? How does social inequality manifest itself spatially and what are the implications for thriving spaces?
- How can we build better links between urban/core and rural/peripheral spaces? What form could sustainable urban–rural/core–periphery partnerships take?
- How can we solve these issues without exhausting natural resources?

Tackling the underlying causes of unsustainable lifestyles: Current lifestyles lead to excessive consumption and resource use, both in Switzerland and abroad. High levels of resource consumption and mobility lay claim to ever more land and cause pollution and greenhouse gas emissions. We need to understand how we can foster more sustainable lifestyles despite structural constraints and strong public demand for mobility. Structural conditions that induce mobility can be found in the ways our economies have developed (tertiarization, location of industries, models of work, etc.). Individual behaviour and incentives (infrastructure, low-cost fossil fuels, and subsidies, etc.) have encouraged unsustainable mobility. New solu-

tions are needed to transform these complex underlying conditions.

Concrete questions:

- What are key causes of unsustainable lifestyles? What are the underlying institutional, political, and structural arrangements that lock them in? How can widely accepted sustainable lifestyles be fostered?
- What are new visions for how communities can meet essential needs and enable well-being (e.g. the ‘15-minute city’ in which all necessary functions such as work, shopping, leisure, etc. are walkable and accessible on foot or by bike)?
- Can such visions enhance or even replace our current ideas about how to develop urban and peri-urban spaces? What can we learn from the COVID-19 crisis to reconceptualize mobility in sustainable ways?
- Will digitalization (e.g. teleworking, integrated mobility services, ‘industry 4.0’) lead to further land consumption or will physical proximity assume a new role in the context of an increasingly digitalized society?

Implications of (economic) cost transparency on thriving spaces:

Many aspects of spatial development entail (e.g. ecological) costs that are not internalized. In some cases, political actions such as subsidies produce costs that are not accounted for. Examples include the use of pesticides that spread into surface and ground waters, or transport systems that create noise and emit pollutants. Internalizing such external costs and creating positive spillovers are key to move forward. Measures such as congestion pricing, carbon taxes, and payment for ecological benefits appear to have great potential. One way of moving forward may be to establish positive incentives for the creation of ecological benefits. We should also consider new approaches such as that of a ‘sharing society’ or circular economy and how they could reduce externalized ecological costs.

Questions include:

- What are the external costs, including those arising abroad, resulting from our economic and private activities related to use of space, especially for ecosystems, their diversity, and the ecosystem services they provide?
- Which framing conditions are needed to create cost transparency and internalize external costs related to how various actors use land and space? Which incentives have the potential to create ecological benefits?
- How can the internalization of external costs be implemented politically, e.g. road pricing in the case of mobility?

Climate protection and adapting to climate change: It is predicted that built-up areas in Switzerland will suffer from more frequent extreme weather events such as heatwaves and

heavy precipitation, which will lead to increased surface runoff. On the one hand, sustainable urban development should include measures that facilitate adaptation to these effects of climate change. On the other, further measures for climate protection must be taken in order to increase the resilience of the biosphere. These measures include reducing CO₂ emissions and strengthening ecosystems in urban areas by increasing their biological diversity. Blue and green areas as well as smart urban layout will be key to keeping such areas liveable.

Important questions are:

- How can built-up areas be developed based on their natural surroundings and landscape in order to adapt to climate change and assist climate protection?
- How can spatial development be supported by dialogue between experts from a broad range of academic and non-academic fields with different perspectives on the implications of climate change?
- What are concepts of resilience for thriving spaces that enable adaptation to climate change?

Realizing thriving spaces: Taking action in sustainable urban development is not easy. New governance and planning approaches capable of identifying and resolving conflicts of interest need to be developed. Observing the principle of participation in decision-making, citizens need to be proactively engaged in these processes. Such participation could raise awareness about how human activities are dependent upon, and also influence, nature. In addition, experts from science and practice – including fields as diverse as urban planning, architecture, political science, biology, geography, etc. – need to be engaged in respective partnerships. They need to help decision-makers and citizens in understanding the complex nature and relationship between the various topics associated with thriving spaces. In addition, such approaches could also help to build a shared understanding of the importance and relevance of transformative change for each individual and society as a whole. Experimental instruments such as test planning, real world laboratories, and pilot projects that promote public participation need to be mainstreamed.

Concrete questions:

- How can we as a democratic society develop the necessary decisions for sustainable land use and thriving spaces?
- How can citizens be more strongly engaged in sustainable urban development?
- How can pilot formats like test planning, real-world laboratories, and pilot projects be used for collectively realizing desirable, sustainable thriving spaces?
- What new governance approaches are needed to address conflicting goals and interests?

- How can inclusive processes to realize thriving spaces be shaped, and how can climate protection and adaptation to climate change be made integral parts of them?

Expected relevance for Switzerland and internationally

There are many areas of policy in Switzerland that have spatial implications. Some of these are cross-sectoral, such as the New Regional Policy (NRP) and the agglomeration policies, while others are sectoral, including economic, agricultural, energy, transport, environmental, and financial policies. To a large extent, these policies are inadequately aligned and pay insufficient attention to sustainability goals. In some cases, they even directly conflict with each other. Research is urgently needed to help develop policy frameworks capable of supporting overarching sustainability goals. Answers to a variety of questions are particularly important: To what extent should the goals of the Swiss Sustainable Development Strategy guide federal government and the cantons in their funding decisions? How can budgets be aligned with sustainability goals? Can public policy become more mission-oriented when it comes to public investments resulting from these programmes? What about synergies and conflicts between the policies, subsidies, etc.? How can policy-makers dynamically adapt their programmes to changing conditions such as increasing risks and uncertainties due to climate change?

The cross-cutting concept of *thriving spaces* introduced here can significantly improve people's understanding of conflicting objectives regarding the use of space and provide innovative ideas for more sustainable futures. Switzerland's democratic and federalist structure offers the opportunity to test innovative approaches.

Links with the other thematic areas that need to be addressed

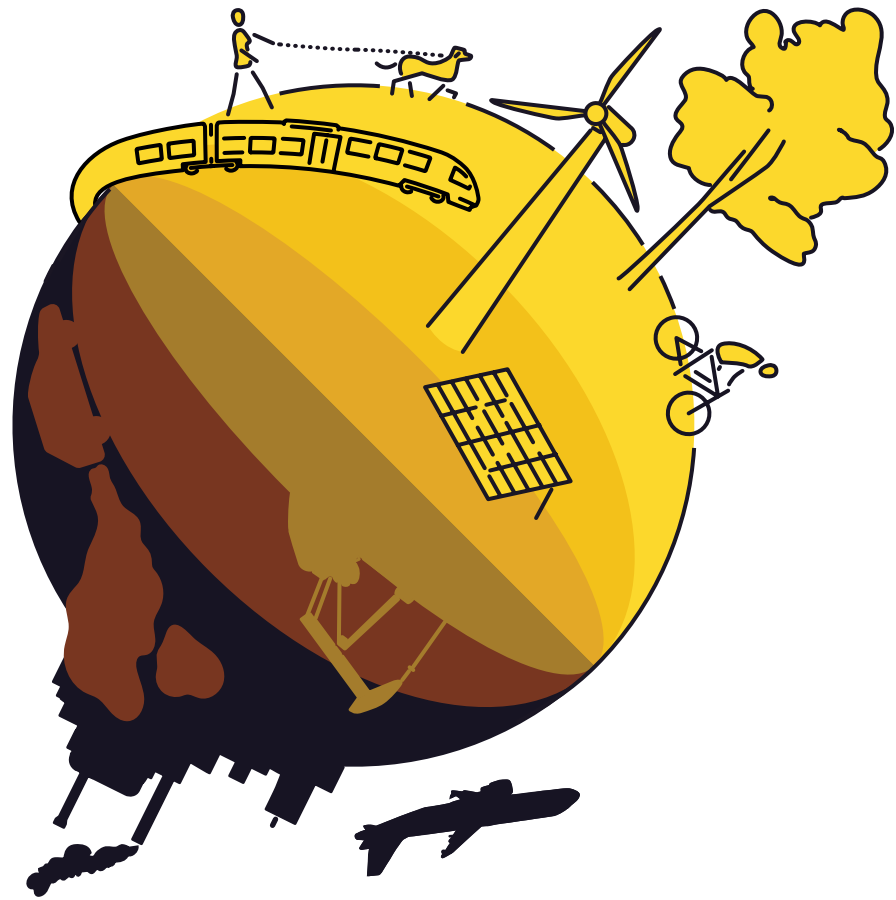
The use of land and water resources for *food production* may compete with or reinforce visions of thriving spaces – food production and spatial issues are inseparable. Key questions centre around whether and how strongly food systems are divided from other uses of land or are integrated in settlement structures, e.g. in the form of vertical farming structures that challenge the notion of agriculture being based solely on use of land areas. This example also shows that such solutions can simultaneously contribute to improved climatic conditions in settlement areas, including cities.

Thriving spaces are closely linked with property and land use rights both in Switzerland and abroad. The process of financialization noted above highlights how strongly issues around land, resources, and space are permeated by the dominant thinking and power of the financial system. This trend is leading to more social inequalities, land grabbing, and generally more ecological degradation. Further, it is an expression of Switzerland's strong global interdependencies. The way we deal with our space is strongly interlinked and dependent on where the products we consume are manufactured and which country provides the respective space. How can promising models of *green* and *just economies* consider the global perspective of thriving spaces?

Social *values*, *visions*, and *pathways* are fundamental to realizing the ideal of thriving spaces and for addressing issues of protection and use of space. Our spaces are the result of societal visions. Spatial planning has a long tradition of working with visions. To change values in a direction that makes realization of thriving spaces possible, a change in perspective and consciousness is needed in terms of how we view our relationship to nature. However, broader debates on such a change in perspective have largely been missing to date. It could be worthwhile to examine the underlying values shaping such visions, and investigate which actors share and influence them. Dealing with explicit, known values must also be complemented by efforts to learn more about *implicit* values that influence how landscapes are produced and reproduced. One interesting research area could centre on kinds of transformations that happen in spaces and how underlying values change in the process.

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4. Net-zero Greenhouse Gas Emissions Society

To achieve the very specific goal of reducing net greenhouse gas emissions to zero by 2050, many technical challenges and conflicts of interest must be overcome. How can a strategy be developed that is politically and socially acceptable? Research is needed to support societal efforts to rethink the links between energy use and human well-being.

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Problem statement

Under the Paris Agreement, Switzerland is committed to halving its anthropogenic greenhouse gas emissions, relative to 1990 levels, by the year 2030. In addition, the Swiss Federal Council has set the goal of achieving net-zero greenhouse gas emissions (net-zero GHG) by 2050, as recommended in the most recent IPCC report. Exactly what this goal will entail and how it can be achieved remain unclear both to experts and the public. The Federal Climate Strategy 2050 will propose ways of achieving it, laying out possible emissions pathways and discussing the potential need for negative emissions technologies.

Options for a techno-economic transition to a net-zero CO₂ energy system in Switzerland are currently being assessed

by the Energy Commission of the Swiss Academies of Arts and Sciences. Drawing on the *Energy Perspectives 2050+* (Swiss Federal Office for Energy), the assessment will address future demand scenarios as well as opportunities for renewable energy, improved energy efficiency, and carbon sequestration. The research priority presented here complements this work, focusing more on the socio-economic and political implications of moving towards a net-zero GHG society. It also considers other types of greenhouse gases, such as methane from agriculture and nitrous oxide from industry, and explore in greater detail the implications of deploying negative emissions technologies to address GHG emissions that are hard to abate. Much of this research relates to cultural, ethical, social, behavioural, economic, legal, and political issues, such that the social sciences and the humanities will have important

contributions to make. Taken together, the two initiatives of the Swiss Academies aim to provide a roadmap for essential research needed for the establishment of a net-zero GHG society. This contribution of science will be based on societal deliberation and linking of energy provision and net-zero imperatives with human well-being.

The goal of achieving net-zero GHG in just 30 years presents an enormous scientific and technological challenge. Given the extensive time horizons required to build infrastructure, our opportunities for rapid change are limited. Progress has been made in decarbonizing energy provision, land transport, and industrial production, but eliminating GHG emissions from sectors such as aviation and agriculture is more challenging. In these cases, significant progress will require innovations in areas such as carbon-neutral fuels and negative emissions technologies. At present, we lack realistic trajectories and pathways towards net-zero GHG, and it is critical to identify the most promising strategies. To be successful, any such strategy must be informed by a broad societal debate and supported by appropriate economic incentives and policy interventions.

In addition to technological feasibility, achieving net-zero GHG will critically depend on economic, social, legal, and institutional conditions. To identify realistic pathways to net-zero GHG, it is important to consider the kinds of socio-economic transformations needed and to explore socially and ecologically sound alternatives. Any pathway will involve difficult trade-offs and ethical tensions, for example, regarding the use of land for either food production or carbon storage. Informed public debate about these trade-offs and tensions, and especially their implications for social justice and security, will be essential.

The research needs identified by the SRI working group can be summarized as follows. First, conceptual work is needed to clarify key concepts such as net-zero GHG emissions and negative emissions technologies, and how these relate to similar concepts used elsewhere. Second, research is needed to develop visions and scenarios for a net-zero GHG society and to consider the implications of these for all sectors of society. Third, the legal, economic, social, and justice issues related to storage and transportation of liquefied CO₂ must be considered, especially potential legal challenges to transporting and storing CO₂ in the European Union. Fourth, the international dimensions of different net-zero GHG scenarios must be considered. For example, do particular scenarios lead to outsourcing of emissions to other parts of the world? Does the import of renewable energy threaten economic security? Finally, the financial costs of developing and implementing necessary technologies must be analysed.

Key unresolved questions

What is a net-zero GHG society? It is necessary to clarify what is meant by the goal of ‘net-zero GHG’ and how this should be tackled. The Swiss Federal Office for the Environment has outlined the Swiss government’s interpretation of net-zero GHG. But it remains unclear how different stakeholders perceive the challenges ahead and the kinds of solutions needed. Achieving a consensus on these issues is vital as there are several definitions of net-zero in use, each with different societal implications and potential ethical conflicts that must be resolved. Establishing an overview of the various terms used across countries, programmes and sectors – and their respective consequences for potential action – is an essential analytical step on behalf of subsequent investigations.

More concretely, the SRI working group proposes asking questions like the following:

- What is meant by a net-zero GHG emissions society in various countries, programmes, and sectors, and what respective paradigms of transformation are invoked?
- How do these understandings relate to each other, and are there significant inconsistencies in terms of ideals, values, social practices, or institutions?
- In current social discourse, which of these interpretations are used by whom and to what effect?

Conceptual clarifications: The role and potential of negative emissions technologies in Switzerland was clarified in a report adopted by the Federal Council in early September 2020³. However, additional conceptual clarifications are needed to understand how different solutions can contribute to a net-zero GHG society. For example, what are the distinctions between negative emissions technologies (NETs), greenhouse gas removal (GGR) technologies, and carbon dioxide removal (CDR)? Further, it remains unclear whether NETs should be treated as mitigation and whether the distinction between ‘natural’ and ‘non-natural’ NETs is legitimate. Such framings are important and powerful in politics, but often hard to defend scientifically. Given that the social and political contexts of different measures matter, it is important to analyse the history of the net-zero goal from both social science and philosophical-ethical perspectives. Such analyses should include the institutional and economic contexts favouring different solutions (e.g. sustainable forestry as a socially produced storage system) as well as alternatives to value chains that increase carbon emissions. Without these conceptual clarifications, both scientific analysis and related policy recommendations will be hard to compare and easy to dispute.

³ <https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-80271.html>

Concrete questions:

- What is the Swiss discourse on net-zero GHG and negative emissions technologies and (how) does it conceptually and substantively differ from the international discourse?
- What are the ethical and legal-institutional implications of different framings and what do they mean for policy?
- Is a single net-zero GHG target sufficient, or do we need one for mitigation and one for carbon removal? And if two separate targets are needed, how do they relate?
- Which pathways to a net-zero GHG society and related measures are currently being considered at the national, cantonal, and city levels in Switzerland? How do they differ, and how are they justified?
- What emissions can reasonably be eliminated by technological means (replacement, efficiency) and what emissions must be reduced by sufficiency as well as mitigation measures? What GHG emissions will be hard to mitigate and may require NETs? How can the moral hazard of delaying mitigation be prevented?

Strategic options: A broad systemic perspective is needed to establish net-zero GHG pathways that avoid the pitfalls of considering different sectors or individual technologies separately. Details are needed on how the portfolio perspective demanded by the Swiss Federal Council should be composed. For example, the same land and biomass cannot be used at the same time to produce food, energy, and building materials. Any proposed solution should be based on an understanding of the potential conflicts or synergies with other societal needs and values.

Concrete questions:

- What are possible net-zero GHG pathways involving all sectors, what are their costs, and what are their additional energy demands? How effective and efficient are these different pathways? What are their respective positive and negative side effects or risks, and how are they perceived?
- While digitalization dematerializes the economy in many areas, demand for electricity as well as cooling from servers will increase and the demand for critical resources such as lithium, cobalt, nickel, and rare-earth metals will grow. Is there a trade-off between the benefits of digitalization in dematerializing economic activity and the energy and resource demands created by the same process?
- Artificial general intelligence (AGI) is seen as both a singular opportunity to create a better world and an existential risk for humanity. How can the potential of AGI be harnessed for sustainability while minimizing its risks?
- How can digitalization efforts support the transformation process? Clearly, unnecessary trips can be significantly reduced, supply chains further optimized, and

resource use minimized – but what are the limits to digitalization of the economy?

- What are the systemic interrelations between proposed pathways of different sectors, how do they respond to each other, and how could potential trade-offs be reconciled? What are possible sets of pathways across all sectors that are independent of other sectors and thus do not have any consequences for achievement of other (sustainability) goals?
- What ethical conflicts result from different pathways in different sectors and how can they be analysed?
- At the macro level, and more fundamentally: (how) can net-zero GHG scenarios be reconciled with economic growth and productivity, and what are the implications of respective transformations, e.g. with respect to new jobs required?

Enabling societal transformation: In developing net-zero GHG pathways, the necessary socio-economic transformations must be analysed. The ongoing coronavirus crisis vividly illustrates both the complexities and the possibilities of such transformation processes. Societal transformations are not easy to achieve and may benefit from the results of both ‘transformation’ and ‘transformative’ research, as distinguished by the German Advisory Council on Global Change. This research can benefit from intense collaboration between science and various other sectors, including public, private, and non-profit organizations. In fact, many local initiatives already exist experimenting with decarbonization pathways. They offer valuable, concrete experiences for learning about required social transformations.

Concrete questions:

- What set of policies is needed for different net-zero GHG pathways? Who would win, who would lose? What trade-offs with other policy domains (health, social, economics, etc.) must be tackled?
- What is needed to achieve broad societal acceptance for such pathways? What are the hindering factors, and what are the politics behind that? How can such pathways be supported more efficiently?
- How can we overcome the known social challenges resulting from the unequal distribution of environmental burdens and risks associated with different net-zero GHG pathways and CDR technologies?
- How can we achieve policy implementation? What role is there for public participation by civil society or the private sector? What role do bottom-up initiatives play and how can these be leveraged for a net-zero GHG society?
- What role do individual consumption patterns play on behalf of a net-zero GHG society? And, in contrast, what role do structural forces play? How do individual and structural change interact?

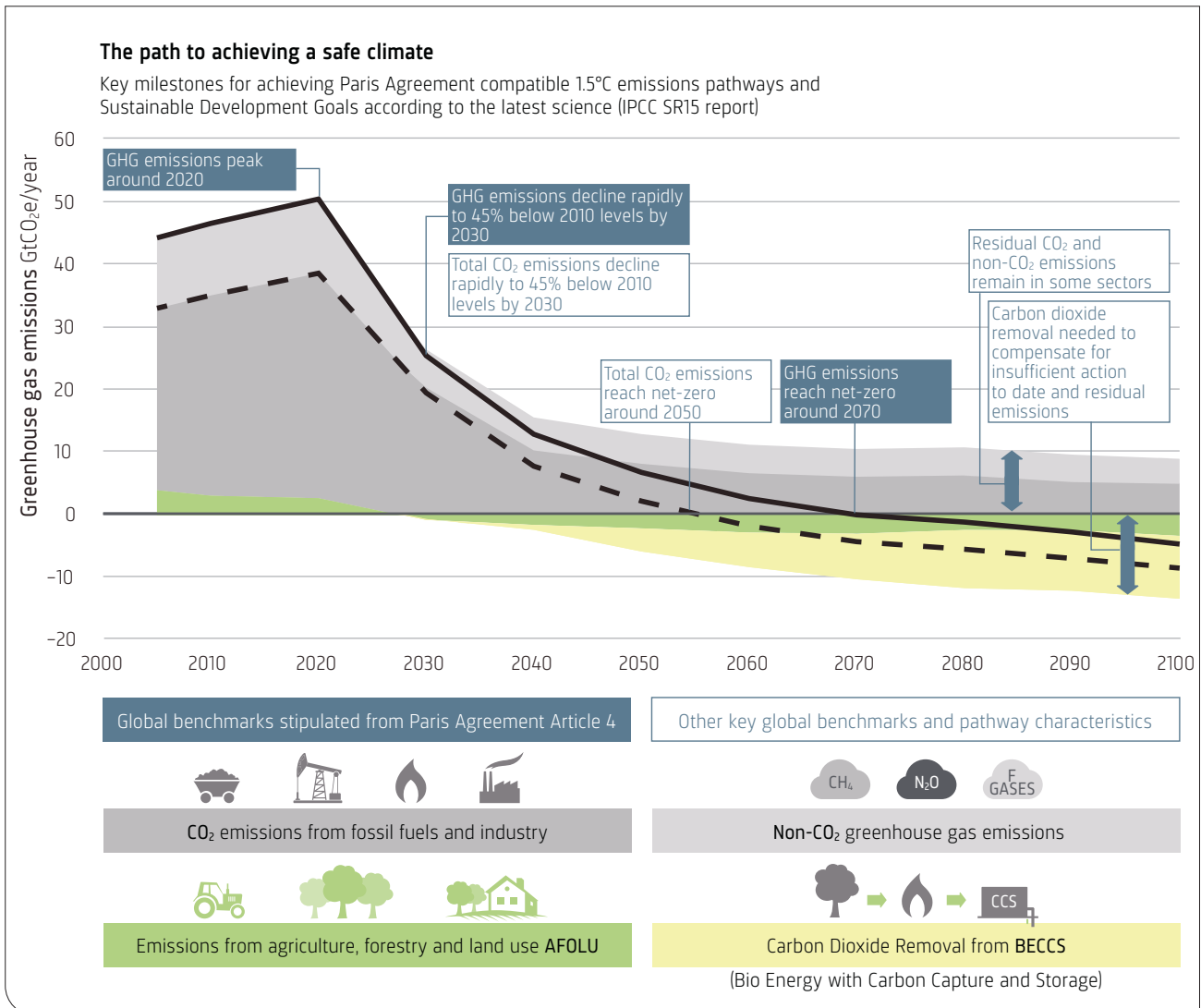


Figure 4.1: Illustration showing the predicted decline of emissions to below net-zero. Important: Net zero CO₂ should be reached by 2050 (dotted line), net zero greenhouse gases (GHG) around 2070 (solid line). Switzerland has opted for a net zero GHG balance in 2050. It is expected that CO₂ removal technologies (yellow and green) will play a key role in achieving net-zero. Source: Schaeffer M. et al. (2019) Insights from the IPCC Special Report on 1.5°C for preparation of long-term strategies. Climate Analytics gGmbH, Berlin

- What role can and should science play? How can it support such transformation processes? How can it assist and facilitate existing initiatives, programmes, ideas, activities, etc. that are experimenting with net-zero GHG pathways? How can social experiments, living labs, and real-world labs help to produce necessary knowledge and gain concrete experience? How can science systematically analyse ongoing experimental pathways, learn from their success and failures, and scale them up and out from the niche level?

Expected relevance for Switzerland and internationally

Effectively tackling climate change is a crucial challenge within the framework of the sustainable development goals – particularly SDG 13, but also including interrelations with many other SDGs, e.g. 3, 5, 6, 7. With ‘net-zero GHG’, the Swiss government has set an ambitious target that will require close collaboration by government, industry, civil society, and science. Major innovations will be needed, both from a technological perspective and, especially, from a social perspective. The research agenda described here will provide essential inputs needed for

Switzerland to transform towards a net-zero GHG emissions society.

Links with other thematic areas that must be addressed

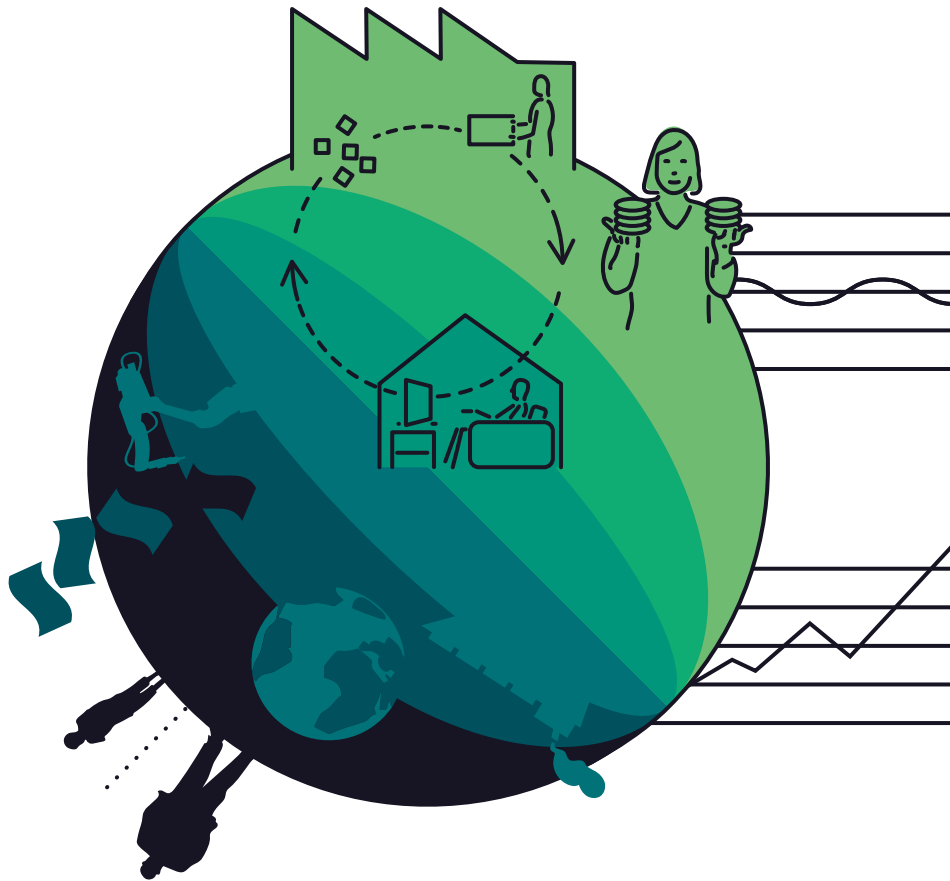
Food production, on the one hand, and the use of (potentially cultivable) land and biomass to realize the net-zero GHG goal, on the other, require trade-offs with respect to available land resources. Visions of *thriving spaces* need to include spaces for both renewable energy production and negative emissions technologies. Well-managed space can also help to reduce demand for transport, a sector in which emissions reductions and decarbonization are challenging. Agriculture has the potential to store more carbon in the soil (or reduce carbon losses), but it could also become a net energy producer again (e.g. by reducing highly energy-intensive fertilizer inputs).

Energy production is both fundamental to, and influenced by, the framing conditions, rules, and mechanisms of the *economy*. Thus, transforming our economic system also impacts energy provision and use, and vice versa. Further, the way the net-zero GHG emissions concept is currently framed and discussed in Switzerland excludes the investments of Swiss finance institutions (including the Swiss National Bank) in CO₂ intensive markets.

Social *values*, *visions*, and *pathways* are fundamental for understanding various actors' notions of a net-zero GHG society. Many issues will determine whether or not their respective vision of a net-zero GHG society can be achieved. How is the vision framed, by whom, and how much power do these actors have to promote that vision? Is the goal to be net-zero CO₂ or GHG? Is the target year 2030 or 2050? What will be the relative importance of technological solutions vis-à-vis changes in consumption and economic growth? Will emissions generated abroad in the production of imported goods be taken into consideration or not? Different sectors and actors will favour different visions, largely driven by diverging values, which translate into different pathways.

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5. Economic and Financial Systems for Well-being

Our current economic system tolerates or even encourages highly unsustainable practices. Finance is increasingly disconnected from the real economy and the huge volumes of assets traded in uncontrolled, speculative and manipulated financial markets have contributed to economic and financial instability. The costs of resulting crises, overconsumption, pollution, resource depletion, and social inequalities are far too high, both for present and future generations. Our current economic paradigm must be transformed into one that serves sustainable development.

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Problem statement

Today's dominant economic system is globalized, strongly financialized, and oriented towards growth. The incentives inherent in this system foster inequalities, both within and among countries. They also cause increasing damage to the Earth's natural systems – especially to the climate, biodiversity, and natural resources. These inequalities and environmental impacts are exacerbated by legal frameworks that grant property owners broad freedoms to use and exploit natural resources and labour. In all this, the needs of the poor and others who suffer the consequences of environmental degradation are neglected, as are those of future generations.

Economic practice is strongly influenced by the dominant paradigm of neoclassical models, which also inspired the so-called Chicago School of thought. These models are based on rather unrealistic assumptions of efficient markets and rational behavioural patterns (*homo oeconomicus*) that are seldom questioned. Financial markets are modelled as perfect and efficient, ignoring the fact that, in practice, they are both biased and manipulated on a large scale. In the context of sustainability, four aspects of modern economic systems deserve special mention because of their evident consequences for social and environmental well-being.

First, dominant economic models do not consider how the economy is *embedded* in society. Rather, mainstream theories describe the economy largely by and for itself, and evaluate societal and environmental factors in purely economic terms, treating ecological and social problems as ‘externalities’.

Second, the mainstream economic paradigm promotes a form of globalization that increases international competition, pushes down prices of many commodities, and massively increases transportation. To a large extent, this paradigm ignores the negative impacts of globalization, including overexploitation of natural resources, increasing wealth inequalities, pollution, and our growing vulnerability to economic, societal and health crises, such as pandemics.

Third, mainstream economic thinking is infused with an optimistic belief that technological progress coupled with market mechanisms is capable of overcoming all limitations of natural systems and solving all environmental problems. In reality, this optimism is disproved by many examples showing that ‘more, bigger, and better’ technologies can even increase a country’s ecological footprint. Further, the benefits of technological innovations such as digitalization and robotics are unevenly spread across societies and countries, and often generate even greater inequalities.

Finally, all these trends are exacerbated by the increasing disconnection of finance from the real economy. Further, perceived opportunities to earn vast sums rapidly by trading in financial markets have contributed to economic and financial instability and aggravated social inequality.

Given these deficiencies, many researchers and thought leaders have called for the economic system to be transformed so that it reflects the normative aim of ‘sustainable well-being’. Many proposals have been made on how to achieve this, proposed under labels such as circular, flourishing, regenerative, restorative, ecological, common good, and doughnut economics; *décroissance*/degrowth, well-being economy, strongly sustainable business models, *buen vivir*, and thriving. A growing literature, much of it produced through interdisciplinary, policy-oriented research, is showing how such approaches could be implemented. These studies emphasise the need to align investments with long-term sustainability pathways, divest from fossil fuels, and decouple the benefits of economic activities from environmental degradation while aiming for convergence in living standards and opportunities. There is also widespread agreement that sustainable economies need to be based upon indicators that, unlike GDP, support and measure well-being rather than economic growth and profit. Scholars also agree that

sustainable economies must be resilient, in the sense that they are both resistant to shocks and able to recover from them (unlike the economic responses to the 2008 global financial crisis, or the 2020 coronavirus pandemic!).

To date, however, these ideas have had little impact on mainstream economics, whether in Switzerland or elsewhere. Indeed, there is currently no real pluralism in terms of schools of thought, and very little serious discourse about alternative paradigms.⁴ An important goal of the research proposed here is to stimulate a vigorous scientific debate about alternatives. In the view of the SRI working group, this is an essential first step towards transforming the economic system.

Key unresolved questions

Potential models for sustainable economies: There is extensive theoretical literature concerning sustainable economic systems. One main problem is the implementation of such systems. An informed and broadly-based debate on implementation is required to develop innovative policy recommendations. Such a debate should ask how dealing with environmental resources, limits, and societal values can be put at the core of the economic system. To that end, existing theories on growth, capital, property, profit, competition, power, well-being, and the role of the financial sector need to be critically discussed and analysed.

Unresolved questions include:

- What are the main discrepancies between current models of economic systems and the sustainability principles of the UN?
- What are promising understandings, visions, and models of sustainable economic systems? What are their underlying assumptions and paradigms, and what are their key characteristics? How can they be concretized, at different scales and for Switzerland specifically, and how can corresponding transformation be fostered? What are inspiring success stories?
- How can models interlinking economics and finance be constructed to include environmental and social concerns?
- What are scientifically robust arguments substantiating that economic policy and public debates solely guided by GDP and the growth imperative are not compatible with sustainable development and thus need to be complemented with alternative metrics? How can such new metrics be established?

⁴ Attempts to promote interdisciplinarity include the establishment of the Center of Competence for Sustainable Finance at the University of Zurich

Towards altered patterns of production and consumption: Sustainable economic systems will almost certainly entail altered patterns of production and consumption. It would be useful to identify realistic options for change in different sectors and regions. Also, it is unclear what the implications could be for the current, largely globalized division of tasks in these systems.

Unresolved questions include:

- What are concrete options, requirements, and framing conditions for national and global sustainable production and consumption, and for which sectors?
- What are the major tasks in developing technical systems and societal structures to enable altered patterns of production and consumption? What are potentials and limitations of the circular economy? What is the potential of sufficiency in consumption and how can it be fostered?
- Where might increased efficiency be enough to minimize costs to the environment and society, where are major innovations also needed in the supply of goods and services, and where do we need to rethink demand more radically?
- How can the value of common-pool resources and non-commodity ecosystem services appropriately be considered for realizing sustainable production and consumption patterns?

Adjusting public finance systems: The current national and international tax systems and national systems of public finances were set up several decades ago and have not been adequately adapted to meet the challenges of sustainability, globalization, and increasing inequality.

Questions include:

- What elements of the present tax systems contribute to unsustainability or hinder the solutions to sustainability problems?
- What are truly inclusive approaches to public finance, subsidies and taxes, given that e.g. taxing mainly labour or consumption is counterproductive?
- How can the tax system evolve into a mechanism that lessens environmental pressure, contributes to the income generation, reduces social inequality, and stimulates the economy to become sustainable?

The role of finance: The current financial system is largely globalized and its mechanisms are extremely complex. Alternative business models and regulatory reforms for the financial system are needed to turn it into a sector that serves sustainable development.

Unresolved questions include:

- What are the role and core characteristics of a sustainable financial system? What form and degree of global

collaboration would a sustainable financial system ideally feature?

- How would money creation occur in a sustainable economy? What would be the implications for the roles of capital, debt, property, and power?
- What are the contradictions between the financialization of the economy and the principles of sustainable development?
- How can the banking and financial system support the real economy in its transition to more sustainability? What is the role of central banks investments, especially in mitigating climate change?
- How can the considerable systemic risks emanating from toxic financial assets be measured and eliminated?

Enabling public debate about economic systems: To achieve the goal of developing sustainable economic and financial systems, economic research must be conducted in close collaboration with other disciplines and societal actors. The general public, and students in particular, need to understand what is at stake and be involved in a critical debate about our economic and financial systems.

Key questions are:

- How can the scientific discourse about different schools of thought in economics and finance be promoted in research and teaching activities? What conditions and structures need to evolve?
- How can an open debate about the economic and financial system be organized in such a way that it results in policy recommendations serving sustainable development goals? Who needs to be included in this debate, and how can power imbalances be dealt with?
- Which systems of sustainable economies would be preferred by the different relevant actors, and what considerations shape the respective social discourses?
- How can a fruitful interdisciplinary discourse be established between business, scientists, economists, sociologists, political scientists, and philosophers? Which structures need to evolve to link these disciplines again?

Expected relevance for Switzerland and internationally

There is still very little awareness about the role of economic and particularly financial activities in many sustainability crises. Nevertheless, scholars from different fields, such as climate and biodiversity sciences, have begun calling for alternative economic models.

Our research proposal sheds light on fundamental assumptions and mechanisms of current economic systems and takes an interdisciplinary, policy-oriented approach to promoting more sustainable economies. It contributes

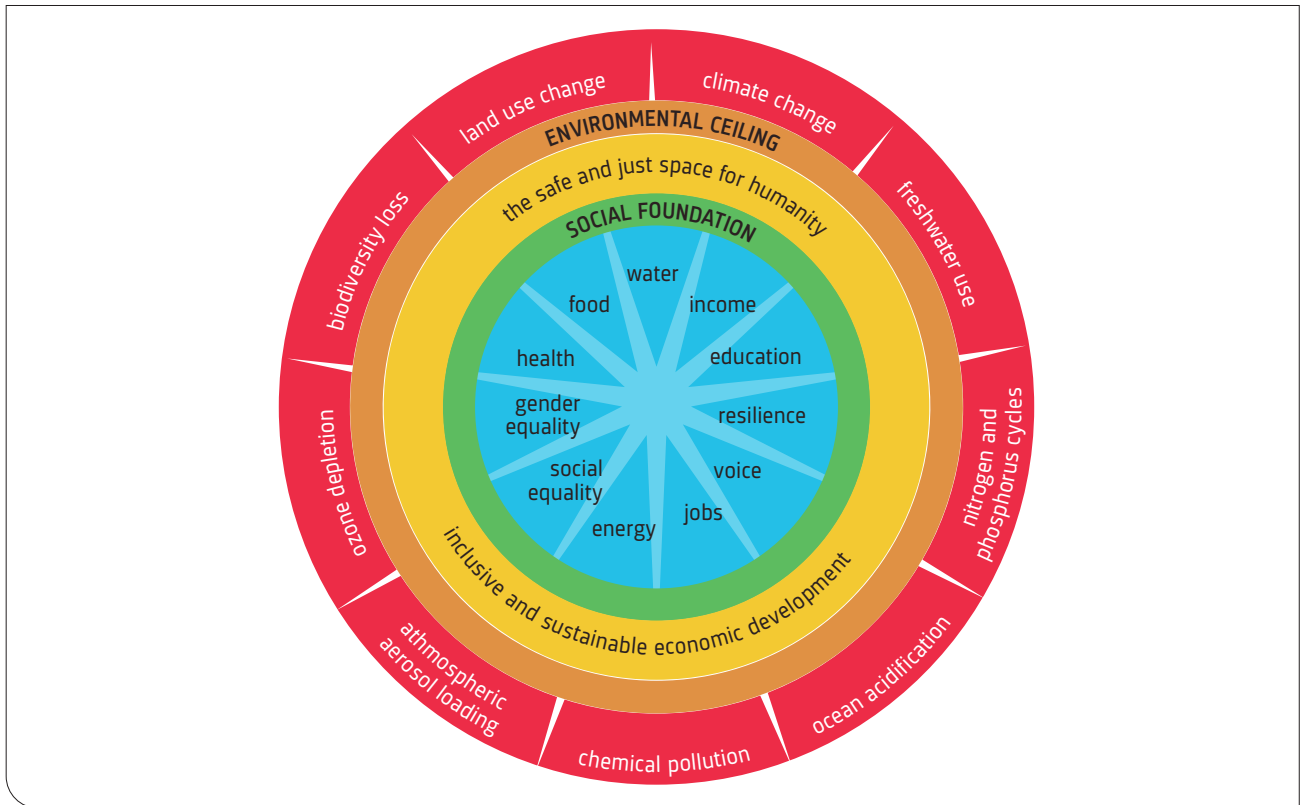


Figure 5.1: The doughnut economic model. The inner ring of the doughnut represents minimum requirements for leading a good life, based on the SDGs. The outer ring represents the ecological ceiling, beyond which human kind damages its natural environment.

The 'dough' in-between is where everyone's needs and that of the planet are met.

Source: Raworth K (2012) *A Safe and Just Space for Humanity: Can We Live Within the Doughnut?* Oxfam, Oxford.

not only to a new open policy design, but also promotes expanding existing work on policy mixes, combining economic policy with social and environmental regulatory tools in an optimal way. Single approaches can no longer be considered adequate. Moreover, our research proposal is aimed at the needs of transformation and recommends systematic policy monitoring that combines economic, social, and environmental instruments.

Such an approach is urgently needed in Switzerland, where mainstream economic thinking dominates policy-making, even though the need for interdisciplinary approaches is increasingly recognized.

Economic instruments for environmental protection must be complemented by social policies. The boundaries and bureaucratic implications of, for example, national and international emissions trading systems have to be clearly designed. Also, the potential contribution of the Swiss financial sector to sustainable development needs to be studied in an open and independent manner that care-

fully examines different policy options (voluntary agreements, incentives, direct control).

Links with the other thematic areas that need to be addressed

Our *food systems* are strongly influenced by economic practices and the economic interests of particular groups. The profitability expectations of food industry actors diverge from agricultural realities on the ground. Farms are generally heavily indebted. High-tech advances and robotics are leading to even higher financing requirements. Global seed and pesticide producers contribute to such trends – in Switzerland and globally. Consequently, farmers are forced to intensify their productivity continuously. At the same time, agriculture is, or should be, a special case, protected from conventional market forces, since it cultivates a public good. Non-commodity ecosystem services still play a critical role in food production, and there is significant scientific work on how to demonstrate the value of such services. Swiss agricultural policy strives

to combine social, economic, and environmental instruments, but our food system continues to produce major negative environmental impacts here and abroad, particularly due to agricultural imports. A possible free trade agreement with Mercosur, for example, would offer governments in South America, in particular in Brazil, even more incentives to continue destroying Amazonia to increase meat and soy sales to Europe.

Economic incentives alone will not be enough to achieve the *target of maximum 1.5° Celsius of warming* set by the Paris Agreement. In this regard, fossil fuel divestment represents an important potential lever of the financial sector globally. The responsibility of banks, the shadow banking sector, the Swiss National Bank – as well as the impact of their activities abroad (and globally) – need to be studied and integrated in models of sustainable economic and financial systems. For the Swiss financial sector to genuinely orient itself towards sustainability, and consolidate its international importance, it will require new business models. The institutional conditions for such reforms must be carefully studied. Overall, financial investment decisions will strongly impact sustainability trends going forward.

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6. Shared Values, Visions, and Pathways for Sustainability

'Sustainability', far from being an objectively defined concept, is underpinned by assumptions, discursive elements, values and paradigms, many of which are implicit and even contradictory. These need to be identified and debated so that we can develop a shared vision of a sustainable future and a strategy for achieving it. The scientific community can support this societal process with research that is collaborative and inclusive.

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Problem statement

Despite decades of research, policies, and actions for sustainable development, the kinds of social changes we need have yet to occur on a significant scale. One key reason is the failure to recognize that 'sustainability', far from being an objectively defined concept, is underpinned by assumptions, discursive elements, and paradigms, many of which are implicit and even contradictory. To make real progress, we must address the problem at its core, namely, by focusing on how societies can develop shared values, visions, and pathways that support social change towards sustainability. In this context, the SRI uses values as a shorthand for all those ideals, beliefs, and social norms that underlie representations, narratives, and practices of

sustainability; visions to describe notions and images of a sustainable future; and pathways to denote the processes of change by which sustainable development is realized.

In a rapidly changing world, with accelerating climate change and the current COVID-19 pandemic, it is urgent that we achieve a new consensus on meeting the legitimate social needs of all while protecting our environmental support systems. The scientific community can support this 'sustainability discourse' by providing the knowledge needed for informed decision-making, including *systems knowledge, target knowledge, and transformation knowledge*. It can also contribute to a better understanding of the narratives and knowledge systems upon which societies base their actions. In any society, there are inevitable

tensions between economic, social, and ecological aspirations, all of which are inextricably interconnected. An important impediment to sustainable development is that certain narratives are bolstered by powerful actors, while others are obscured or marginalized. Given the strong interests promoting economic growth, consumerist lifestyles, and individualized responsibilities, it is scarcely surprising that these narratives have a disproportionate influence on development trajectories. A vision of sustainability that privileges profit and growth, for example, will produce markedly different outcomes from one that subordinates economic interests to environmental priorities or people's longer-term social well-being. To achieve the kind of deep societal transformation needed for sustainable development, it is essential to uncover the problem framings that enable some solutions to prevail over others.

Despite these important roles for research, the paradigms of science, their value implications, and the reliability of the knowledge produced also need to be questioned. Indeed, questions of how science itself is informed by, embedded in, and contributes to societal discourses on sustainability are themselves important lines of inquiry. New ideas and concepts that emerge from academic research, such as the 'planetary boundaries' concept or Raworth's 'doughnut economics', may be valuable in formulating pathways, but must also be critically reviewed.

More generally, the role of science should not necessarily be to advocate particular positions, but rather to depict possibilities based upon a sound understanding of social, economic, and ecological circumstances. In doing so, the academic community must recognize the limitations of scientific knowledge, especially as it relates to the behaviour of complex socio-economic systems. It should also be open to traditional forms of social knowledge as expressed, for example, in the sustainable governance of common-pool resources and common property. Finally, the challenges we face are urgent and many important decisions relating to sustainability must be made with incomplete knowledge. The scientific community is called upon to help chart pathways towards greater sustainability by participating in processes that are collaborative and inclusive.

Key unresolved questions

Fundamental unresolved questions on values, visions, and pathways, involving participatory processes and transdisciplinary approaches

When it comes to values, there is usually broad agreement within stable societies such as Switzerland. However, these societal values are typically not explicit, may not be held by everyone, and may not even be consistent. It is necessary to clarify these value systems, especially because the discourse on 'sustainability' often involves competing values that are difficult to reconcile.

What remains to be studied:

- How are values (re)produced and how can they be justified against the background of social conditions? What processes and institutions enable some values to take precedence over others, especially in terms of material resources and power relations?
- Who has the power and who – from an ethical perspective – *should* have the power to define what values are at stake? How might changes undermine values of other groups? What does this reveal about inequalities?
- How can diverse values be brought together, including concerns for societal well-being, human health, environmental and economic imperatives, etc.?
- Switzerland has long-standing experience with the protection of natural resources, but its biodiversity is declining – including the loss of critical pollination capacity. In certain areas, our drinking water is polluted with pesticides, and glaciers are melting at a dramatic pace. How can our social and economic values and norms be made to include much stronger stewardship of natural resources? How can values of human health and well-being be made more inclusive of ecological considerations?

When it comes to visions, unresolved questions remain about how visions emerge through societal processes, and how the development of coherent sustainability visions can be stimulated. The aim of this research should be to learn from bottom-up processes, so that visions of sustainability can emerge collectively rather than being imposed by powerful actors.

What remains to be understood is:

- What are societal visions, and what role do these visions play, especially regarding intergenerational responsibilities? Do visions actually have a deeper meaning for people or are they merely 'constructed' as part of planning processes or historical narratives?
- What are compelling visions of 'the good life', what do they mean for different social groups, and how could related imaginaries be interpreted in practice?

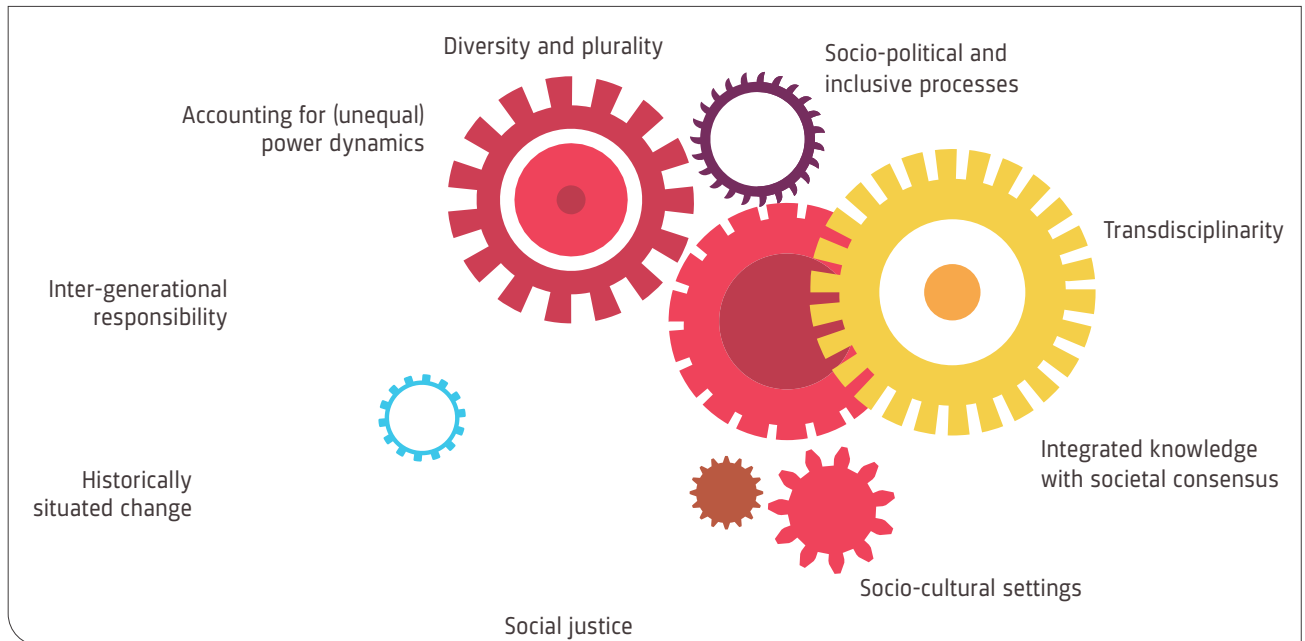


Figure 6.1: Inter-related elements that come together towards shared values, visions and pathways for sustainability

- How can visions be distinguished from the means that intrinsically depend on specific socio-cultural settings and political contexts?
 - How can sustainability visions be conceptualized in relation to environmental resources? How can theories of human needs, or systems of provision for material/energy resources, contribute to a sustainable well-being paradigm? What interdisciplinary approaches would be useful in developing such concepts?
 - What social and political processes are necessary to develop sustainability visions for Switzerland in its global context – acknowledging interrelations and interdependencies – and how can science contribute to such dynamics?
- When it comes to pathways,** it is important to translate values and visions into practical actions that diverse groups can relate to in their everyday lives. Switzerland's direct-democracy system offers one important mechanism for evolving pathways, but other types of participatory engagement are also possible and deserve to be investigated. Examples include many bottom-up institutions for protecting the local environment and managing resources held in common.

What remains to be uncovered is:

- What are the workings of social change processes in relation to complexity? What is the role of digitalization in these processes? How can systems change be understood and supported?
- What factors were responsible for major societal changes in the past, including both gradual and disruptive

changes, and what factors produced stability (i.e. resistance to change)? To what extent are apparent transformations the cumulative effect of many small changes?

- How are changes proposed in our society and in what way are different measures taken? How can social change towards 'sustainability' be further supported, accelerated, and amplified?
- How can change be understood at different scales and with multiple actors, from policymakers to civil society and the private sector? How can underprivileged groups be included more effectively?
- How can vehicles such as citizen-led and multi-stakeholder panels help to support efforts towards sustainable pathways, e.g. by accompanying the elaboration of the research agenda presented here – from the early stages of design, through implementation and assessment?
- How can the normative dilemmas of socio-economic pressure and the destruction of ecosystems be reconciled, considering the stakes of diverse actors? How can the need for integrated knowledge and societal consensus be met?

More specific key unresolved questions

Shaping truly inclusive processes on behalf of new visions, values, and pathways

- How can we legitimately move more boldly towards collective action and a truly inclusive and ecologically sustainable society?
- What social processes are needed for collectively defining, understanding, and achieving a vision of the good life for all, compatible with sustainability goals? How can needed reflections around framing be initiated?
- How can and should collective, societal decision-making processes regarding complex, controversial issues be aligned with sustainable development? What lessons can be learned from local bottom-up processes?
- How can complex visions of sustainable futures be interpreted and supported by everyday people, in their dual role as consumers and citizens?
- Where do people gain knowledge and how? How can knowledge be drawn from intergenerational learning and experiences?
- What are the roles of research in processes of collectively exploring pathways to sustainability? And what form(s) could take the co-production of knowledge with local communities?

Uncovering what has been left implicit and unspoken, and contesting power dynamics

- What are common narratives about values and visions in Swiss society, and how accurate are these narratives, given that other value systems also exist and should be given due consideration?
- Who currently defines and who – from an ethical perspective – *should* define narratives, beliefs, and values within and across different societal groups? What beliefs presently inform the debates about sustainability in science and society at large? How do such beliefs influence perceptions of actions such as ‘grabbing’ of commons and unsustainable use of resources in the global economy? How do these perceptions contribute to lower levels of resilience?
- How can relevant power dynamics be accounted for and diverse people be engaged in exploring sustainable pathways while providing neutral platforms for otherwise silenced voices to be heard? How can we simultaneously critically reflect on normative ethical implications and potential conflicts with other social values and norms?
- How do we presently deal with and how – from an ethical perspective – *should* we deal with current market-related structures that cause massive economic and political inequalities, as opposed to more collective forms of property and organization of life? How could a combined private and communal way of life and system

of redistribution help to achieve social and environmental justice?

- How can society avoid the negative effects of the increasing individualization of (environmental) responsibility, given various interdependencies that are global in scope, inherent power dynamics, and societal/biophysical limits?
- How can and should our society deal with the ‘losers’ of redistribution measures and transformation processes and create sustainability-relevant incentives to secure fair social circumstances for all?

Timely research action in light of compounding crises and the digitalization of society

- How can and should society (re)define the collective good life, or well-being, in the context of the current pandemic, ecological breakdown, resource constraints, the climate crisis, migration crises, etc.?
- What do social and ecological values and community mean in a digitalized, globalized world and how do these meanings conflict with existing traditional values and understandings?
- How can ‘data donation’ contribute to the public good (e.g. pandemic prevention) while preserving personal rights?

Expected relevance for Switzerland and internationally

Understanding how societies develop common visions, values, and pathways is a precondition for progress towards sustainability. Our proposed research is especially urgent in the face of current uncertainties, as growing numbers of people are exposed to compounding health, economic, and environmental crises. Notably, the current COVID-19 pandemic has become a massive test case for rapid change and adaptation, revealing the inextricable interconnectedness of our social–economic–ecological systems, replete with diverging interests and uncertain outcomes.

The SRI’s proposal for research on shared values, visions, and pathways is committed to planning for social change through collaborative and inclusive collective action, and to working with others to design for change rather than merely reacting to crises. The corresponding research thrust could facilitate the establishment of learning networks and collective actions that inform how society is organized – with relevance for everyday life and policy domains. Transdisciplinary approaches to co-produce key forms of knowledge (i.e. systems knowledge, target knowledge, transformation knowledge) represent promising tools for the collaborative design of sustainability pathways.

Links with the other thematic areas that need to be addressed

The present research topic is concerned with social change and recognizes the need to further engage in trans-disciplinary efforts towards understanding and working with visions, values, and pathways to sustainability in Switzerland. It is a transversal topic in that it relates to and underpins all of the other proposed topics. Particularly relevant questions in the other thematic areas include, but are not limited to:

What are basic assumptions that shape the way we perceive and frame problems? Whose perspectives do such assumptions overwhelmingly represent? What are the corresponding values or ideals? What evidence and normative presumptions are they based upon? How do corresponding problem statements impact societal perceptions and opinion-making?

What is the current role of the *economy* in our society? How can we engage critically with the ongoing imperative of economic growth? What is the 'value' ascribed to money and finance in our societies?

What *spaces* are produced by and reproductive of certain values, visions, and notions of social justice? What is the contribution of a values-based perspective to sustainable *food production and consumption*? How can pathways be charted to more sustainable food systems?

Who has a vested interest in carbon-intensive industries and who has the power to change such dynamics on behalf of *net-zero emissions*? What opportunities are there for societal self-governance? How do solutions emerge from and through societies?

Current measures to address the COVID-19 pandemic illustrate the need for close attention to visions, values and pathways: decisions are made as to the value of human life, often at the cost of economic development; certain economic sectors are privileged over others; inter-dependencies and connections between mobile people across countries is made evident; and societal negotiations are necessary, to help achieve sustainable wellbeing for all. This challenge necessitates a societal process for collective aims.

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7. Synergies, Trade-offs, and Common Threads

The all-encompassing ambition of sustainable development requires the pursuit of many equally important goals in parallel. This frequently involves co-benefits among some goals and trade-offs among others. Progress towards achieving the SDGs will require systemic research aimed at identifying, understanding, and prioritizing interactions among sustainability goals.

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Problem statement

Sustainable development is an all-encompassing ambition that entails pursuing many important goals in parallel. Understanding how different goals influence each other is thus crucial for making progress towards sustainability. Individual goals may conflict with one another, in which case the challenge is to minimize those conflicts (dilemmas). Alternatively, different goals may support each other, and the aim should be to identify and exploit those synergies or co-benefits. Very often, the interactions are more complicated, with synergies among some goals and trade-offs among others. Restoring a river, for instance, might generate benefits for biodiversity, public health, and sustainable tourism, but reduce opportuni-

ties to generate hydroelectricity; this, in turn, could affect business models in the energy sector and increase the cost of electricity.

The need to pursue multiple goals poses a challenge for all segments of society. To deal effectively with trade-offs and synergies, public administrations and policymakers must ensure that policies in different areas are coherent with each other. International trade agreements like EFTA-Mercosur, for instance, concern not only the government agency responsible for trade negotiations, but also the agencies responsible for agriculture, environment, and development and cooperation. Such agreements usually have wide-ranging consequences around the world, many of which are difficult to foresee. For ex-

ample, globalized trade arrangements may conflict with efforts to conserve rainforests, which are essential for the functioning of natural systems – including the climate. In the private sector, the challenge of multiple goals is encountered in efforts to reconcile the shareholders' demand for profits with sustainable use of resources and fair working conditions. Dealing with such interdependencies requires new forms of collaboration among actors in academia, the private sector, politics, and civil society that transcend conventional patterns of societal activity. Without progress in these areas, we risk one-sided actions that have negative consequences for sustainability in other sectors.

As noted in the UN Global Sustainable Development Report 2019, progress towards achieving the SDGs has been generally slow. One major reason identified by the report is limited understanding of the interrelations between the many goals and targets in the 2030 Agenda. This is especially true for interrelations operating at different spatial scales or across national borders, such as those associated with international trade. Because of this complexity, general statements about how pursuing one objective enables or conflicts with the achievement of another may not always be true. Whether ensuring access to affordable energy through solar farms, for example, supports or hinders conserving terrestrial and inland freshwater ecosystems depends on the location, the structure of the energy market, and the energy demand. To date, few frameworks have been proposed for assessing and monitoring the interlinkages between SDGs. Most indicators currently used to monitor the SDGs are based on statistical correlations rather than on any understanding of causal mechanisms. Systemic research aimed at identifying, understanding, and prioritizing interactions among sustainability goals is, therefore, urgently needed.

One problem in conducting such research is that there are many ways to cluster and frame sustainability questions. The UN Global Sustainable Development Report 2019 recommends six thematic areas as 'entry points' for research into the all-embracing topic of sustainable development. In the discussions leading to the research priorities presented in this white paper, the SRI Steering Committee identified five thematic areas as especially relevant to the challenges facing Swiss society (see Fig. 7.1), while acknowledging that other groupings are possible.

Regardless of how issues are clustered, there is always a risk of creating new 'silos' and thereby overlooking important interdependencies. Examples of research questions that arise from such interdependencies between thematic areas are shown in Box 7.1. The goal of the proposed research should be to ensure the greatest possible alignment between sustainability policies in different sec-

tors. Another risk is that issues common to all aspects of sustainable development receive less attention than they deserve. These common issues are typically of a fundamental character, such as wealth concepts, personal lifestyles, and social inequalities. Some examples, which the SRI calls 'common threads', are shown in Box 7.1. Because of their broad relevance to policy in many areas of sustainable development, these common threads merit special study.

Box 7.1 Examples of interdependencies and common threads emerging from the five thematic areas (see also Chapters 2 – 6):

Interdependencies:

- How will a net-zero society (Chapter 4: Net-zero Greenhouse Gas Emissions Society) influence future use of space in Switzerland (Chapter 3: Thriving Spaces: Sustainability and Spatial Development) and efforts to develop a more sustainable economic system (Chapter 5: Economic and Financial Systems for Well-being)?
- How can social and political processes (Chapter 6: Shared Values, Visions, and Pathways for Sustainability) contribute to designing more sustainable food systems (Chapter 2: Food for People and Planet?)

Common threads:

- Economic paradigms and activities causing social distributive injustice and environmental damage.
- Concepts of wealth, well-being, and contentment, and how changes in these might, for example, prevent excessive consumption and related harms.
- Questions about lifestyles, individual choices and freedoms, and social trends concerning the responsibility of various actors – including businesses, policymakers, and consumers – regarding external effects and profit maximization at the expense of others.
- Various forms of participation and collaboration and inclusive decision-making, especially among actors who do not traditionally work together.
- Access to knowledge and education to empower present and future generations to take responsibility for our common future.

Supporting policy alignment across sectors of society: Sustainability problems are linked with diverse sectors of society. Developing pathways to sustainable development requires pursuing multiple goals and anticipating consequences of actions taken in a problem area for a number of sectors. New ideas for net-zero energy production, for instance, may challenge powerful energy companies, conflict with international trade agreements or spatial planning regulations, or trigger resistance from concerned residents and NGOs.

Key questions include:

- How can synergies and trade-offs related to change strategies of different sectors be anticipated and dealt with? Are there exemplary case studies relating to the five priorities presented in this white paper?
- Which political and administrative systems are addressed by the five topics? How can collaboration be designed to cope with the complex interdependencies implicit in the respective sustainable development goals?
- How can the private sector be enlisted to respect the key potential synergistic and conflicting sustainability goals affected by their concrete business activities?

Towards a systemic perspective on causalities of synergies and trade-offs: Concrete country- or region-specific problem areas, such as the five themes presented here, feature many interdependencies that must be considered in both research and action for sustainable development. A systemic perspective is required to analyse and understand underlying causalities. For example, if research proposes changes to the way food is produced, distributed, and consumed, it needs to be sufficiently understood how these changes will affect greenhouse gas emissions and the use of land, both nationally and globally.

Key questions include:

- What scientific evidence is there about interactions between the priority topics presented here and about underlying causalities? Are these simple causalities or complex systems of causes, e.g. forming positive and negative feedback loops? Are causalities identified in a specific case and socio-ecological context generalizable, independent of case and context?
- How can science address the causal links between priority topics in a systemic way? How can science account for underlying causalities in the practice of everyday research? For instance, how can be ensured that a concept of wealth developed in one priority area is considered in other areas? How can new economic paradigms and actions suggested in one area be prevented from creating new dilemmas in the way the economy is understood elsewhere?

Expected relevance for Switzerland and internationally

Faced with the complex, manifold interrelated goals inherent in the concept of sustainable development, research can provide a more differentiated understanding of conflicts and synergies. Research can also help in formulating approaches and developing tools to prioritize and address these interactions – not only in policymaking, but also in the private sector, in non-governmental organizations, and among individuals.

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8. Enabling Transdisciplinary Sustainability Research

Peter Edwards (ETH Zurich), Gabriela Wuelser (SCNAT)

Introduction

No-one doubts that traditional modes of doing research – including contract-oriented research and bottom-up, curiosity-driven research – will continue to be important. However, many scientists, including participants in the Swiss Academies' Sustainability Research Initiative, believe that universities and other research institutions must strengthen their capacity to undertake *transdisciplinary* research aimed at solving complex societal problems.

Transdisciplinary research for sustainability differs in important ways from most academic research. First, its ultimate purpose is to support the process of societal transformation towards greater sustainability, which requires not only *systems* understanding, but also knowledge about *targets* and options for *transformation*. Second, the research objectives must be aligned both to principles of sustainability and to stakeholder needs. This is no simple task, especially when scientific understanding is limited or when societal interests diverge strongly. It can only be achieved through close involvement of stakeholders throughout the research process. Third, such research is often conducted in unconventional settings, such as real-world laboratories, living labs, and pilot or demonstrator projects. Although working in these settings can be demanding, they offer the researcher valuable opportunities to develop innovations, such as new concepts and methods of knowledge co-production.

Given the importance of transdisciplinary research for sustainability, there is growing interest in finding and further developing ways to facilitate it. One of SRI's objectives is to stimulate discussion about the special demands of such research and how these can most effectively be met. The following sections propose ways to strengthen the enabling environment for sustainability research in Switzerland (see also Fig. 8.1). These proposals are already practised to varying degrees in Swiss academic institutions, but they are presented here as a basis for dialogue between scientists, universities, funders, and various actors in science policy.

Incentive systems

The single most important criterion for a successful university career today is an excellent record of academic publication. This one-dimensional evaluation system gives scientists little credit for contributions to collaborative work and acts as a strong disincentive to becoming involved in complex problem-oriented projects. Indeed, a recent survey in the European Union found that researchers regarded inter- and transdisciplinary careers as risky. In response, various initiatives (e.g. www.betterscience.ch/en/) have begun to emerge that seek to tackle the factors that hinder needed research, such as excessive self-marketing pressure on academics. To further reduce these obstacles and encourage more scientists to become involved in sustainability research, the criteria for making appointments and promotions must be broadened. While the conventional criteria will continue to be important for many academic positions, research institutions should be more open to appointing scientists with a strong track record in interdisciplinary and transdisciplinary collaboration, project management, and non-traditional forms of knowledge transfer. An important step is the San Francisco Declaration on Research Assessment (DORA), signed by the SNSF, which aims to improve procedures for evaluating scientific research, including giving credit to forms of scientific output other than academic papers.

- Develop recognition and incentive systems within research institutions to encourage researchers to participate in transdisciplinary sustainability research.

Science – policy dialogue

Intensified dialogue between science and policy will be essential for effective sustainability research. On the one hand, scientists and knowledge brokers need to communicate more effectively such things as opportunities and risks of new technologies and their understanding of major environmental trends under different scenarios. In particular, they need to explain the limitations and biases of their methods, and the uncertainties in their conclusions. On the other hand, policymakers and politicians need to make clear the complexity of the policy process and the many factors that constrain decision-making. Such dia-

logue can provide a basis for research that supports the process of societal transformation.

- Exchange between science and policy needs to be further developed and strengthened.

Partnerships

Sustainability research benefits greatly from enduring relationships with non-academic partners, not least to ensure that research questions are formulated in a way that is relevant to people's practical needs. Unfortunately, many transdisciplinary teams only work together for a limited period, which is usually determined by funding. A particular problem for non-academic partners is that research grants rarely cover the costs of their participation, so they must assume the expenses themselves. A promising model for long-term partnerships between researchers and stakeholders are real-world laboratories, which are frequently focused on particular transformation goals and involve close collaboration with decision-makers and agencies responsible for implementation.

- Enduring partnerships with non-academic partners are essential for effective sustainability research and should not only be cultivated, but also suitably funded.

Education and training

New forms of teaching are needed to build capacity for transdisciplinary sustainability research. Such research requires the ability to understand problems from the perspective of different actors and disciplines, and it requires highly developed teamwork and communication skills. Further, it is especially important to grasp the complexity of policymaking as well as 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.

- Institutions of higher education should offer training programmes designed to develop the skills needed for sustainability research.

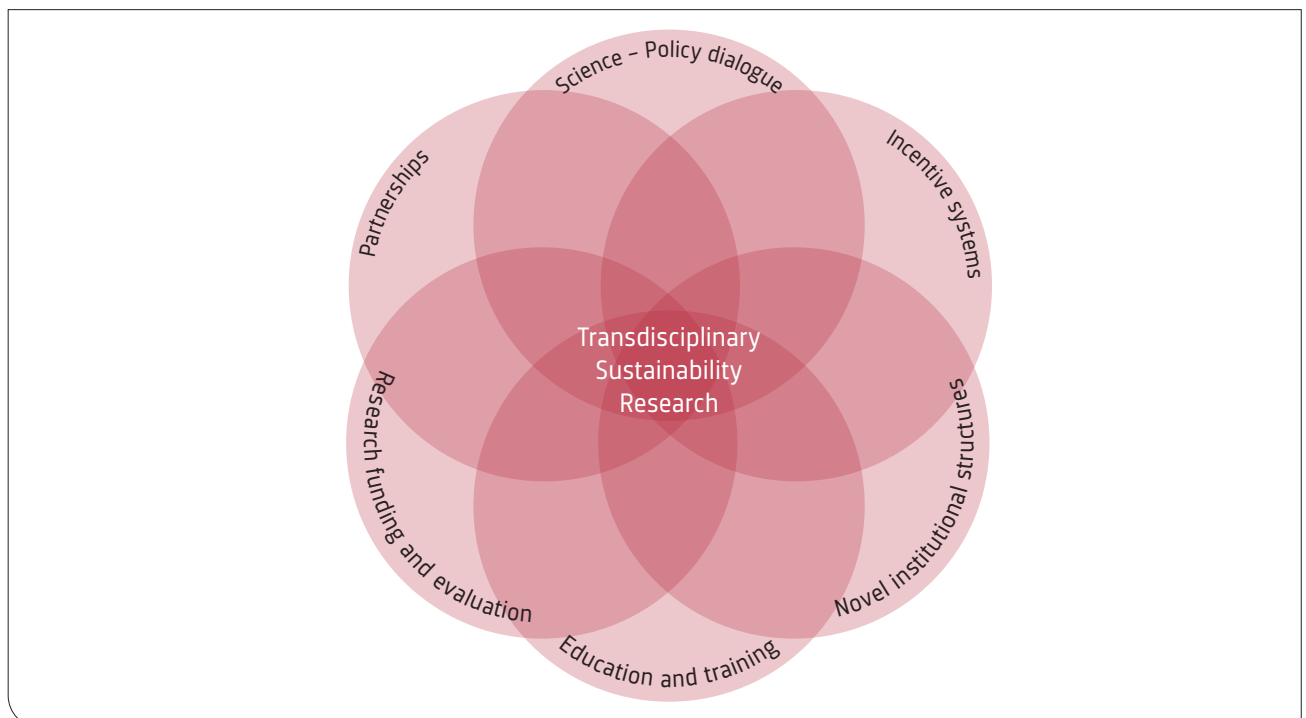


Fig. 8.1. Preconditions for effective sustainability research.

Novel institutional structures

Institutional arrangements are key for sustainability research to flourish. Many universities have experimented with novel structures to promote interdisciplinary and transdisciplinary collaboration that cuts across conventional organizational boundaries. Examples in Switzerland include ETH's TdLab and Institute of Science, Technology and Policy, and the University of Bern's Centre for Development and Environment (CDE). There are also models from universities in other countries, such as the Stockholm Resilience Centre, Sweden, and the Global Institute of Sustainability at Arizona State University, USA. Among other activities, such institutions can provide research and training in transdisciplinary methods, develop long-term partnerships with societal actors, and serve as a forum for dialogue with policymakers. In some institutions, novel forms of academic appointments such as professors of practice can enable universities to benefit from outstanding individuals who have pursued most of their career in industry or public administration.

- Novel, cross-disciplinary institutional structures are an important way to link disciplines and strengthen collaboration with non-academic actors.

Research funding and evaluation

Switzerland has several existing funders and funding instruments that can be used to support sustainability research. Problem-oriented research that includes interdisciplinary and transdisciplinary collaboration is regularly funded by private foundations like Stiftung Mercator Schweiz and by the Swiss Innovation Agency (innosuisse), the federal government, and SNSF Swiss National Research Programmes (NRPs). However, other dedicated funding mechanisms are needed to build a thriving sustainability research community. It is also important to strengthen procedures for evaluating transdisciplinary research proposals. Funding instruments should be designed to support transformation processes, for example by encouraging non-conventional forms of scientific collaboration and output. Because sustainability research requires considerable input from non-academic stakeholders, funding would also be needed to support partners from the private sector or civil society, who might otherwise be unable to collaborate.

- Funders should increase the budget for programmes in the area of sustainability;
- Funders should ensure that their evaluation and award procedures are consistent with the special requirements of transdisciplinary research for sustainability;
- Funding mechanisms are needed to ensure participation of non-academic partners.

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Authors



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Until his retirement in 2017, Peter Edwards was Professor of Plant Ecology at ETH Zürich. He is author of some 400 refereed scientific papers and author/editor of several books covering a wide range of ecological and environmental topics. 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.



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Heike Mayer is Professor for Economic Geography at the University of Bern. She is a member of the Institute of Geography and the Center for Regional Economic Development in Bern. As an economic geographer, she is interested in the ways in which innovative and entrepreneurial initiatives emerge in the periphery and how marginality allows for transformative change towards a more economically just and sustainable world. She is also interested in crossing the boundary of academic life by taking time to engage in transdisciplinary outreach activities.



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Urs Niggli was the Director of the Research Institute of Organic Agriculture (FiBL) for 30 years. His competences include all areas of agricultural production, ecosystem services and the food chain. Urs teaches at the Universities of Kassel and Beijing. He holds a PhD in plant production at ETH and both an honorary professorship and honorary PhD. His current assignments are strategic advisor of Agroscope, member of the Scientific Group of the UN for the Food Summit 2021 and president of FiBL Austria.



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Christian Pohl is an expert in theories, methods and tools for understanding and navigating transdisciplinary research processes. He was funding co-director of td-net of the Swiss Academies of Arts and Sciences and is co-director of TdLab of the Department of Environmental Systems Science at ETH Zurich. In his research he studies transdisciplinary projects in the field of sustainable development and explores tools to support knowledge co-production.



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Michael Stauffacher, who holds a doctorate in sociology and is a professor at ETH Zurich, is co-director of the Transdisciplinarity Lab of the Department of Environmental Systems Sciences. Within the Swiss Academies, he is a member of the board of the 'Swiss Academy of Humanities and Social Sciences', on the steering committee of the Sustainability Research Initiative and on the Energy Commission. Michael's core research domains are currently big and potentially contested infrastructures like deep geothermal energy, negative emission technologies, and railway stations.



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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.

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