1 Global Change Research for Sustainable Development

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Abstract

This article is the introductory chapter of a book synthesising experiences of an international programme conducting partnership-based research for sustainable development. We argue that global change can be governed for sustainable development, and that research can contribute to this aim by developing and applying intercultural, transdisciplinary, and disciplinary conceptual approaches, by finding ways of reducing or avoiding negative processes and impacts of global change, by designing innovative solutions based on multi-stakeholder and multi-level collaboration, and by developing multi-scale applications for fostering positive impacts of global change. We also argue that while climate change is an important process of global change, many other processes have reached similar dimensions and are equally challenging to address, both in the global North and in the global South. The research insights briefly introduced here and synthesised in the present volume relate to global change triggered by environmental, social, economic, political, and institutional processes that have reached such a large scale because local problems and potentials were overlooked, neglected, or not perceived as important. The negative impacts of global change dominate the current scientific and political debates; however, global change in our analysis can also be considered necessary to achieve sustainable development. The question is to what extent it will be possible to mitigate negative impacts and processes while enhancing or developing innovative solutions to avoid them altogether.

Keywords: Global change; climate change; natural resources; poverty; sustainable development; human–environment systems; normative valuation; knowledge types; governance; research partnership; NCCR North-South.

1.1 Introduction

1.1.1 Avoiding negative and fostering positive impacts of global change

In much of the scientific and political debate on the environment and on development, the term "global change" is used to refer to processes with supposedly negative impacts on societies and the environment at a scale at which several countries or regions of the world are affected. Most prominent among these processes is climate change, which is often perceived as today's most important global threat, affecting the environment, societies, and the economy in multiple ways. Indeed, global warming and weather extremes have started to affect biodiversity, water cycles, sea water levels, food security, and the ecology of entire regions (IPCC 2007). For example, the tropical zone is expected to expand with global warming (Seidel et al 2008). Other potential effects include ecological zones becoming drier or wetter, with unknown consequences, both positive and negative, for ecology and human life (IPCC 2007; UNDP 2007). According to the 2007/2008 Human Development Report,

> *[w]ith the global rise in temperature, local rainfall patterns are changing, ecological zones are shifting, the seas are warming and ice caps are melting. Forced adaptation to climate change is already happening across the world. In the Horn of Africa, adaptation means that women have to walk further to find water in the dry season. In Bangladesh and Viet Nam, it means that small-scale farmers have to cope with losses caused by more intense storms, floods and sea surges.* (UNDP 2007, p 26)

Besides climate change, however, there are many other undesirable processes of global change that tend to be neglected by research and politics, although their impacts are equally widespread. These include the aggravation of poverty, the spreading of human and animal diseases, malnutrition, persistent hunger and famines, as well as changes in the atmosphere and in ecosystems, uncontrolled land cover and land use changes, accelerated degradation of non-renewable natural resources such as soils, biological systems, and water, uncontrolled urban sprawl, undesired side effects of technological innovations and their uses, and increased conflicts between societies and among individuals. These undesirable processes of global change tend to increase existing disparities and hinder human development (Hurni et al 2004).

Only few studies address positive impacts of global change processes; most of these studies have been written in economic fields. For example, the rates of population growth over the past decades have been decreasing, as has the rate of global poverty. Although the absolute number of poor people has remained high, "extreme poverty was reduced worldwide from 52% in 1981 (1.9 billion people) to 26% in 2005 (1.4 billion people)" (Bauer et al 2008, p 6). The gross national products of almost all developing and transition countries have been growing much faster than those of highly developed countries, and education, health, and sanitation systems are being developed at an accelerated pace in most countries, particularly those with lower incomes. These achievements are commendable and need to be emphasised as well. Indeed, although it has become mandatory to understand and avoid or mitigate the negative impacts of processes of global change, it is just as important to explore and support positive impacts that have the potential to make development more sustainable.

1.1.2 Global change as a prerequisite for sustainable development

The term "sustainable development" is used as a common denominator for positive outcomes of development efforts, that is, situations where development efforts succeed in maintaining or enhancing the capacity of environmental, economic, and social systems to evolve and interact in harmony with one another and with a long-term perspective (Barbier 1987, 1989; WCED 1987; Wiesmann 1998). Consequently, development at the local, regional, national, and global levels is only sustainable if it meets the requirements of all three dimensions of sustainability: the social, the economic, and the environmental. When evaluating or estimating sustainability, one should therefore consider that "changes in one of the components of this system […] will have impacts on other components through a complex series of relationships […]; i.e. positive changes on one scale may be linked with negative changes on another scale" (Wiesmann 1998, p 185).

Unfortunately, many researchers and policymakers perceive and address the different dimensions of sustainable development as separate issues – and primarily understand sustainable development as an environmental issue. A prominent example of such a perception is a current global research initiative that claims to be centred on "five Grand Challenges that, if addressed in the next decade, will deliver knowledge to enable sustainable development, poverty eradication, and environmental protection in the face of global change" (ICSU 2010, p 1). Three of the five challenges focus on forecast-

ing, observing, and confining environmental change, based on the premise that humankind has not been able to manage this change so far. Other major dimensions of unsustainable development, particularly the social and economic dimensions, but also the institutional and political ones, are perceived primarily as a means to improve environmental sustainability, rather than as global change processes in themselves, and are addressed only in the two remaining challenges on responding and innovating. Another prominent example of a one-sided initiative is the Millennium Development Goals (MDGs), which focus almost exclusively on poverty as a social issue of unsustainability, to be overcome primarily by means of human development (United Nations 2009). The MDGs – and MDG-related research – thus largely neglect both environmental and economic aspects of sustainability, which may be a major reason why these goals will hardly be fulfilled by 2015.

The shortcomings of these two major international initiatives are understandable: Indeed, the goal of sustainable development always requires a process of finding a balance between the three dimensions of sustainability, based on negotiated norms. Establishing such a normative balance means making choices and setting priorities. As a result, initiatives cannot address all dimensions of sustainability in a perfect way, but they can strive to meet at least the most urgent needs of the stakeholders concerned and the most urgent requirements identified for biophysical systems, with a view to doing things better in future. A mapping of sustainable development debates by Hopwood and co-authors (2005) reveals a growing concern for environmental challenges as well as issues of socio-economic disparities, human well-being, and equality that necessitate reform or even transformation. This confirms that all dimensions of sustainable development have to be addressed.

Global change embraces all aspects of global dynamics in the social, cultural, political, ecological, institutional, and economic spheres. In an earlier synthesis volume presenting partnership-based research for sustainable development, we argued that

> *humankind today is confronted with numerous threats brought about by the speed, scope and unpredictable interconnectedness of global change dynamics. A concerted and informed approach to solutions is required to address the magnitude and severity of the numerous crises we are facing, related to the global economy, climate change and natural resource degradation, food security, poverty and social exclusion, water and sanitation, and conflict*

> *and governance, to name but a few. Generating shared knowledge and developing the ability to cross multiple borders between understandings of realities and issues are a key to addressing such global challenges.* (Hurni 2010, p 13)

As asserted above, however, global change should not be perceived as having only negative impacts: Indeed, some processes of global change have in many respects led to greater sustainability. Economic growth, for example, has enabled people and entire societies to improve their livelihoods, which has in turn led them to pay more attention to their environment. Kuznets (1955) and other authors proved the correlation between economic growth and environmental quality. They showed that "in the course of economic growth and development, environmental quality initially worsens but ultimately improves with improvements in income levels" (Gangadharan and Valenzuela 2001, p 514). When

> *income per capita and the development level rise, institutions are pressed by public opinion to include environmental protection in the policy agenda, therefore playing an active role to designate policy actions (and regulations) oriented towards a sustainable development path.* (Costantini and Martini 2006, p 25)

Whether the outcome of such growth leads to a higher degree of sustainability can, however, only be assessed in hindsight – a challenge that research needs to be well equipped to deal with.

Indeed, according to Raskin (2008, p 461), "sustainability research studies the dynamics and prospects of co-evolving human and ecological systems, a subject of inherent complexity and deep uncertainty". The authors of the present book assume that despite such uncertainty, global change *can* be governed for sustainable development. Drawing on theoretical thinking and research experiences conducted in many regions of the world within the framework of a 12-year partnership-based research programme, they are even convinced that (global) change is needed to achieve sustainable development; but this change has to be steered to avoid negative consequences. Today's global change problems exist mainly because local problems were overlooked, neglected, not addressed, or not perceived as important while they were gradually growing into global issues. Thus the question is not whether or not there should be global change, but to what extent it will be possible to reduce or mitigate its negative impacts and processes, enhance the positive ones, and find innovative solutions while trying not to generate new problems.

Fig. 1
Partnership regions of the Swiss National Centre of Competence in Research (NCCR) North-South research programme. (Source: Hurni et al 2010, p 13)

1.1.3 The approach taken in this introductory article

This article is based on a review of literature on current research concepts and frameworks used to address issues of global change and sustainable development. This review was guided by a conceptual and theoretical reflection on sustainable development, and supported by insights into factors of success drawn from empirical experiences gained during the partnership-based research that has been carried out within the framework of the Swiss National Centre of Competence in Research (NCCR) North-South programme since 2001. Based on a discussion of this material, we introduce the major outcomes of the syntheses conducted by the authors of the subsequent articles in the present volume, and offer conclusions on partnership-based research for sustainable development drawn from these results and from experiences gained in nine regions located mostly in the global South (Figure 1).

1.2 Research for sustainable development: conceptual framework and research experience

1.2.1 Background

Establishing an integrative conceptual framework of sustainable development: The most common definition of sustainable development was established by the World Commission on Environment and Development (also known as the Brundtland Commission), saying that sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). This definition places human beings at the centre of sustainable development and at the same time implies that all other living beings, that is, plants and animals, as well as other natural resources must not be depleted if they are to remain available to future human generations for meeting needs at various levels, reaching from food supply and ecosystem functions to aesthetic and cultural values.

In the sustainability debate of the 1990s (see United Nations 1997) three major dimensions of sustainable development were postulated, namely the social, ecological, and economic dimensions; moreover, the normative character of sustainable development was put at the forefront of the sustainability concept (e.g. Wiesmann 1998; see Figure 2). The definition of sustainable development presented in Figure 2 is rooted in a systems approach that includes a focus on the biophysical system with renewable natural resources, the social system with political, economic, and institutional characteristics, as well as an interface between the two major systems, namely a land use system where human use and natural resources are linked in a spatial, that is, landscape context (Messerli and Messerli 1978). Although developed in the context of research on rural areas in mountains, such a systems approach is capable of including urban areas as well, as long as they are seen in a broader context of urban–peri-urban systems.

When considering the three dimensions of sustainable development we could argue that the economic dimension is not a basic sustainability dimension with a long-term perspective, but a tool to achieve sustainable use of natural resources between the ecological and social spheres. This priority of the ecological and social dimensions over the economic dimension, however, could be counter-argued by the need to keep goods and services flowing between individuals and societies, requiring a sustainable economy; hence

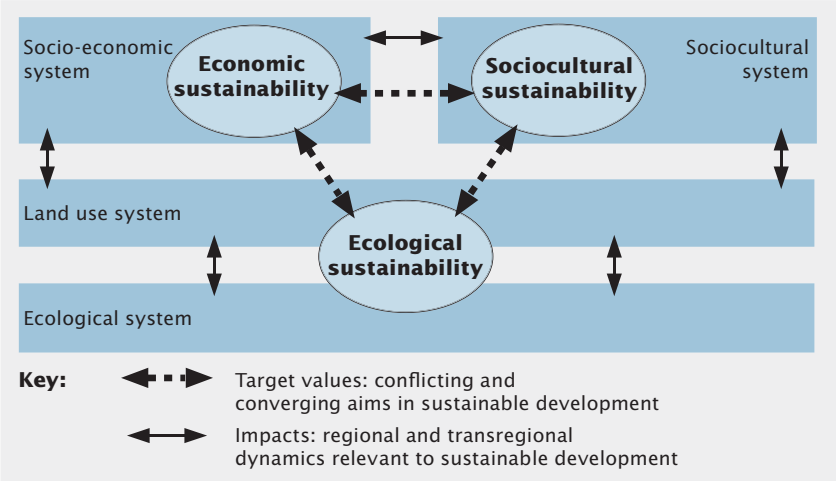

Fig. 2
Conceptual framework combining an analysis of human–environment systems and their interaction with a normative appraisal of sustainable development. (Source: Hurni and Wiesmann 2004; adapted from Wiesmann 1998)

this should also be a fundamental dimension of sustainability. We may further argue that an institutional and political dimension of sustainable development should be considered as well; these two additional aspects could be subsumed under the social dimension of sustainability.

Our understanding of global change research as research that contributes to sustainable development – and not just as research that attempts to better understand global change – raises a number of methodological and conceptual questions:

- Can each of the multiple dimensions of sustainability be dealt with exclusively in a disciplinary manner?
- Can ecological, social, and economic research questions be merged and addressed in a comprehensive and holistic way?
- How can negotiation of the normative elements of sustainable development become part of global change research?
- How can society help to formulate research questions and shape research approaches?
- How can research contribute to more than just a better understanding of processes and increased knowledge about them; how can it help to shape visions and find pathways for more sustainable development?

A first step towards establishing development-oriented research as an approach was made when three distinct types of knowledge were defined in a participatory workshop by Swiss scientists in 1997. They differentiated

between (a) systems knowledge, which leads to a better understanding of systems, (b) target knowledge, which is generated in participatory processes involving scientists and non-scientific stakeholders, and (c) transformation knowledge, which results from research into concrete solutions (ProClim 1997). Based on these knowledge types, research programmes such as the NCCR North-South have shown how disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary methodologies and approaches can be used for defining a common vision, setting multiple goals, listing concrete objectives for research to be conducted by individuals and teams, and shaping the research process and working steps (Hurni et al 2004). The importance of innovative global institutions in linking knowledge and action has been advocated more recently as well by van Kerkhoff and Szlezák (2010), though based on another approach.

An equally important step in the process of developing the conceptual and research policy framework for development-oriented research, as well as the approach and methodology for such research, was the development of transdisciplinary approaches to combine work in the social and natural sciences and involve the local knowledge of non-scientific stakeholders (Hirsch Hadorn et al 2006; Hirsch Hadorn et al 2008). Transdisciplinary approaches were designed to enable more effective research for sustainable development than is possible using participatory approaches, which tap local information for furthering systems knowledge alone, while neglecting target and transformation knowledge. Experience with transdisciplinary research has been well documented, for example by Wallner and Wiesmann (2009) regarding a process of multi-stakeholder management planning for a World Natural Heritage Site in Switzerland. In our experience, global change research for sustainable development, and in particular the above questions, can be handled in a fairly adequate manner using transdisciplinary concepts and approaches.

Current processes of global change: As mentioned in the introduction, in the societies and scientific communities of the global North, climate change is commonly perceived as the most important process of global environmental change. There are, however, many other Earth system processes with global change impacts. According to Rockström and co-authors (2009) these include the rate of biodiversity loss, the nitrogen and phosphorus cycles, stratosphere ozone loss, ocean acidification, global freshwater consumption, land use changes and conversion into cropland, atmospheric aerosol loading, and chemical pollution. Rockström and colleagues claim that certain biophysical thresholds in the above processes have been, or are being, crossed, and that this

may have disastrous consequences for humanity. They argue that identifying and quantifying planetary boundaries that must not be transgressed could help to prevent human activities from causing unacceptable environmental change.

These biophysical, or environmental, processes and impacts have been addressed in numerous research frameworks developed for assessing and understanding processes and finding solutions to influence them (Acutt et al 2000; Biermann 2007; Niemeijer and de Groot 2008; Raskin 2008; Tapio and Willamo 2008; Biermann et al 2009; Reid et al 2009). Much less research has been done on the human aspects of environmental change, such as its cultural, social, or economic consequences and opportunities – a fact pointed out by many authors (e.g. Guha-Khasnobis et al 2007; Hodgson et al 2007; Grimm et al 2008; Poteete et al 2010; Ringler et al 2010). In recent years, the emergence of land change science for global environmental change and sustainability has been a remarkable effort to include the spatial or landscape element into the global change debate (Turner et al 2007). Acknowledgement of the fact that many local effects can easily accumulate into a global threat has led to a widening of system boundaries. This is the case, for example, with all processes of land degradation: One third of the world's total agricultural land has been affected by processes of soil erosion or physical, chemical, and biological soil degradation (Oldeman et al 1990). In sub-Saharan Africa, for example, such land degradation on farmers' fields reduced their productivity and contributed to these farmers' impoverishment; this, in turn, contributed considerably to the emergence of a regional syndrome (WBGU 1997).

In discussions of global change, the global economic and social changes listed in the introductory section of this article have been insufficiently linked to environmental change. In the meantime, poverty has increased in absolute numbers of people affected despite all efforts to reduce it, and the number of the world's poor will soon reach 1 billion (FAO 2009). The other 6 billion, however – that is, the increasing majority of the world population and nations – have mainly experienced positive economic growth and improvements in their well-being over the past two decades. Research on current processes of global environmental change must also look at human disparities, demography, health, environmental sanitation, conflicts, livelihoods, and institutions, as addressed for example in the NCCR North-South programme (Hurni et al 2004).

Consequences for research: Helping to support positive and minimise negative effects of global change is a major goal of research for sustain-

able development. Research can contribute by producing knowledge for improved decision-making as a first but important step. All three knowledge types – systems, target, and transformation knowledge – are required to achieve this purpose. Given the current research foci in the global change debate, there is clearly an urgent need for reorienting scientific research towards addressing all three types of knowledge instead of only systems knowledge. However, apart from generating knowledge and developing technologies, research has to fulfil other requirements in order to foster enabling conditions for human action, which include the ability to take action and adequate heuristic and other tools for action, a positive attitude and the willingness of individuals and groups, and empowerment (Hurni et al 1993).

1.2.2 Frameworks for assessing global change

Integrated studies require useful frameworks for assessing global change and sustainable development. A most prominent framework in global change research which brings together human well-being, (agro)ecosystem functioning, and human land use, as well as their direct and indirect drivers, is the conceptual framework underlying the Millennium Ecosystem Assessment (MA 2005). Apart from the Millennium Ecosystem Assessment, this framework has also been applied in two other international, multidisciplinary, and multi-stakeholder initiatives, namely the Intergovernmental Panel on Climate Change (IPCC 2007) and the International Assessment of Agricultural Science and Technology for Development (IAASTD 2009). The framework is described in more detail further below.

A second framework, called DPSIR, distinguishes Driving forces, Pressures, States, Impacts, and Responses (see Ness et al 2010). According to Kristensen (2004), the National Institute of Public Health and Environment in Bilthoven, the Netherlands, was the first to propose the use of this framework, which has since been widely adopted by many institutions. According to the DPSIR framework, there is a chain of causal links starting with 'driving forces' such as economic sectors and human activities, which create 'pressures' such as emissions or waste, influencing 'states' (physical, chemical, and biological), which in turn have 'impacts' on ecosystems, human health, and functions, eventually leading to political 'responses', such as prioritisation and the setting of targets and indicators. However, according to Svarstad and co-authors (2008), there are discursive biases in what they call the environmental research framework.

A third framework for analysing social-ecological systems is the one proposed by Ostrom (2009). Social, economic, and political settings are related

to ecosystems by looking at interactions between resources (systems and units) and governance (systems and users), which are all influenced by outcomes of these settings and ecosystems, and in turn influence resources, governance, and their interactions.

The first framework was initially applied in the Millennium Ecosystem Assessment. This strongly promoted the concept of 'ecosystem services', which gained international acceptance in science and policy communities (Carpenter et al 2009; Jordan et al 2010). The same framework has also served to define priority research areas for ecosystem services in a changing world (Nicholson et al 2009) and has highlighted the need for interdisciplinary research as a basis for managing ecosystem services (Steffen 2009). Figure 3 shows the framework as it was applied in the IAASTD (2009) initiative. Development and sustainability goals are defined by the societies concerned, while agricultural outputs and services are to be provided by spatially defined ecological or agronomic systems, which are influenced by indirect and direct drivers. Agricultural knowledge, science, and technology systems are seen as the centrepiece, as they can enhance agricultural outputs and services and help to avoid negative effects of agricultural systems on human well-being and the environment. The framework can be used at multiple scales, from local to global, and for multiple dimensions of time, including the past, present, and future.

For the purpose of assessing the performances of a specific (sub)system, such as the climate system (IPCC 2007), ecological systems (MA 2005), or agricultural systems (IAASTD 2009), the framework presented in Figure 3 appears particularly useful, especially when attempting to understand main drivers and major services for human well-being. However, all of the above frameworks are useful in their own way, providing adequate tools to deal with the different types of questions and objectives of research projects, depending on the angle of analysis.

Nevertheless, if the assessment is to go beyond a better understanding of systems and their interactions, the intention being to explore sustainability as target knowledge and improvements of the system as transformation knowledge, a fourth framework may be appropriate: the Sustainable Development Appraisal (SDA) developed by Hurni and Ludi (2000). An SDA begins with a participatory appraisal of the current status and the dynamics of land use and natural resources, as well as of current stakeholders and their social, economic, and cultural settings. Together with these stakeholders, researchers then assess visions, needs, options, and constraints; finally, on this basis,

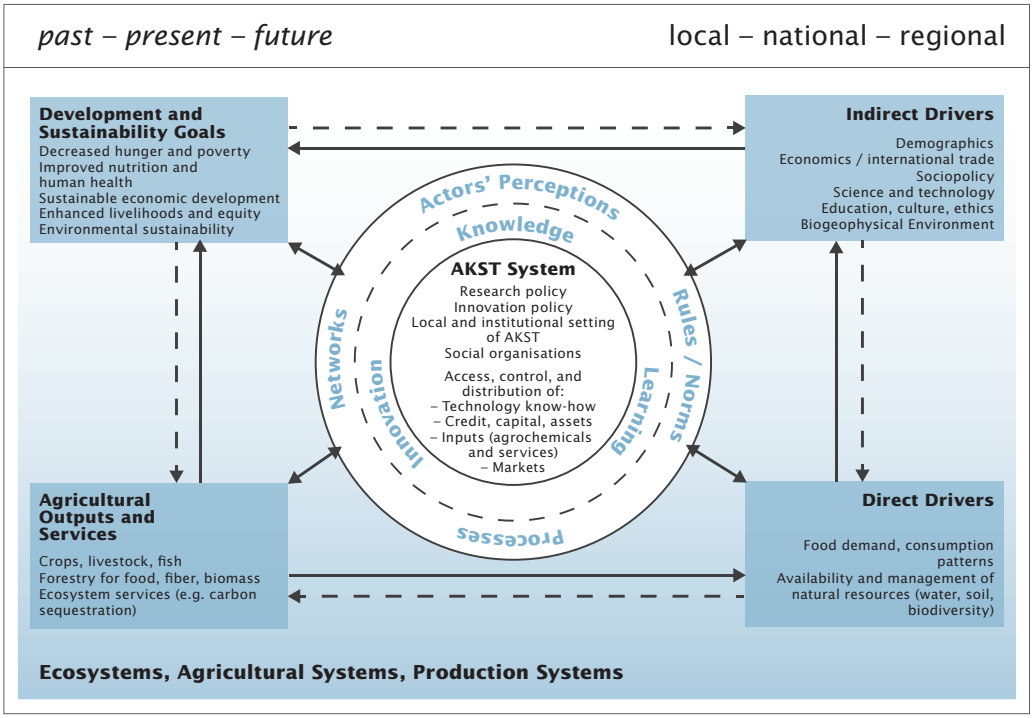

Fig. 3 Framework of the International Assessment of Agricultural Science and Technology for Development, focusing on Agricultural Knowledge, Science, and Technology Systems (AKST). (Source: IAASTD 2009, p 13, slightly adapted)

a common strategy of action is negotiated among stakeholders. By comparison, Tuinstra and co-authors (2008) analyse and stress the effects of learning and evaluation in integrated sustainability assessments, arguing that these activities are an important component of capacity development.

The above four major research frameworks provide guidance in designing research components. However, a research programme that seeks to address issues of global change with the aim of promoting sustainable development worldwide faces challenges at an entirely different level as well, namely the North–South context. As mentioned in the introduction, undesirable processes of global change occur around the globe and affect all parts of the Earth, but many of them are felt most dramatically in the developing countries of the global South, where they tend to aggravate existing disparities and hamper sustainable development. An understanding of these global processes and dynamics can only be achieved through combined research efforts in the global North and South, in broad collaboration among researchers from the different world regions affected (Bradley 2008; Soete 2008).

North–South research partnerships are one way of organising such collaboration. Such partnerships face the challenge of multiple differences and disparities between partners in terms of access to resources, power, knowledge, and capacity, but also with regard to assumptions, world views agendas, and expectations (Johnson and Wilson 2006; UNESCO 2011). How can participating institutions and their researchers bridge these disparities in order to collaborate fruitfully and with equal benefits for all partners? This issue was addressed, among others, by the Commission for Research Partnerships with Developing Countries (KFPE) of the Swiss Academy of Sciences, who developed 11 principles to guide research in partnerships between institutions from the North and the South (KFPE 1998, 2011). These often quoted principles (see Bradley 2007) call for joint agenda-setting, a responsive attitude, clear responsibilities, transparency, mutual learning, capacity development, sharing of data and networks, dissemination of results, equal distribution of profits and merits, and ensuring that results are applied and outcomes secured.

1.2.3 The NCCR North-South approach

Sustainable development is at the core of the NCCR North-South's (2009) research partnership approach, which has been guided by the 11 principles of the KFPE mentioned above. It has recently been recognised that innovative change requires "new, adaptive, and innovative institutional arrangements that can deal with rapidly changing knowledge and have effective learning capabilities" (van Kerkhoff and Szlezák 2010, p 1); the approach taken by the NCCR North-South long ago accommodated such innovative arrangements and has certainly been adaptive, allowing for the programme structure to be modified twice in the course of 12 years to achieve the highest possible degree of integration. The NCCR North-South approach encompasses research efforts in the four directions of specialisation, generalisation, contextualisation, and application. Combining these directions in different ways, four major programme components guide, coordinate, and consolidate research activities (see Figure 4).

Specialisation is essential to capture what is specific. Thus, NCCR North-South research directed towards specialisation leads to increased scientific competence and better systems knowledge in specific fields that are relevant to sustainable development. Sustainability-oriented specialisation within the programme is pursued by thematic, that is, disciplinary, and integrative research projects in the nine partnership regions[4] (see Figure 1).

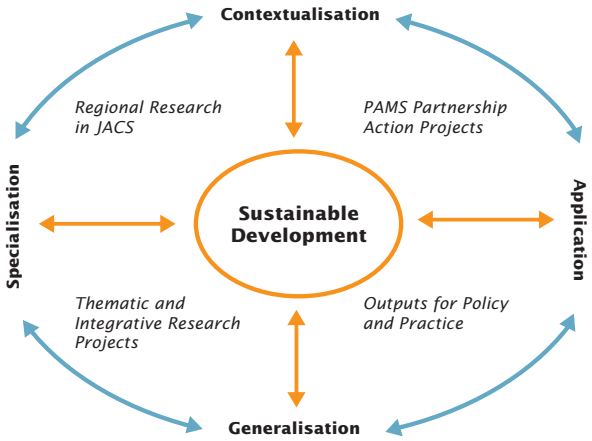

Fig. 4
Research directions (in bold) and components (in italics) that constitute the research approach of the NCCR North-South (2009). JACS: see Endnote 4; PAMS: see Endnote 5.

Contextualisation is the direction taken in research aimed at achieving more sustainable development in concrete situations, as this requires contextual differentiation and, in most cases, transdisciplinary dialogue. The nine partnership regions function as focal points and platforms for concrete partnership-based research, and partnership action projects[5] enable exchange and joint knowledge generation with non-scientific stakeholders. Within its nine partnership regions, the NCCR North-South focused on three main syndrome contexts – the urban and peri-urban, the semi-arid, and the highland–lowland contexts – during its previous phases. These contexts are emphasised less in the final phase of the programme, although at times they are still used as a meta-level reference in the synthesis projects. Contextualisation always involves production of all three types of knowledge – systems, transformation, and target knowledge.

Application guides researchers aiming to develop pathways for concrete mitigation of, or adaptation to, the negative impacts of global change. To conduct application-oriented research, processes of knowledge production and societal action at multiple levels need to be interwoven. Pathways for sustainable development are explored through specific research and action projects, applying research results in concrete situations; they are also taken up in concrete outputs for development policy and practice or in additional projects mandated by development agencies. This type of research concentrates on producing transformation knowledge.

Generalisation is needed to achieve research results that are valid for as broad a research context as possible. It means dealing with sustainable development in an integrative and transdisciplinary manner by applying a 'syndrome mitigation approach' (Hurni et al 2004). This implies looking at patterns of problems and potentials of sustainable development. Research findings from specific case studies and selected contexts are generalised and the overall theoretical, conceptual, and methodological foundations of the programme developed, with a view to gaining more systems knowledge and to some extent also transformation and target knowledge. Generalisation is carried out in scientific synthesis projects, which in turn are used for developing generalised outputs for policy and practice in ongoing global change debates.

In terms of programme components, *regional research projects* usually work towards contextualisation of their (inter)disciplinary specialisation. Conversely, *thematic and integrative research projects* work from regional specialisation towards global generalisation (Hurni et al 2010). The programme recently launched 15 post-doc research projects with regional foci and PhD and Master's studies. In addition, six projects jointly led by pairs of Northern and Southern senior researchers were initiated as contributions to global debates, addressing food security, land transformation, climate change, poverty, water, and migration. The third component, *partnership action projects*, consists of outreach activities that are based on research originating from contextual insights and apply the results at the practical level, with a view to increasing learning opportunities both in science and in society. Finally, generalised insights are made available for policy- and decision-makers at the national to international levels in the form of various *outputs for policy and practice*.

1.3 Experiences

1.3.1 Factors of success

Since 2001 the NCCR North-South programme has had the unique opportunity to gain multiple experiences from a large number of partnership-based research projects on global change for sustainable development. Based on these experiences, the most important principles for this type of research have been extracted here, their fulfilment being considered essential factors of success.

The long-term nature of the programme's global research partnerships has helped to build trust among partners, identify strengths and weaknesses among them, and develop research capacity while pursuing research activities. All partners have been able to rely on guaranteed minimum annual budgets as well as additional funds in case of need or opportunity. Programme steering has been participatory, involving all members of the international board of directors in the North and South. In addition, commonly agreed goals in research, capacity development, societal empowerment, institutional development, application activities, and policy advice have mutually reinforced and augmented the overall quality of each of these components.

The commitment to work not only towards generating systems knowledge, but to equally address target and transformation knowledge, has helped to make the research and capacity development societally relevant and application-oriented. In components directed towards systems knowledge, the programme has attempted to use systemic approaches to the biophysical, social, and economic subsystems, and has applied them at various spatial levels, also looking at genuine stakeholder participation and real process impacts. To enhance the programme's target knowledge, transdisciplinary negotiations were initiated, all activities being strongly oriented to actors and stakeholders. In generating transformation knowledge, finally, we found it crucial to assess systems and target knowledge, find out what actors are involved, and ensure their participation and agency ("Handlungskompetenz").

In relation to global initiatives, possible fields of activity such as mitigation and, to a lesser extent, adaptation were included in the assessments of target and transformation knowledge, as research should provide suitable solutions for these as well. The four research directions of contextualisation, specialisation, application, and generalisation have proved to be particularly useful for understanding where, why, how, and how widely potential solutions could be proposed, and what levels of management and spatial scales are appropriate. Research in support of these activity fields has been mostly cross-disciplinary and has generated extra-disciplinary and combined knowledge using appropriate research tools and approaches, such as biophysical methods, methods from the social sciences and economics, and geo-information methods for spatial and temporal aspects. Last but not least, the NCCR North-South programme considers it essential to also look at itself, observing and reflecting on development-oriented research as an object of research.

1.3.2 Synthesis outputs

The approach to global change research for sustainable development presented in section 1.2.3 is a basic premise of the NCCR North-South programme. The questions "What is global change?" and "What is sustainable development?" are meant to guide research in all four directions – specialisation, generalisation, contextualisation, and application – while putting values at the forefront of research. But who is to determine these values? How should future values be conceived? How should value-explicit strategies be defined and implemented? These questions imply that research takes place at the interface between the scientific community and society. They also imply the need for clarifying what actors participate in defining the fundamental values of development-oriented research, as well as the procedures and conditions under which this is done. These important issues, along with others outlined below, are examined in the present synthesis volume in an attempt to contribute to ongoing debates on research for sustainable development.

Understanding the dynamics of global change from local to global levels is a core issue. The realisation of globally coordinated research for sustainable development raises the central question of how to aggregate and generalise research findings on local, regional, national, and global dynamics.

Knowledge, transdisciplinarity, and reflexivity in research partnerships are other central matters of concern. What form of collaboration do we need, and what knowledge? Sustainable development, transdisciplinarity, and partnership are three concepts that are intrinsically connected to social and societal development processes. They belong together and reinforce each other, like three pillars forming the foundation of research for sustainable development. According to this image, the first pillar supporting NCCR North-South research is a sound understanding of sustainable development. The second pillar is the programme's partnership approach; it bears the challenge of exploring the kinds of research partnership through which sustainable development can best be achieved. Transdisciplinarity – the third pillar of development-oriented research – is implemented in the NCCR North-South through actor- and context-specific combinations of systems, target, and transformation knowledge. A critical question in this regard is how research deals with the threefold frame of reference of (1) one's own scientific discipline, (2) the wider field of interdisciplinary research, and (3) the non-academic knowledge of other societal actors.

Research on sustainable development cannot avoid reflecting upon the role of political structures and practices, since research and researchers both influence and are influenced by power relations and institutions. NCCR North-South experience is therefore investigated in terms of the potentials and limitations of research for sustainable development in reshaping power relations and power flows (politics) in order to reduce existing levels of inequality and exclusion. Important questions are: What knowledge and experience did the NCCR North-South produce regarding the role of political institutions and politics in shaping the human–environment interface? How are power structures and power flows (politics) addressed and tackled in research? Which kind of power relations prevent research for sustainable development from achieving its transformative purposes?

Applying actor-centred approaches is a standard in research for sustainable development. The synthesis findings and experiences of the NCCR North-South regarding the potentials and limitations of research focus on research orientation to actors and systems, providing answers to the following key questions: What role do local stakeholders play in setting the agenda for and evaluating NCCR North-South research and action? What roles do stakeholders in general play in research and mitigation? How can conflicts, dissent, negotiation, and conciliation be dealt with in actor-oriented approaches? What experience has been gained with institutional arrangements that benefit local stakeholders' livelihoods by reducing dependencies and enhancing adaptive capacity?

Access to resources in rural settings is a further core issue in NCCR North-South research. Improving access to natural resources, information, basic sanitation and health services, wildlife habitats, and other assets is a prerequisite and fundamental means of fostering sustainable development, though often this is not underpinned by evidence. This gap calls for NCCR North-South research to provide evidence of, or clarify, important elements and links between access to resources and sustainable development. In this regard, the present synthesis focuses on the following questions: What experience has been gained with links between access to resources and sustainable development? And, more specifically regarding the human–environment interface: How do actions promoting sustainable development influence stakeholder-specific balances of access to natural, social, political, cultural, and financial resources? How are social conflicts triggered or mitigated by changes in access to natural resources? And how are shortages and degradation linked to changing patterns of access to natural resources?

Due to the richness of its epistemological background, NCCR North-South research has evolved through a broad range of approaches. Integrative approaches and multi-level approaches, as well as concepts and approaches grouped under sustainable land management, sustainable health services, or sustainable environmental sanitation, are examples that reflect this diversity of epistemological backgrounds. In this regard, the aim of this synthesis is to elucidate potentials and limitations in dealing with epistemological diversity in research for sustainable development. This includes answering questions about opportunities for combining epistemological diversity on the basis of a common approach. Important questions might be: What commonalities and what differences can be found among the diverse approaches? Is there a common ground for further work? Does 'embracing diversity' supersede a common approach?

1.3.3 Outline of this book

The articles comprising the present volume tackle the above questions from different angles and in the context of different research topics. The book is organised in five parts, focusing on the NCCR North-South's theoretical foundations, as well as concepts, perspectives, and tools applied and developed, and insights into a number of important development issues examined from a sustainability perspective.

Foundations of research for sustainable development: Part I, which includes the present introductory article, reflects on the very foundations of the programme, discussing the overall setting of NCCR North-South research within the global debate on research for sustainable development. In Article 2, Wiesmann and co-authors argue that sustainability must be viewed as a normative concept which calls for societal co-production of knowledge at the interface of scientific communities and society as a whole. Programmatically, for the NCCR North-South, transdisciplinarity and research in partnership are two fundamental preconditions in the quest to bridge the gaps between disciplines (or paradigms) and between science and society.

Concepts of research for sustainable development: Part II discusses important and innovative research approaches taken by the NCCR North-South. The first two articles in this part of the book reflect on the way in which NCCR North-South researchers work together to produce knowledge for sustainable development. Article 3 by Upreti highlights the role of social learning processes in developing capacity among individuals and institutions and shows how NCCR North-South research activities provided an opportunity for partners

in the South to enhance their visibility and recognition. During or after their participation in the programme, many obtained better employment and came to occupy better positions; many were also able to attract more resources for research and publish more, expanded their academic activities, and collaborated more with other institutions. In Article 4, Zingerli examines the role of collaborative and intercultural knowledge production for sustainable development and highlights the importance of this form of research based on experiences from numerous NCCR North-South case studies.

The subsequent articles focus on the relations between research and other parts of society involved in the quest for sustainable development. In Article 5, Goetschel looks at the interface between development policy and research from a development perspective. Article 6 by Rist and colleagues explores the implications that incorporating endogenous knowledge in development processes has for research for sustainable development, and examines under which conditions endogenous and scientific communities can enter into a dialogue in order to jointly produce knowledge for more sustainable development. Lacroix and colleagues underline in Article 7 that social and political participation in sustainable development research and practice is indispensable, and has to be coupled with a focus on governance. Governance is further explored in Article 8 by Hufty, who describes four approaches to this concept – corporate governance and the sociology of organisations, global governance, good governance, and modern governance – and analyses their strengths and weaknesses with a view to developing a new tool for analysing governance processes. In Article 9, Bieri and colleagues present insights from gender-considerate research on global change and show that a gender perspective can function as a tool for thought and transformation. Article 10 by Zinsstag and co-authors, finally, shows how the recognition of gaps between disciplinary knowledge generated from an external perspective and actual development processes has resulted in a new awareness, leading to the incorporation of other disciplines in order to achieve broader social, behavioural, and economic perspectives on the different technical issues under study.

Actor perspectives in research for sustainable development: Part III offers discussions of actor-oriented concepts that have played a fundamental role in research for sustainable development both generally and within the NCCR North-South, including livelihoods, actors, gender, and vulnerability and resilience. In Article 11, Wiesmann and co-authors argue that deeper reflection on the conceptual foundations of livelihoods approaches is crucial in developing an adequate concept of 'actors'. Geiser and colleagues show in Article 12 that by re-theorising livelihoods approaches based on theories

from the social sciences dealing with power, inequality, and everyday social practices, they can be developed into a challenging livelihoods perspective in critical development studies. In Article 13, Obrist and co-authors argue for shifting the focus of mitigation research from vulnerability to resilience and thus on how actors can develop proactive mitigation strategies. Article 14 by Ott and Bieri analyses the NCCR North-South 'gender route', highlighting useful insights into gender mainstreaming policies and strategies both for future research within the NCCR North-South and for other development-oriented institutions. In Article 15, Geiser and colleagues reflect on the concepts of livelihood assets and access to these assets within a broader context of contested political processes and show how this broader understanding of social realities contrasts with the social analyses usually underpinning development interventions. Article 16 by Thieme develops a theoretical basis for transnational migration studies that allows combining a livelihoods approach with a perspective on transnational social spaces in order to examine how migrants manage their multi-local lives.

Tools in research for sustainable development: Part IV discusses a number of tools for working with the above concepts and approaches and tackling various research questions regarding global change and sustainable development. In Article 17, Gallati and Wiesmann show that system dynamics complies with the majority of epistemic requirements of transdisciplinarity, and recommend it as a valuable tool for transdisciplinary research, highlighting its potential for overcoming difficulties in generalising transdisciplinary findings. Article 18 by Ehrensperger and colleagues synthesises experience with the potentials and limitations that geographic information sciences (GIS) and geo-information tools have in developing participatory and multi-stakeholder processes for sustainable development, basing their assessment on considerations of spatial scales and policy levels. Spatial scales are an important focus of Article 19 as well, in which Messerli and co-authors propose a new approach to describing landscape mosaics, focusing on a meso-level spatial scale and interpreting them in terms of human–environment interactions. In Article 20 Hufty, based on his analysis of different approaches to governance in Article 8, develops a practical methodology for investigating governance processes.

Thematic foci in research for sustainable development: The articles in Part V synthesise experiences and insights gained in research projects investigating global change processes from a sustainability perspective. Article 21 by Breu and co-authors, for example, establishes factors affecting land users' efforts to sustain the productive use of natural resources as a crucial

prerequisite for sustainable land management. A similar point is made in Article 22 by Goetschel and Péclard, although in a different context: While confirming that climate change, and especially resource scarcity, can lead to violent conflict, the authors underline that it is crucial to put social and human dimensions at the centre of the analysis when trying to understand the relationships between changes in the environment and violent conflict. Social and human dimensions are also the focus of Article 23 by Haller and Galvin, who argue that grassroots participation in conservation initiatives has to be based on local land rights and the opportunity to take part in crafting the institutional design of protected areas.

The following two articles focus on the relations between economy and development. In Article 24, Ludi and colleagues explore the potential of speciality coffee production as a way out of poverty for small-scale producers in Africa and show that this market still needs to be improved in order to offer producers sustainable development benefits. Another important economic insight is presented in Article 25 by Kappel and Agrawal, who demonstrate that the direction of causality is from income growth to poverty reduction, rather than the other way round. The results from this study in India illustrate how important it is to implement policies and institutional reforms promoting economic growth in order to reduce poverty. In Article 26, based on an analysis of transformations in the livelihoods of livestock-based populations in West Africa, the Horn of Africa, and Central Asia, Bonfoh and co-authors underline the importance of equitable and effective access to pastoral resources based on an appropriate institutional framework and equity-effective basic social services.

Article 27 by Rabinovich shifts the focus from rural to urban contexts. Based on comparative research on different continents she shows that innovation in 'urbanism' thinking has increasingly responded to the need for linking heterogeneous players, diverse scales, and multiple dimensions. In Article 28, Schnabel and co-authors examine human security in urban settings and conclude that a security concept which focuses on humans as a referent object can reveal unexpected causes of urban insecurity and thus guide efforts towards improvement. Article 29 by Zinsstag and colleagues, finally, focuses on equity effectiveness in health interventions. Synthesising findings from various studies in Africa and Asia, the authors argue that equity in the provision of basic services such as health care, drinking water, and environmental sanitation are essential elements and a precondition of development and environmental sustainability.

Endnotes

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[4] The NCCR North-South partnership regions are also known as Joint Areas of Case Studies (JACS). Regional Coordination Offices (RCOs) were established in each of these JACS at the outset of the programme. The original function of the RCOs was to coordinate research; in the ongoing final phase of the programme, RCOs are working to consolidate the existing research network in the South and function as knowledge hubs for generating new research projects and partnerships.

[5] Partnership Actions for Mitigating Syndromes (PAMS) are projects implemented by local actors together with scientific and non-scientific stakeholders. As a component of the NCCR North-South programme they are designed to implement and validate approaches, methods, and tools developed in research, with a view to finding promising strategies and potentials for sustainable development. Moreover, they are intended to promote mutual learning and knowledge-sharing between academic and non-academic partners in sustainable development.

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