

**Chapter 20. Climate-Resilient Pathways:
Adaptation, Mitigation, and Sustainable Development**

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1 Executive Summary

2
3 Sustainable development within the context of climate change calls for new approaches to development that take
4 into account complex interactions between climate and society. Climate-resilient pathways are not predetermined
5 routes defined by a given set of practices. Rather, they are potential trajectories that link current decisions and
6 actions with an emergent future – a future which recognizes that the consequences of climate change call for
7 transformative planning and responses. These responses include both climate change risk reduction through
8 mitigation and adaptation and also resilience in sustainable development pathways themselves.
9

10 This chapter integrates a variety of complex issues in assessing climate-resilient pathways in a variety of regions at a
11 variety of scales: sustainable development as the ultimate aim, mitigation as the way to keep climate change impacts
12 moderate rather than extreme, adaptation as a response strategy to cope with impacts that cannot be (or are not)
13 avoided, and elements of sustainable development pathways that contribute to resilience. Climate-resilient pathways
14 recognize that impacts are certain, because climate change can no longer be avoided. Ignoring this source of stress
15 will endanger sustainable development. As a result, vulnerability assessments and risk management strategies are
16 important, considering both possible/likely climate effects – extremes as well as average – and also development
17 conditions such as demographic, economic, and land use patterns and trends; institutional structures; and technology
18 development and use. In most cases, vulnerabilities and appropriate risk management approaches will differ from
19 situation to situation, calling for a multi-scale perspective built solidly on fine-grained contextual realities. But most
20 situations share at least one fundamental characteristic: threats to sustainable development are greater if climate
21 change is substantial than if it is moderate.
22

23 This chapter's assessment findings are the following. Although they are based on a high level of consensus in source
24 materials and in the expert communities, the amount of supporting evidence is usually limited by the fact that so
25 many aspects of sustainable development and climate change mitigation and adaptation, considered together over
26 periods many decades into the future, are surrounded by issues that are beyond past and current observation and
27 experience.
28

29 **Climate change is a significant threat to sustainable development, especially if climate change is substantial**
30 **rather than moderate.** (High confidence: high agreement, moderate evidence; see section 20.2.2). Climate change
31 can no longer be avoided; and, added to other stresses on sustainable development, its effects will make
32 sustainability more difficult to achieve for many locations, systems, and affected populations.
33

34 **Reducing this threat will require both resilient sustainable development pathways and actions to reduce**
35 **climate change and its impacts, including both mitigation and adaptation.** (High confidence: high agreement,
36 moderate evidence; see sections 20.2.3, 20.3, and 20.4) Adaptation and mitigation can both contribute to and impede
37 sustainable development, and sustainable development strategies and choices can both contribute to and impede
38 climate change responses.
39

40 **Integrating these elements of climate-resilient pathways, often in place-based contexts, offers potentials for**
41 **win-win consequences.** (Moderately high confidence: moderately high agreement, moderately strong evidence: see
42 sections 20.2.2, 20.3.3, 20.4, 20.3, and 20.5.4) Development pathways that are fully resilient from a sustainable
43 development standpoint are also likely to be the pathways best-suited to be climate resilient; strategies to achieve
44 each goal have the potential to reinforce each other.
45

46 **With more substantial change, resilience will often require transformational adaptations: responses that**
47 **change the nature, composition, and/or location of threatened systems in order to sustain development.** (High
48 confidence: high agreement, moderately strong evidence; see sections 20.2.2, and 20.4.2) Larger increases in climate
49 extremes or climate-related severe weather events are less amenable to incremental adaptations to climate change.
50

51 **At a global scale, climate-resilient pathways will include actions that promote both climate change adaptation**
52 **and mitigation in a sustainable manner, while at sub-global scales climate-resilient pathways will involve a**
53 **range of actions appropriate to differences in potentials for vulnerability and risk reduction.** (High
54 confidence: high agreement, moderately strong evidence; see section 20.5.3) Although at a global scale, both

1 mitigation and adaptation will be essential, relatively local scales in many developing regions have limited
2 capacities to include mitigation in their climate-resilience strategies because they contribute very little to the causes
3 of climate change.

4
5 **Although payoffs from specific long-term pathways may be uncertain, strategies and actions can be pursued
6 now that will reduce climate change risks, promote adaptive management, and contribute significantly to
7 prospects for climate-resilient pathways while helping to improve human livelihoods and social and economic
8 well-being.** (High confidence: high agreement, moderate evidence; see section 20.5.4) Actions at the present time
9 will emphasize co- benefits and iterative learning, with risk management strategies refined continually on the basis
10 of growing bases of knowledge and experience.

11 12 13 **20.1. Introduction**

14
15 Following summaries of *what we know* about climate change impacts, vulnerabilities, and prospects for adaptation
16 (Chapter 18) and of *what we should be most worried about* (Chapter 19), this concluding topical chapter of the
17 Working Group II Fifth Assessment Report summarizes what is currently known about options regarding *what to do*
18 in responding to these risks and concerns.

19
20 As evidence of climate change begins to emerge, the need to address both near-term and longer-term implications of
21 climate change is increasing as an issue for policymaking and decision-making. This includes responses to *observed*
22 impacts as well as managing risks of *projected* impacts, which in many cases converts “what to do” from prudent
23 long-term contingency planning to planning for relatively near-term actions. Reconciling short-term and long-term
24 goals is thus becoming an increasingly important dimension of sustainable development policies. This is important
25 not only in response to climate variability and extreme events, as was highlighted in the SREX report (IPCC 2012),
26 but also in response to the impacts of more gradual changes, which are becoming increasingly evident around the
27 world (Chapter 19).

28
29 As a result, the big-picture, long-term consequences of climate change are now being seriously considered, along
30 with the types of responses that can contribute to sustainable development. For example, UNFCCC negotiations
31 have included attention to such questions as: What strategies and actions, on the part of all nations, can contribute to
32 effective approaches to sustainable development, including appropriate climate change mitigation and adaptation
33 commitments and actions? How should climate change policy be integrated into sustainable development? What are
34 alternative pathways for developing countries to achieve sustainable development in the context of challenges from
35 climate change? These questions derive from principles contained in Articles 2 and 3.4 of UNFCCC with the
36 ultimate objective of stabilizing greenhouse gas concentrations in the atmosphere, as expanded by the Delhi
37 Ministerial Declaration on Climate Change and Sustainable Development: Decision 1/CP.8 (see Box 20-1).

38
39 _____ START BOX 20-1 HERE _____

40 41 **Box 20-1. UNFCCC Goals for Climate-Resilient Pathways**

42
43 *Climate resilient pathways are trajectories of combined mitigation and adaptation that are consistent with the aims
44 of sustainable development and which do not traverse the threshold of “dangerous anthropogenic interference with
45 the climate system” as specified in Article 2 of the Convention.*

46
47 Article 2 of the United Nations Framework Convention on Climate Change presents the ultimate objective as the,
48 ‘stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous
49 anthropogenic interference with the climate system.’ According to the Convention, the climate system must not be
50 dangerous in order to “allow ecosystems to adapt naturally to climate change, to ensure that food production is not
51 threatened and to enable economic development to proceed in a sustainable manner”. Article 3.4 recognizes that
52 “Parties have a right to, and should promote sustainable development.” The Copenhagen Accord of 2009 states, “To
53 achieve the ultimate objective of the Convention to stabilize greenhouse gas concentration in the atmosphere at a
54 level that would prevent dangerous anthropogenic interference with the climate system, we shall, recognizing the

1 scientific view that the increase in global temperature should be below 2 degrees Celsius, on the basis of equity and
2 in the context of sustainable development, enhance our long-term cooperative action to combat climate change.”
3

4 The Cancun Agreements Decision 1/CP.16 confirms this with a view that “... recognizes ... deep cuts in global
5 greenhouse gas emissions are required according to science, and as documented in the Fourth Assessment Report of
6 the IPCC, with a view to reducing global greenhouse gas emissions so as to hold the increase in global average
7 temperature below 2°C above preindustrial levels...consistent with science...[and] also recognizes the need to
8 consider, in the context of the first review... strengthening the long-term global goal on the basis of the best
9 available scientific knowledge.
10

11 The 2011 Conference of the Parties in a decision known as the Durban Platform increases the strength of the
12 language in the decision -/CP.17 to conclude, “... climate change represents an urgent and potentially irreversible
13 threat to human societies and the planet and thus requires to be urgently addressed ... with a view to accelerating the
14 reduction of global greenhouse gas emissions.... Current UNFCCC negotiations have once again adopted +2°C as
15 the desirable target upper limit and equated this with “dangerous” in Article 2.
16

17 _____ END BOX 20-1 HERE _____
18

19 In many cases, reducing the long-term impacts of climate change on nature and society will require transformational
20 changes that address the drivers of both greenhouse gas emissions and social vulnerability to impacts. Limiting the
21 rate and magnitude of climate change and its impacts on society is thus becoming a key dimension of sustainable
22 development, and there is a growing recognition that transformation of behaviors, systems, cultures and institutions
23 may be a prerequisite for avoiding dangerous climate change consequences (Raskin et al., 2011; Westley, et al.
24 2011; O’Brien, 2012).
25

26 Sustainable development within the context of climate change calls for new approaches to development that takes
27 into account complex interactions between climate and society. Climate-resilient pathways are not predetermined
28 routes defined by a given set of practices. Rather, they are potential trajectories that link current decisions and
29 actions with an emergent future – in this case a normative, desirable future that recognizes that the consequences of
30 climate change call for transformative planning and responses which include both mitigation and adaptation, carried
31 out in a reflexive and ethical manner to promote equitable and sustainable development (Gallopín, 2006; Nelson,
32 Adger, and Brown, 2007; Robinson et al., 2006; Miller, 2007).
33

34 Chapter 20 integrates a variety of complex issues in assessing climate-resilient pathways in a variety of regions at a
35 variety of scales: sustainable development as the ultimate aim, mitigation as the way to keep climate change impacts
36 moderate rather than extreme, adaptation as a response strategy to cope with impacts that cannot be (or are not)
37 avoided, and development pathways as contexts that shape choices and actions. It is organized in five parts:
38 sustainable development as a context for climate resiliency, posing challenges for both climate change responses and
39 sustainable development pathways (20.2), contributions to resilience through climate change responses (20.3),
40 contributions to resilience through sustainable development strategies and choices (20.4), perspectives on
41 appropriate and effective pathways (20.5), and important gaps in existing knowledge for clarifying what to do
42 (20.6). The chapter shows that adaptation and mitigation can both contribute to and impede sustainable
43 development, and sustainable development strategies and choices can both contribute to and impede climate change
44 responses. Climate resilient pathways can be considered those trajectories that not only recognize the relationship
45 between mitigation, adaptation and sustainable development, but also invoke transformative actions to deliberately
46 avoid dangerous climate change and its impacts (see Box 20-1).
47

48 Several of the terms that are central to this chapter have been defined earlier in the Working Group 2 Fifth
49 Assessment Report, including climate, adaptation, and mitigation. In addition, by “resilient” we mean a system’s
50 capacity to anticipate and reduce, cope with, and respond to and recover from external disruptions (IPCC SREX,
51 2012). For literatures on “sustainable development,” see section 20.2.1 below. A summary definition is development
52 that achieves continuing human progress and assures a sustainable relationship with a physical environment that is
53 already under stress, reconciling tradeoffs among economic, environmental, and other social goals through
54 institutional approaches that are equitable and participative in order themselves to be sustainable.

1
2 The aim of the chapter is to consider the attributes and characteristics of pathways for sustainable development that
3 are resilient to impacts of climate change, including potentials and possible limitations. The chapter considers
4 pathways that can incorporate climate change as one of many issues for development in order to avoid serious
5 disruptions, from both adaptation and mitigation perspectives (Figure 20-1). For instance, prospects for climate-
6 resilient pathways are rooted in potentials for climate change adaptation in order to enhance coping capacities, but
7 they are profoundly shaped by the rate and magnitude of climate change, which depend on potentials for climate
8 change mitigation. Effects of climate change interact with other factors that shape development – economic, social,
9 institutional, environmental, political, and technological – in an immense variety of development contexts: e.g.,
10 different threats, different locations, different time frames, different vulnerable systems/populations, different
11 response capacities. Although this diversity complicates any attempt to offer broad generalizations that are of value,
12 the chapter provides a framework for thinking about this problem and offers some examples of both challenges and
13 possible response strategies.

14
15 [INSERT FIGURE 20-1 HERE

16 Figure 20-1: Sustainable development depends on effective responses to climate change and other stresses.]
17
18

19 **20.2. Sustainable Development as a Context for Climate Resiliency**

20

21 Climate-resilient pathways bring together (a) sustainable development as the larger context for societies, regions,
22 nations, and the global community with (b) climate change effects as threats to (and possibly opportunities for)
23 sustainable development and responses to reduce those effects that would undermine future development and even
24 offset already achieved gains (Figure 20-1).
25

26 **20.2.1. *The Challenge of Sustainable Development***

27
28

29 “Sustainable development” is a concept rooted in many decades of concerns about relationships between society and
30 nature (e.g., Brown, 1981). These concerns grew during the 1960s and 1970s in connection with observations of a
31 declining quality of the environment coupled with increasing needs for resources as populations expand and living
32 standards rise. Early initiatives focused more on individual attributes of the environment, including water quality, air
33 quality, management of hazardous substances and natural resources. Some of the outcomes from these initiatives
34 included a complex array of regulations intended to manage and improve development, a movement toward
35 recycling of consumable resources, and an emphasis on renewable energy as a substitute for energy production that
36 consumed non-renewable fossil fuel resources (Frey and Linke, 2002). While the initiatives taken regionally had
37 many positive effects, it soon became evident that there were global environmental issues that needed to be
38 addressed as well.
39

40 The Brundtland Report defines sustainable development as that which meets the needs of the present without
41 compromising the ability of future generations to meet their own needs (WCED, 1987). The report also recognizes
42 that poverty is one of the main causes of environmental degradation and that equitable economic development is key
43 to addressing environmental problems both in developing and developed regions. (Halsnaes et al., 2008; Lafferty and
44 Meadowcroft, 2010). From a practical perspective, sustainable development has been “operationalized” through
45 Agenda 21, which is a comprehensive plan of action adopted at the 1992 Earth Summit by more than 178
46 governments (Sitarz, 1994), and “Rio+20” in June 2012 is expected to urge countries to renew their commitment to
47 sustainable development. Meanwhile, although the existing global discourse and practice around sustainable
48 development has helped to establish some commonly held principles, the concept itself remains elusive and
49 contested (e.g., Hopwood, Mellow, and O’Brien, 2005; Jabareen, 2008). For example, sustainable development has
50 been criticized as being vague and immeasurable; and its connections with continued economic growth have drawn
51 suspicion from both those who believe sustainable development is a strategy to slow or limit development in the
52 developing world and from those who think that continued growth is itself non-sustainable (e.g., Robinson, 2004).
53 Whereas some authors equate sustainable development with equity and values through which climate policies can be
54 implemented (Najam et al., 2006), in practice some national authorities tend to interpret sustainable development as

1 economic development, perhaps in part because the term sustainable development has gained political currency,
2 despite an apparent lack of attention to distributional impacts.
3

4 Conceptual understandings of sustainable development have developed considerably, particularly over the past two
5 decades, as the short- and long-term implications of climate change and extreme events have become better
6 understood, although empirical evidence of progress with sustainable development is often elusive. The discussion
7 of sustainable development in the IPCC process has evolved since the First Assessment Report, which focused on
8 the technology and cost-effectiveness of mitigation activities, and the Second Assessment Report (SAR), which
9 included issues related to equity and to environmental and social considerations. The Third Assessment Report
10 (TAR) further broadened the treatment of sustainable development by addressing issues related to global
11 sustainability, and the Fourth Assessment (AR4) included chapters on sustainable development in both WG II and
12 III reports, with a focus on both climate-first and development-first literatures.
13
14

15 *20.2.2. Links between Sustainable Development and Climate Change*

16
17 As the extent of implications of climate change become better-understood (Chapter 18) and as particular reasons for
18 concern have begun to come into focus (Chapter 19), climate change has been increasingly seen as an issue for
19 sustainable development – with the potential either to aid or impede its sustainability (e.g., Halsnaes, et al., 2008;
20 Munasinghe, 2010). The links between sustainable development and climate adaptation and mitigation are cross-
21 cutting and complex. First the effects of climate change may derail current sustainable development policy and
22 potentially offset already achieved gains (see Boxes 20-2 and 20-3). Second, mitigation has the potential to keep
23 these threats at a moderate rather than extreme level and adaptation will enhance the ability of different systems to
24 cope with the remaining impact, therefore modulating negative effects on sustainable development. Third, many of
25 the conditions that define vulnerability to climate impact and the ability to respond to them are firmly rooted in
26 development processes (e.g., structural deficits and available assets and entitlements). Fourth, current levels of
27 sustainable development intersect with many of the drivers of climate change, especially regarding energy
28 production and consumption and ability to mitigate emissions. Fifth, because several of the conditions that predict
29 success of mitigation and adaptation may overlap with those of sustainable development, systems where sustainable
30 development has been effectively embraced may provide a more conducive context for the implementation of
31 successful mitigation and adaptation. Finally, climate mitigation and adaptation, if planned and integrated well, have
32 the potential to create opportunities to further fostering sustainable development (see section 20.3.3 below).
33 Understanding how to enhance positive feedbacks while minimizing negative ones is an essential part of planning
34 for and pursuing climate-resilient pathways. In the next paragraphs we discuss these links in light of empirical
35 findings and specific examples (Boxes 20-2 and 20-3). While some of the links described above have been
36 contemplated in the scholarly literature, there remain considerable gaps on our knowledge base to inform climate
37 resilient pathways.
38

39 _____ START BOX 20-2 HERE _____
40

41 **Box 20-2. Key Reasons for Concern about Climate Change Effects on Sustainable Development**

42
43 Chapter 19 of IPCC's Fourth Assessment Report, Working Group 2, was concerned with "Addressing Key
44 Vulnerabilities and the Risk from Climate Change" (IPCC, 2007). Changes in perceived risks compared with the
45 Third Assessment Report were reviewed in Smith et al., 2009.
46

47 As reported in these sources, key vulnerabilities to climate change that might affect sustainable development include
48 the following, recognizing that the distribution of such impacts can be uneven and variable across both space and
49 time:

- 50 • Increases in the frequency and/or intensity of extreme events
- 51 • Loss of glaciation and sea-ice cover
- 52 • Loss of biodiversity: threats to unique and threatened systems
- 53 • Loss of coral reefs and some Arctic ecosystems
- 54 • Decreased agricultural productivity and food security in some areas

- 1 • Decreased water availability and increased drought in some areas
- 2 • Potentials for environmental migration
- 3 • Increases in human mortality

4
5 [to be updated from AR5 Chapter 19 FOD]

6
7 Especially at risk are Africa, small islands, dense concentrations of population in vulnerable coastal areas, and
8 biological populations adapted to conditions in border zones between climatic regimes. Cross-cutting reasons for
9 concern include possible limitations and/or costs of adaptation in some areas and the possibility of thresholds (e.g.,
10 TAR pointed to possibilities of “large-scale singularities”: IPCC, 2001).

11
12 _____ END BOX 20-2 HERE _____

13
14 _____ START BOX 20-3 HERE _____

15 16 **Box 20-3. Connecting Representative Concentration Pathways with Shared Socioeconomic Pathways**

17
18 The climate change science community has developed a new set of visions of a range of climate futures, called
19 “Representative Concentration Pathways” or RCPs, intended to replace the rich families of SRES scenarios (IPCC,
20 2000) that were used extensively by IPCC and others for a decade. As reported in Moss et al., 2010, the RCPs
21 include four representative pathways to illustrate the range of possible climate futures, defined in terms of
22 approximate radiative forcing levels. These scenarios represent a broad range of potential climate outcomes, both
23 over the near term (to 2035) and longer term (2100 and beyond).

24
25 To accompany these RCPs and provide context for assessing impacts of such futures, the climate change science
26 community is also developing a set of representative socioeconomic futures, reflecting different pathways of
27 economic intensity, capacity for societal problem-solving, and other dimensions of socioeconomic futures, called
28 Shared Socioeconomic Pathways (SSPs), each defined by a storyline and supported by qualitative and quantitative
29 characterizations (Kriegler et al., 2011). In principle, it will be possible to compare socioeconomic conditions (SSPs)
30 with climate forcings (RCPs) to evaluate such issues as differences in needs and challenges for mitigation or the
31 feasibility of adaptation associated with different contexts regarding driving forces (see section 20.5).

32
33 _____ END BOX 20-3 HERE _____

34
35 Is it possible to have sustainable development that is not climate resilient? The relationship between climatic change
36 and development has often been theorized as mainly twofold. On the one hand, climate change will affect
37 development policy as needs to respond to negative, and perhaps positive, impacts arise (Schipper, 2007; Burton et
38 al., 2002; Halsnaes and Verhagen, 2007). On the other hand, development policy critically shapes carbon emission
39 paths, the ability to develop sustainable adaptation and mitigation options, and to build overall adaptive capacity
40 (Bizikova, Robinson, and Cohen, 2007, Garg, et al., 2009, Metz and Kok, 2008, Lemos, et al. 2007). Because of the
41 recognized relationship between development and climate change drivers and responses, some authors have called
42 for a “political economy of climate change” that takes into considerations ideas, power and resources at different
43 scales from the local to the global (Allouche and Tanner, 2011). Enhancing resilience to respond to effects of
44 climate change includes adopting good development practices that are consonant with building sustainable
45 livelihoods and, in some cases, challenging current models of development (Boyd et al., 2008). Moreover,
46 promoting development pathways that are both equitable and sustainable is also key to addressing climate change
47 (Wilbanks, 2003, Nelson et al. 2007). It is now widely recognized that activities necessary to enhance adaptive
48 capacity are also important for promoting sustainable development and vice-versa, although adaptation on its own --
49 without sustained mitigation of greenhouse gas emissions-- cannot offset all of the negative impacts of climate
50 change. And yet, whereas climate change impacts are often strongly correlated with threats to sustainability, the
51 debate on climate change has tended to run separately from the wider sustainability discourse (Cohen et al., 1998,
52 IPCC, 2001). Integrating sustainable development and overall climate change policy can be all the more relevant if
53 “cross-linkages between poverty, the use of natural capital and environmental degradation” are recognized (Veeman
54 and Politylo, 2003: 317; also see Matthew and Hammill, 2009). Especially in less developed countries/regions, the

1 relationship between vulnerability to climate impacts and development is often inclusive and mutually dependent as
2 such realities as low per capita income and inequitable distribution of resources; lack of education, health care, and
3 safety; and weak institutions, unequal power relations and weak democracy fundamentally shape sensitivity,
4 exposure and adaptive capacity to climate impact (Garg et al., 2009; Lemos et al., 2007). In these regions, reducing
5 risks that affect resource-dependent communities is increasingly viewed as a necessary, but insufficient way to
6 tackle the myriad of problems associated with climate change impacts (Jerneck and Olsson, 2008). Hence, building
7 adaptive capacity is both a function of dealing with underdevelopment and of improving risk-management (Mirza,
8 2003; Schipper and Pelling, 2006; Tompkins, Lemos, and Boyd, 2008). In this context, it becomes critical not only
9 to understand the relative importance of different kinds of interventions (climate and non-climate) in building
10 adaptive capacity but also the potential positive and negative synergies between them. They include both actions that
11 address underdevelopment such as socio-developmental policies (e.g. poverty alleviation, reducing risks related to
12 famine and food insecurity, enabling/implementing public health and mass literacy programs) and also conventional
13 climate impact risk management (e.g. alert systems, disaster relief, crop insurance, climate forecasts).

14
15 While research increasingly highlights the intersection between vulnerability, adaptive capacity and developmental
16 structural deficits, however, there is also growing recognition that the intractability of many of these problems may
17 inhibit the development of climate resilient pathways. For example, research by Wolf et al. (2009) on climate
18 change responses in western Canada shows that self-efficacy and ecological citizenship play an important role in the
19 identification and implementation of sustainable responses to water scarcity. In contrast, a lack of voice can suppress
20 innovative decisions about the future. Research focusing on disaster response in Mexico shows that alienation of
21 individuals is instrumental to creating a compliant citizenry, and that resilience is undermined by a limited breadth
22 of learning and experimentation, centralized power, and limited economic diversity (Pelling and Navarrete, 2010).
23 In NE Brazil, the fact that local traditional politics relied on client-list relationships with drought-affected
24 households to maintain power suggests that there was little incentive for policies that dramatically decreased their
25 level of vulnerability (Tompkins, Lemos, and Boyd, 2008). Omolo (2010) argues that in the Northern western
26 Kenya, in pastoralist societies of Turkana, in spite of increasing numbers of women headed households,
27 participation of women in key decisions such as investment, resource allocation, and planning on where to move or
28 settle in the aftermath of drought and floods is still quite low. One serious concern is that our inability to readily
29 address these structural problems may limit options for future generations of marginalized social groups as active
30 agents of a climate resilient future. In this sense, it is critical to understand how existing path dependent
31 trajectories (e.g., socio-technical, behavioral, institutional) that form the contextual basis for climate change action at
32 different scales (Burch 2011) may inhibit (or help) the realization of future climate resilient pathways.

33
34 The role of values in responding to climate change becomes important from a variety of perspectives, including
35 intergenerational, particularly when those currently in positions of power and authority assume that their prioritized
36 values will be shared by future generations (O'Brien, 2009). Acknowledging the importance of intergenerational
37 equity, it has been argued that participatory processes and 'deliberative democracy' can include the concerns, values
38 and perceptions of a wide range of stakeholders, raising some of the ethical impacts attached to climate related risks
39 (Backstrand, 2003, see also Deere-Birebeck, 2009). Such an approach could have a bearing on the way those risks
40 are assessed and addressed at the science-policy interface, with significant implications for sustainable development.
41 A number of studies recognize that not every possible response to climate change is consistent with sustainable
42 development, in that some strategies and actions may have negative impacts on the well-being of others and future
43 generations (Eriksen, et al., 2011; Gardiner et al., 2010). For example, some mitigation measures, such as changing
44 the composition of the atmosphere through geoengineering, could influence large-scale weather systems and create
45 potentially dangerous conditions or new problems for many others (Gardiner et al., 2010, Carlin, 2007; Brovkin et
46 al., 2009; de Sherbinin et al., 2011; also see section 20.2.3.4). Likewise, some adaptation measures, such as using
47 more surface water or groundwater for irrigation, may have negative effects on other users and more rapidly deplete
48 scarce natural resources that could come under increasing pressure with climate change (Eriksen et al., 2010). The
49 consequences of responses to climate change, whether related to mitigation or adaptation, can negatively influence
50 future vulnerability, unless they are linked to the wider context of sustainable development (Bizikova et al., 2010).
51 In light of the complex interactions among climate change responses and sustainable development, there is a need
52 for more holistic responses that place human well being and security at the forefront, while building on existing
53 strengths and capacities (Tompkins and Adger, 2004; O'Brien et al., 2010). This entails integrating multiple

1 objectives and policy goals to promote sustainable responses to climate change that contribute to resilience
2 (Meadowcroft, 2000; Tompkins and Adger, 2004).

3
4 One reality in many countries may be that development – which seeks to increase economic wealth – can enhance
5 the capacity to adapt while at the same time adding to greenhouse gas emissions. Yet, the World Development
6 Report 2010 suggests that climate change responses have the potential to enhance sustainable development as, for
7 example, in the case of financial assistance with transition to low-carbon growth paths (World Bank, 2010) or in the
8 case of mitigation policies that increase incomes in vulnerable groups such as REDD (Reducing Emissions from
9 Deforestation and Forest Degradation in Developing Countries). And while vulnerable sectors such as agriculture
10 give us particular reasons for concern (see Box 20-4), they may offer opportunities to reduce climate related risks
11 and threats by integrating both adaptation and mitigation strategies as a lever for reducing poverty and promoting
12 climate compatible development. Particularly necessary is addressing institutional and social capacities for
13 responding to both climate change impacts and mitigation responses. For example, Chhatre and Agrawal (2009)
14 show that climate change mitigation can benefit livelihoods if ownership of forest commons is transferred to local
15 communities. These kinds of possible implications of climate change connect with drivers of sustainable
16 development, and in turn social and economic dimensions of development affect the likelihood of effective
17 responses to climate change risks (see Box 20-4). Moreover, some interventions related to climate change responses
18 aim to combine goals of sustainable development, climate change adaptation, and climate change mitigation into
19 “triple win” approaches that highlight overlaps between these goals. Examples include mechanisms such as CDM
20 and IJI (e.g., Millar, Stephenson, and Stephens, 2007), which seek to offset carbon emissions, build adaptive
21 capacities of local communities, and provide sustainable development dividends (Corbera and Brown, 2008).
22 Because relationships among the three goals can lead to both positive and negative consequences, however, it is
23 important to unravel conditions that lead to desirable outcomes (Chhatre and Agrawal, 2009). (See section 20.2.3.3.
24 for a detailed discussion).

25
26 _____ START BOX 20-4 HERE _____

27 28 **Box 20-4. Climate-Related Vulnerabilities and Adaptation of African Smallholder Farming**

29
30 Small holders in Africa are vulnerable not just to climate but also to myriad of stressors that increase both their
31 exposure and sensitivity. In Ghana, bushfires and forest clearance in the 1980s forced communities to abandon the
32 once lucrative business of cocoa farming. Instead, communities resorted to maize production. Attempts to re-
33 establish cocoa farms after the bush fires were unsuccessful mostly because of to decline in soil fertility, declining
34 rainfall and high rates of deforestation. Adaptation options to help improve soil fertility and boost production of
35 maize included planting of early maturing crops, planting of different crop varieties; planting of drought tolerant
36 crops; changing of planting times; construction of firebelt and intercropping. As a result of intercropping activities,
37 farmers reported an increase in maize grain yield from 0.90 t ha⁻¹ to 3.0 t ha⁻¹ on unfertilized plots. What this case
38 study reveals is that without viable adaptation strategies that include appropriate knowledge and access to improved
39 technologies, poor communities may resort to unsustainable farming practices which deplete ecological goods and
40 services, further jeopardizing the well-being of the ecosystems and reducing choices to live off the land (see, for
41 example, Green and Raygorodetsky, 2010; Nyong et al., 2007; Speranza et al., 2010).

42
43 In the Ugandan areas of the Tororo, Kisoko and Osukuru, soil quality is poor and farmers’ capacity to adopt
44 recommended soil fertility management practices remains weak. Rainfall in the Tororo district tends to be bimodal –
45 with two annual crop growing seasons. Because sorghum and finger millet have been replaced by maize and upland
46 rice in marginal areas largely suited for small grain crops, there has been an overwhelmingly high rate of crop
47 failure, leaving many households vulnerable to food shortages. Adaptation options include the implementation of
48 Integrated Soil Fertility Management (ISFM) through which farmers were able to boost the productivity of sorghum,
49 millet and prioritized grain legumes under changing climate where rainfall conditions were poor and erratic. Yet
50 risks related to food deficits as a result of soil fertility problems worsened, and coupled with climatic change, has
51 and could further expose smallholder farmers threatening the sustainability of their prevailing livelihoods structures.

52
53 In Northern Zambia, deforestation is a major problem and it is largely attributed to charcoal burning and slash/burn
54 Chitemene shifting cultivation system. Climate variability including floods, droughts and other extreme events

1 contributes to decreasing livestock population, crop failure, food insecurity and reduced crop yields. Knowledge
2 generated from learning centres indicates that late-planted crops result in high yield penalties. For instance, a four-
3 week delay in planting reduced maize yields from more than 6 t/ha to 1.5 t/ha in Mungwi
4 (http://www.aec.msu.edu/fs2/zambia/wp47_final.pdf). Poor natural resource management practices tended to
5 reinforce their vulnerability. Inorganic fertilizers, lime and hybrid seeds represented potential solutions, but
6 remained out of the reach of poor farmers. Communities embarked on a number of adaptation strategies including
7 using drought-tolerant crops such as cassava; engaging in intercropping activities; and taking advantage of available
8 irrigation furrows for crop production. During periods of floods, they used indigenous fruits as a source of food;
9 planted local maize varieties that are perceived as more robust, and used varieties that can tolerate floods.

10
11 Source: Mapfumo *et al.* (2010)

12
13 _____ END BOX 20-4 HERE _____
14

15 Given these natural connections, there is growing consensus in the literature about the need to integrate development
16 and climate policies (Huq *et al.*, 2005; Jerneck and Olsson, 2008; Klein, Schipper, and Dessai, 2005; Kok *et al.*,
17 2008; Metz and Kok, 2008). However the means to achieve this integration differ. One option is the “development
18 first” approach which suggests that the incorporation of climate concerns within prevalent development
19 interventions is the best option since development is what most countries care about (Kok *et al.*, 2008). In this
20 approach, governments take into consideration tradeoffs between different dimensions of sustainability and look for
21 climate-inclusive policy options that offer positive synergies with development, aiming at both low greenhouse gas
22 emissions and low vulnerabilities to climate impacts. Lessons from this literature also emphasize the contextual and
23 place-based character of these processes and the need to understand opportunities and constraints relative to local,
24 national, and global priorities (Wilbanks and Sathaye, 2007). Moreover, factors constraining the ‘mainstreaming’ of
25 climate adaptation into development include discrepancies between immediate development goals and future climate
26 change scenarios, especially in less developed regions and emerging economies. They also include a growing
27 disconnect between donors’ goals and developing countries’ own development agendas (Agrawala, 2004; Klein,
28 Schipper, and Desai, 2005), potentially inhibiting the development of robust local institutions that can effectively
29 integrate or mainstream climate change policy into to their development priorities. Many developing countries lack
30 technical assistance and capacity development to support their climate change agendas and to identify and manage
31 risks. Often, programs tend to be poorly coordinated, fragmented and bureaucratic, thus accentuating the isolation
32 that vulnerable communities feel with regard to access to such programs (Chukwumerije and Schroeder, 2009).
33 Other factors such as lack of financial and human resources, unclear distribution of costs and benefits, fragmented
34 management, mismatches in scale of governance and implementation, lack and unequal distribution of climate
35 information, and trade-offs with other priorities may also limit the smooth mainstreaming of climate adaptation
36 action into development (Agrawala and van Aalst, 2008; Bizikova *et al.*, 2007; Eakin and Lemos, 2006; Kok *et al.*,
37 2008; Metz and Kok, 2008). Finally, empirical evidence suggests that the relationship between development
38 variables and climate change responses can be a mixture of positives and negatives, if development variables are not
39 managed well (Garg *et al.*, 2009). For example, in a study of the relationship between malaria incidence,
40 development and climate variables in India, Garg *et al.* (2009) found that while some development interventions
41 such as increased availability of irrigation canals and dams can negatively affect the incidence of malaria and water-
42 borne diseases, others such as higher per capita income can reduce negative health impacts of climate change
43 significantly – although the distribution of benefits can differ between types of interventions (also see Campbell-
44 Landrum and Woodruff, 2006).

45
46 Understanding how development variables intersect with climate responses is especially important because
47 governments and other actors rarely make decisions in isolation; rather they respond to multiple stressors both in
48 rural and urban environments (Agrawal, 2008; Eakin, 2005; Wilbanks and Kates, 2010). Moreover, some evidence
49 suggests that in practice, decision-makers (from heads of households to policy-makers) often do not place climate
50 change at the top of their priority list of critical issues to address (Garg, Shukla, and Kapshe, 2007; Kok *et al.*, 2008),
51 although in some regions (e.g., in Africa) special climate-oriented bureaus are being placed strategically in the
52 offices of government leaders. For instance, in Kenya and Tanzania special a climate change coordination units have
53 been created in high-level scales of government. These institutional arrangements constitute a growing realization of
54 the strategic place that climate change matters occupy in some countries in Africa. The growing importance of

1 climatic change in shaping social and governmental policy agendas has resulted in multiple examples of specific
2 interventions to respond to climate change both in developed and developing regions (Ayers and Huq, 2009; Burch,
3 2010; Dang, Michaelowa, and Tuan, 2003), for reasons that appear to vary widely.

6 **20.2.3. Contributions to Climate Resiliency**

7
8 If greenhouse gas emissions continue along trajectories leading to relatively significant climate changes and impacts
9 (NRC, 2010b), resilient pathways for sustainable development will require explicit attention to climate change
10 responses in virtually all regions, sectors, and systems. Sustainable development will depend fundamentally on
11 changes in social awareness and values that lead to innovative actions and practices, as well as to changes to
12 institutions and systems that currently support unsustainable practices in order to support vulnerable groups that are
13 showing capacities for self-organization and adaptation. In most cases, such a new climate-resilient development
14 paradigm is likely to benefit from bottom-up engagement in risk management and evolving problem-solving and
15 from human development to enhance capacities for risk management and adaptive behavior (Tompkins, Lemos, and
16 Boyd, 2008).

17
18 One of the most challenging aspects of climate-resilient pathways is that they are rooted in distinctive local contexts,
19 but at the same time that they are shaped by external linkages which require attention and care. For example,
20 resilience cannot be achieved in a few privileged places if it is not achieved in others, because instabilities in
21 adversely impacted situations will spill over to other situations through such effects as resource supply constraints,
22 conflict, migration, or disease transmission (Wilbanks, 2009).

23
24 Addressing these profound challenges will require combinations of two kinds of responses. One key component will
25 be actions to reduce vulnerabilities to climate change through climate change mitigation and adaptation in balanced
26 and integrated strategies (20.3). But the other key component is sustainable development pathways themselves and
27 how they enable (or complicate) effective resolution of complex nature-society tradeoffs (20.4).

30 **20.3. Contributions To Resilience Through Climate Change Responses**

31
32 Combined with appropriate development strategies (Section 20.4), pathways for sustainable development become
33 more climate-resilient by risk management and vulnerability reduction strategies that include (a) reducing the net
34 rate of growth of greenhouse gas (GHG) emissions and stabilizing – or reducing – their concentrations in the
35 atmosphere (mitigation) and (b) improving capacities to cope with climate changes without disruptions of systems
36 that we value (adaptation). Recently, discussions also been initiated about a third, last-resort option that is
37 surrounded by uncertainties and concerns: geoengineering.

40 **20.3.1. Mitigation**

41
42 In IPCC's assessment reports, mitigation is the subject of Working Group III, to which the reader is referred for
43 comprehensive information about options and strategies for reducing GHG emissions and increasing GHG uptakes
44 by the earth system. For this chapter, the issue is how climate change mitigation relates to sustainable development,
45 which is addressed by Chapter 12 of Working Group III's Fourth Assessment Report (IPCC, 2007) and Chapter 4 of
46 its Fifth Assessment Report, including attention to equity issues.

47
48 In general terms, mitigation is important for sustainable development in two ways. First, it reduces the rate and
49 magnitude of climate change, which reduces climate-related stresses on sustainable development, including effects
50 of climate extremes and extreme events (IPCC SREX, 2012). For example, many smaller developing nations argued
51 at UNFCCC COP 15 in Copenhagen in December 2009 that stabilizing the global atmospheric concentration of
52 carbon dioxide at 450 parts per million (ppm) projected to result in a 2°C increase in global mean temperature),
53 which appeared to be the goal of many larger countries, would mean unacceptable impacts on their prospects for
54 sustainable development; in fact, some low-lying island nations would cease to exist in the face of the eventual sea-

1 level rise that would be implied by that concentration level. For these countries, any concentration level above 350
2 ppm (projected to result in a 1.5°C increase), was considered simply unacceptable (Liverman and Billett, 2010). In
3 this sense, mitigation is a critically important part of climate change risk management (Washington et al., 2009).

4
5 Second, trajectories for technological and institutional change in order to reduce net GHG emissions interact with
6 development pathways. In some cases, national strategies to promote low-carbon growth (e.g., Table 20-1) may be
7 congruent with development transformations such as green growth strategies, for instance by reducing local and
8 regional air pollution, enhancing prospects for development transformations, and encouraging broader participation
9 in development processes. In other cases, such effects as higher energy prices associated with transitions from fossil
10 fuels to renewable energy sources have the potential to have adverse effects on local and regional economic and
11 social development (IPCC SRREN, Chapter 9). The challenge for climate-resilient pathways is to identify and
12 implement mixes of technological options that reduce net carbon emissions and at the same time support sustained
13 economic and social growth. For example, such strategies as increasing carbon uptakes in the soil through better
14 agricultural management practices can improve soil water storage capacity and also reduce the workload of women,
15 and practices such as conservation tillage can also increase water retention in drought conditions and help to
16 sequester carbon in soils.

17
18 [INSERT TABLE 20-1 HERE

19 Table 20-1: Examples of national plans for low carbon growth (Araya, 2010).]

20
21 However, mitigation and development also interact in a third fundamental way in that different groups and
22 countries' ability to implement mitigation critically depends on their 'mitigative capacity' (Yohe, 2001), that is, their
23 "ability to reduce anthropogenic greenhouse gas emissions or enhance natural sinks" or the "skills, competencies,
24 fitness, and proficiencies that a country has attained which can contribute to GHG emissions mitigation" (Winkler et
25 al., 2007). Here, many of the determinants of mitigative capacity are fundamentally shaped by different countries'
26 level of development, including their stock of human, financial and technological capital, such as the ability to pay
27 for mitigation; the cost of available abatement opportunities; the regulatory effectiveness and market rules; the
28 education and skills base; the suite of mitigation technologies available; the ability to absorb new technologies, and
29 the level of infrastructure development.

30 31 32 **20.3.2. Adaptation**

33
34 Adaptation is the subject of four chapters of this Working Group II Fifth Assessment Report (14-17), to which the
35 reader is referred for comprehensive descriptions of concepts, options, strategies, and examples of adaptation
36 practices.

37
38 Two decades ago, climate change adaptation was a lower priority than climate change mitigation. First, some
39 interested parties were concerned that attention to adaptation reduced an essential emphasis on mitigation, thereby
40 increasing the likelihood of substantial climate change. In addition, it was assumed that the impacts of climate
41 change would emerge slowly over time and could be dealt with piecemeal, as they appeared. It was also assumed
42 that adaptation was largely local and could thus be managed at national level or lower, with some financial
43 assistance for the most vulnerable countries. Both of these assumptions are now recognized as too limited (e.g.,
44 Pielke and Sarewitz, 2011). Climate change has been swifter than initially anticipated. Impacts are already being
45 observed and greenhouse gas emissions and atmospheric concentrations continue to rise, while the projections imply
46 a significantly more rapid emergence of enhanced climate risks. In short, the reality of substantial and no longer
47 avoidable climate change has been recognized at an international level (IPCC, 2007; IPCC SREX, 2012).

48
49 Historically, global climate change impact and adaptation research has often been predicated on a global mean
50 surface temperature increase of plus 2 degrees Celsius (e.g., Richardson et al., 2009; UK Royal Society, 2011),
51 although other scenarios have been considered as well (IPCC, 2007). Recent trends in GHG emissions and
52 projections of climate futures, however, are suggesting that it may be more realistic to ask what adaptation would
53 mean if the average temperature increase is 4 degrees or more (e.g., Auerswald, Konrad, and Thum, 2011; Smith et
54 al., 2011). If so, adaptation cannot be limited to gradually emerging responses at national and sub-national scales;

1 impacts of climate change will be serious and widespread, demanding adaptive measures to match. Adaptation can
2 include incremental changes that are relatively inexpensive because they offer co-benefits for other development
3 objectives, but adaptation may also require considering transformational changes, in which potentially impacted
4 systems move to fundamentally new patterns, dynamics, and/or locations (Schipper, 2007; Kates, Travis, and
5 Wilbanks, 2012). In both cases, desirable adaptation strategies are likely to vary according to climate change threat,
6 location, impacted system, the geographical scale of attention, and the time frame of strategic risk management
7 planning (Heltberg, Siegel, and Jorgensen, 2009; Thomalla et al., 2006; NRC, 2010a).

8
9 Effective and efficient adaptation choices vary from place to place according to local circumstances. There is no
10 single measure for adaptation on a global scale in the way that mitigation can be measured by emissions and
11 concentrations. But it is crucial for sustainable development and for climate resilience that the world community of
12 nations as a whole be effectively adaptive. Successful adaptation in any one place or region does not mean, of
13 course, that such places or regions would be immune to the impacts of climate change, because lack of adaptive
14 capacity in one place or region will inevitably spread to some degree to other regions, such as neighboring regions
15 where transboundary effects will be felt and also in distant places by interconnections through world trade and other
16 economic and social linkages (NRC, 2010a). For example, where food production is adversely affected, this may
17 result in higher global prices and/or increases in poverty, disease, and migration affecting distant places.

18
19 A pathway that includes sustainable and resilient climate change adaptation is one that contains a number of
20 components in order to avoid maladaptive or unsustainable pathways/practices. Climate resilient adaptation
21 pathways can ensure or promote food and water security, human health, and air and water quality and natural
22 resource management, while promoting gender equality. By selecting environmentally friendly materials; promoting
23 energy, water and other resource conservation; promoting re-use and recycling; minimizing waste generation;
24 protecting habitat and addressing needs of marginalized groups (Bizikova et al., 2008), adaptation can contribute to
25 double win or even triple win options that promote resilience and a diverse array of development goals.

26
27 In any case, the challenges for climate-resilient pathways include enhancing adaptive capacity, so that systems at
28 risk can assess vulnerabilities and respond to reduce risks, and providing adaptation options: technological,
29 institutional, and financial (Wilbanks et al., 2007). Adaptation can be vitally important in reducing stresses on
30 development processes, especially in vulnerable areas, it can help to promote and support sustainable development
31 (see Box 20-5), and it can stimulate participative social processes. For example, in many cases climate change
32 adaptation planning is encouraging communities to think more clearly about broader sustainable development goals
33 and pathways (NRC, 2010a). On the other hand, it is clear that some potential adaptations might not lead to
34 equitable and sustainable outcomes (Thomas and Twyman, 2005; Eriksen et al., 2011; Eriksen and Brown, 2011; K.
35 Brown, 2011). Moreover, adaptation at one scale may negatively affect vulnerability in another. For example, in
36 Vietnam, policies for forestry protection and the construction of electric dams while benefiting low land areas (by
37 regulating flooding) have critically constrained the access to land and forest products to mountain populations,
38 decreasing their adaptive capacity (Beckman, 2011).

39
40 _____ START BOX 20-5 HERE _____

41 42 **Box 20-5. Case Studies from China**

43
44 Water-saving irrigation has enhanced the climate change adaptation capacity, improved ecosystem services, and
45 promoted regional sustainable development in China.

46 47 *Water-Saving Irrigation Measures in Cropland Adaptation to Climate Change*

48
49 For sustainable development in developing countries, facing impacts of climate change, low-carbon emission
50 strategies and effective adaptation to climate change are especially important. Water-saving irrigation is one
51 effective measure to deal with the water scarcity and food security issues caused by climate change (Hanjra et al,
52 2010; Tejero et al., 2011). Given an increase in non-agricultural water use, China's agriculture could be faced with a
53 situation of severe shortages of water resources (Xiong et al, 2010). The saved water was expand the irrigated
54 cropland by 3.80-7.80 Mhm² and increased grain production by 14.68-30.15 Mt, ensured one year grain needs of 73-

1 151 million people in 2009 (Zou et al., 2011). It is also estimated that the performance of water-saving irrigation
2 from 2007-2009 saved about 61.81-129.66 Bm³ of water and 9.59-20.85 Mt of standard coal and reduced 21.83-
3 47.48Mt CO² emissions (Table 20-2). Therefore, water-saving irrigation has a positive significance in dealing with
4 climate change and sustainable development (Zou et al., 2011).

5
6 [INSERT TABLE 20-2 HERE

7 Table 20-2: Effectiveness of water-saving irrigation dealing with climate change (Zou et al., 2011).]

8 9 *Water-Saving Irrigation Measures in Alpine Grassland for Adapting to Climate Change*

10
11 Northern Tibet is the headwater region for the Yangtze, Nu (Salween River), Lancang (Mekong River), and
12 numerous other rivers and high mountain lakes (Gao et al., 2009). Sustaining the environmental conditions in the
13 region is of vital importance not only for Tibet but also for the whole China. Being a fragile ecosystem, the alpine
14 grassland ecosystem in Northern Tibet is extremely sensitive to climate change and human activity. In recent years,
15 the rise in precipitation and temperature results in the melting of glaciers and expansion of inland high mountain
16 lakes, and affect the alpine grassland degradation with diverse annual fluctuations in Northern Tibet (Ga et al.,
17 2010). Among the many of grassland protection measures, alpine grassland water-saving irrigation measures could
18 be reasonable to redistribute and make full use of the increased precipitation and lake water in the dry period, which
19 would be reduce the negative effects of climate change and make full use of favourable conditions (EBNCCA,
20 2011). The results of three-year demonstration of alpine grassland water-saving irrigation measures showed that
21 alpine grassland yield increased nearly 2 times (Figure 20-2) while the plant species increased from 19 to 29,
22 helping to protect and restore the alpine grassland ecosystem and ecosystem services and to promote the regional
23 socio-economic sustainable development in Northern Tibet (Gao et al., forthcoming).

24
25 [INSERT FIGURE 20-2 HERE

26 Figure 20-2: The demonstration of alpine grassland water-saving irrigation measures for adaptation to climate
27 change in Northern Tibet.]

28
29 _____ END BOX 20-5 HERE _____

30 31 32 **20.3.3. Integrating Climate Change Adaptation and Mitigation for Sustainable Risk Management**

33
34 Recent research suggests that adaptation is likely to be more effective when it is designed and implemented in the
35 context of other interventions within the broader context of sustainability and resilience (Wilbanks and Kates, 2010),
36 and the same is often true for mitigation. Moreover, studies focusing on the intersection between sustainable
37 development and climate policy point out that integration between the two is a desirable although complex path
38 (Halsnaes, Shukla and Garg, 2008; Wilson and McDaniels, 2007; Ayers and Huq, 2009). Wilson and McDaniels
39 (345) argue that the reasons to integrate across adaptation, mitigation and sustainable development are
40 straightforward because (1) many dimensions of the *values* that are important for decision-making are common to
41 all three decision contexts; (2) impacts from any one of the three decision contexts may have important
42 *consequences* for the other contexts; and (3) the *choice among alternatives* in one context can be a means for
43 achieving the underlying values important in the other contexts.

44
45 Integrating mitigation and adaption in a development context is complicated by the facts that the distribution of costs
46 and benefits is different (e.g., mitigation benefits more global, adaptation benefits often more localized), the research
47 and policy discourses are often unrelated, and the constituencies and decision-makers are often different (Wilbanks
48 et al., 2007). In many cases, the challenge of bringing the entire range of issues and options into focus – seeking
49 synergies and avoiding conflicts – is most likely to come into focus in discussions of climate change responses and
50 development objectives in places: localities and small regions (Wilbanks, 2003). In such contexts, a challenge is to
51 reconcile practices that make resources available for mitigation efforts only for reducing emissions beyond that
52 which would have occurred without those resources, while it has been suggested that access to resources for
53 adaptation efforts should recognize the critical role of *co-benefits*, or the positive effect in supporting development

1 in other ways while at the same time reducing vulnerabilities to climate change impacts (NRC, 2010a; also see
2 section 20.3.3).
3

4 The choice of a climate-resilient development pathway varies according to the circumstances of each locality. In the
5 more highly vulnerable countries, adaptation may be seen as the highest priority because there are immediate
6 benefits to be obtained by reducing vulnerabilities to current climate variability and extremes as well as future
7 climate changes. In the case of more highly developed countries, adaptation initiatives have often been seen as a
8 lower priority because there is abundant adaptive capacity and because, in some cases, losses from climate
9 variability and extremes have been less salient. Mitigation may be seen as a higher priority for those countries which
10 contribute the larger proportion of GHG emissions, where their actions can significantly reduce total global
11 emissions.
12

13 As indicated above, one emerging strategy to integrate between climate and development policies is the design of
14 “triple-win” interventions that seek to achieve an appropriate mix of mitigation and adaptation within the context of
15 sustainable development, although potentials for such triple wins may be limited (Swart and Raes, 2007). When
16 integrating across these three goals, decision-makers often need to address issues of scale, complex relationships
17 between ends and means, uncertainty and path dependencies, institutional complexity and insufficient opportunities
18 (Klein, Schipper, and Desai, 2005; Tol, 2004; Wilson and McDaniels, 2007). They must also consider the possibility
19 of ancillary and co-benefits, complementarities and potential trade offs, opportunity costs, and unknown negative
20 and positive feedbacks (for example interaction among options and paybacks: NRC, 2010a; Kok, et al., 2008;
21 Wilbanks and Sathaye, 2007; Swart and Raes, 2007; Rosenzweig and Tubiello, 2007; IPCC, 2007: Chapter 18). For
22 example, in Bangladesh, waste-to-compost projects contribute to mitigation through reducing methane emissions; to
23 adaptation through soil improvement in drought-prone areas; and to sustainable development through the
24 preservation of ecosystem services (Ayers and Huq, 2009). In synthesizing evidence from a series of empirical
25 articles focusing on the intersection between mitigation and adaptation (M&A), Wilbanks and Sathaye (2007: 958)
26 argue that M&A pathways might be alternatives in reducing costs, complementary and reinforcing to each other
27 (e.g., improvements in building energy efficiency), or competitive and mutually contradictory (e.g., coastal
28 protection vs. reductions in sea level rise).
29

30 There is also growing research focusing on the relationship and feedbacks (trade-offs and complementarity) between
31 mitigation and adaptation in different sectors, including energy, e.g. to what extent the siting of nuclear power plants
32 might constrain future adaptation to sea-level rise (Kopytko and Perkins, 2011) or how the production of biofuels
33 might affect local adaptation (La Rovere, Avzaradel and Monteiro, 2009); agriculture and water (Rounsevell et al.,
34 2010; Turner et al., 2010; Rosenzweig and Tubiello, 2007; Falloon and Betts, 2010; Shah, 2009); conservation
35 (Rounsevell et al., 2010; Turner et al., 2010); use of mitigation programs to finance adaptation (Hof et al., 2009);
36 and the urban environment (Biesbroek, Swart, and van der Knaap, 2009; Hamin and Gurrán, 2009; Roy, 2009;
37 Romero-Lankao et al., 2011).
38

39 Swart and Raes (2007) suggest a number of factors that should be taken into consideration when evaluating
40 combined adaptation and mitigation policy designs, including: (1) *avoiding trade-offs* - when designing policies for
41 mitigation or adaptation, (2) *identifying synergies*, (3) *enhancing response capacity*, (4) *developing institutional*
42 *links* between adaptation and mitigation - e.g. in national institutions and in international negotiations, and (5)
43 *mainstreaming* adaptation and mitigation considerations into broader sustainable development policies.
44
45

46 **20.3.4. Third Climate Change Response Option: Geoengineering** 47

48 If climate change mitigation is not successful in moderating the rate of increase in GHG emissions, and if climate
49 change adaptation is not successful in coping with the resulting impacts without socially unacceptable pain and
50 distress, policymakers may be faced with the question: what do we do now?
51

52 A third option is geoengineering: intentional large-scale interventions in the earth system either to reduce the sun’s
53 radiation that reaches the surface of the earth or to increase the uptake of carbon dioxide from the atmosphere. An
54 example of the former is to inject sulfates into the stratosphere. Examples of the latter include facilities to scrub

1 carbon dioxide from the air and chemical interventions to increase uptakes by oceans, soil, or biomass (UK Royal
2 Society, 2009).

3
4 Discussions of geoengineering have only recently become an active area of discourse in science, despite a longer
5 history of efforts to modify climate (Schneider, 1996, 2009; Keith, 2000). Many of the possible options are known
6 to be technically feasible, but their side-effects are exceedingly poorly understood (NRC, 2010b). For example,
7 interventions in the atmosphere might not be unacceptably expensive, but they might affect the behavior of such
8 earth systems as the Asian monsoons (Robock et al., 2008; Brovkin et al., 2009). Interventions to increase uptakes,
9 such as scrubbing carbon dioxide from the earth's atmosphere, might be socially acceptable but economically very
10 expensive. Moreover, it is possible that optimism about geoengineering options might invite complacency regarding
11 mitigation efforts (Barrett, 2008).

12
13 In any case, implications for sustainable development are largely unknown. Even though some advocates argue that
14 geoengineering is needed now, in order to avoid irreversible impact such as the loss of ocean corals, the general
15 view is that this is a research priority rather than current decision-making option (NRC, 2010b). The challenge is to
16 understand what geoengineering options would do to moderate global climate change – and also to understand what
17 their ancillary effects might be – so that, if policymakers find some decades from now that social responses to
18 climate change have not been sufficient to avoid severe disruptions and, as a result, there is a need to consider rather
19 dramatic technology alternatives, our understanding of potential costs and benefits for sustainable development is far
20 better than it is now.

21 22 23 **20.4. Contributions to Resilience through Sustainable Development Strategies and Choices**

24
25 Although climate change responses can contribute significantly to climate-resilient development pathways, some of
26 the key elements of resilience lie in sustainable development pathways themselves, which can make resilience either
27 more or less achievable. Examples of ways that development strategies and choices can contribute to climate
28 resilience include clarifying objectives of sustainable development, considering determinants and potentials for
29 resilience, being capable of resolving tradeoffs among economic and environmental goals (e.g., Bamuri and
30 Opeschoor, 2007), assuring effective institutions in developing, implementing, and sustaining resilient strategies,
31 and enhancing the range of choices through innovation (e.g., Hallegatte, 2009; Chuku, 2009).

32 33 34 **20.4.1. Clarifying Objectives of Sustainable Development**

35
36 One way that sustainable development pathways can contribute to climate resilience is by pursuing consumption
37 patterns that assure social and economic development without being wasteful of natural resources and the
38 environment. It is possible that if, rather than letting consumption be driven by familiar patterns of resource
39 demands, the desired objectives of consumption might be met in ways that require lesser quantities of resources and
40 produce lesser quantities of environmental emissions (Kates, 2000; also see Leiserowitz, Kates, and Parris, 2005).

41
42 Overall, development is a means to social and economic ends, not (usually) an end in itself; the objective is to
43 develop in order to increase the abundance and reliability of services that are important to well-being, such as food,
44 shelter, productivity, and enjoyment (Sen, 1999; Morgan and Farsides, 2009). For example, we do not develop
45 improved energy systems because we want to consume kilowatts of electricity for their own sake; we consume them
46 because they deliver comfort, convenience, and other qualities that we desire (Von Bernard and Gorbaran, 2010).
47 Within the context of a changing climate, continued use and unlimited expansion of the limited resources of this
48 planet does not seem consistent either sustainable development or climate resilient development (Ehrenfeld, 2008;
49 Gilbert, 2006; also see Victor, 2008 and Victor and Rosenbluth, 2007).

50
51 There is a growing debate about economic growth and material consumption. Sustainable development is all about
52 lifestyles and ways of life, which in turn is associated with – but not necessarily defined by -- the consumption of
53 natural and material resources (e.g., Easterlin, 1974 and 2001). One point of view in social research suggests that
54 ever-increasing material consumption does not necessarily bring greater happiness or satisfaction or material

1 comfort (DeLeire and Kalil, 2010; Cafaro, 2010; Huesemann, 2006). On the other hand, in many cases growth in
2 consumption, especially among populations with incomes rising from low levels, is often greatly beneficial (Clark,
3 Frijters, and Shields, 2008; and Deaton, 2008). Measuring social welfare as a dimension of sustainable development
4 that is not entirely captured by monetary income and level of consumption remains both a challenge and a need
5 (Dolan and White, 2007; Fleurbaey, 2009).

6 7 8 *20.4.2. Considering Determinants and Potentials for Resilience in the Face of Serious Threats*

9
10 A second contribution might be made by pursuing sustainable development pathways that are resilient in the face of
11 a wide range of serious threats: e.g., threats of economic downturns, threats of pandemics, and threats of
12 technological and/or non-climate environmental disasters as well as threats of climate-related extreme weather
13 events.

14
15 Resilience is rooted in capacities to identify threats to human and natural systems, to take actions to reduce those
16 threats, to respond in the event of a threat, and to recover after a threat in ways that make the systems stronger
17 (e.g., Wilbanks and Kates, 2010; Young, 2010). It includes access to information and planning tools, but it is more
18 fundamentally linked to social dynamics that enable problem identification and problem-solving in effective ways,
19 including in the event of surprises or multi-hazard contingencies (e.g., Schipper and Pelling, 2006).

20
21 Resilience is an issue for systems at all scales, from national to local, often focused on community activities
22 supported by appropriate policies and resources at larger scales but also depending on values and actions of
23 individuals. “Resilience thinking” (Walker and Salt, 2006) may provide a useful framework to understand the
24 interactions between climate change and other challenges, and in reconciling and evaluating trade-offs between short-
25 term and longer-term goals in devising response strategies (IPCC SREX, Chapter 8). Resilience thinking suggests a
26 move “away from policies that aspire to control change in systems assumed to be stable, towards managing capacity
27 of social-ecological systems to cope with, adapt to and shape change” (Folke, 2006, p. 254). At the current state of
28 science, however, at least for applications to development rather than ecological change and risk management, it is
29 more of a conceptual construct than an operational goal: e.g., although research is under way to develop indicators of
30 resilience, it remains very difficult to measure the resilience of a community or system in order to monitor changes
31 through time; it is difficult to assess how resilience at one geographical or temporal scale relates to other scales; and it
32 is not yet clear what resilience means for situations faced with threats that seem to require transformational change if
33 development is to be sustained (e.g., Miller et al., 2010).

34
35 What does seem clear is that relatively severe climate change is likely to pose needs for transformational changes in
36 systems and societies in order to sustain development. Transformational change can be defined as fundamental
37 changes in the composition or structure of a system and/or of its location (IPCC SREX, Chapter 8; Pelling, 2010;
38 Schipper, 2007; O’Brien, 2011). Because it involves changes in values and structures, and therefore both winners
39 and losers, transformational change is often difficult to initiate and sustain. Factors that – where they exist – improve
40 prospects for both initiating and sustaining such major paradigm-shifting actions include (a) external drivers such as
41 dramatic focal events that catalyse attention to vulnerabilities, the presence of other sources of stress that also
42 encourage considerations of major changes, and supportive social contexts such as the availability of understandable
43 and socially acceptable options, access to resources for action, and the presence of incentives and (b) internal drivers
44 related to effective institutions and organizations, such as adaptive management, learning, innovation, and leadership
45 (IPCC SREX, Chapter 8).

46
47 In many cases, transformational changes include looking for strategies that allow people to remain where they
48 currently live and work. If transformational change does not take place within the relevant time frame, countries will
49 be called on to identify resettlement strategies that protect people’s lives and livelihoods. In the case of areas where
50 habitable land becomes acutely scarce—such as small island developing countries—it may be necessary to identify
51 appropriate admissions policies in potential destination countries (Martin, 2010; UNHCR, 2011; Leighton et al.,
52 2011; Leighton, 2011).

1 In many ways, such societal responses to environmental stresses as human migration are examples of intersections
2 of sustainable development pathways and the stresses themselves that lead to transformational change. Climatic
3 variability and shifts are already affecting some human mobility patterns (Jäger et al., 2009; de Sherbinin et al.,
4 2011). National adaptation plans from least developed countries repeatedly indicate that loss of habitat and
5 livelihoods could precipitate large-scale migration, particularly from coastal areas that may be affected by rising sea
6 levels and from areas susceptible to increased drought, flooding or other environmental hazards that affect
7 agriculture (Martin, 2010). Several existing plans give examples of migration already occurring in relation to
8 climatic processes combined with other drivers for development. Some movements relate to human migration as a
9 traditional mechanism to manage weather variability. But, increasingly, evidence-based research notes that
10 migration is occurring as a widespread phenomenon related to food and livelihood insecurity (Massey, 2007;
11 Warner et al., 2010; Warner et al., 2009; see Table 20-3).

12
13 [INSERT TABLE 20-3 HERE

14 Table 20-3: The link between scarcity of resources, environmental degradation, and migration for resource
15 dependent communities.]

16 17 18 **20.4.3. Resolving Tradeoffs among Economic and Environmental Goals**

19
20 Clearly, sustainable development pathways are very likely to be more climate-resilient if they develop and utilize
21 socioeconomic and institutional structures that are effective in resolving tradeoffs among economic and
22 environmental goals.

23
24 There is a longstanding assumption that economic growth is in conflict with environmental management (Victor and
25 Rosenbluth, 2007; Hueting, 2010). Much of this thinking can be traced back to Malthus and his assertions that
26 population growth (and associated consumption) would expand at a geometrical rate until the limits of the earth's
27 capacity were reached (Malthus, 1798). The very idea of sustainable development itself springs from a need to
28 respond to such Malthusian ideas. The views expounded in the Brundtland Report, for example, are that
29 development should not be unconstrained but it should be modified into a "sustainable" form (WCED, 1987). More
30 recently arguments have emerged to support the more radical idea that (far from being antithetical) economic growth
31 and environmental quality (protection) are mutually reinforcing (Lovins, 2011). Unlimited damage to the
32 environment and development that is therefore unsustainable can be the result of unconstrained economic growth
33 (WCED, 1987), but it can also be the result of poverty. Poorer countries that are seeking to develop as a way of
34 reducing poverty often do so to the neglect of environmental quality (e.g., air and water pollution and land
35 degradation). But as such societies develop and have more disposable wealth, continued growth can be seen to be
36 more compatible with environment, including opportunities to invest in cleaner energy technologies (Bradshaw et
37 al., 2010; Duraiappah, 1998; Finco, 2009; Broad, 1994; Daly and Cobb, 1989). Some theories of ecological
38 modernization have, however, been criticized as responses to acute and urgent risks because of a lack of marketable
39 technological solutions and because there tends to be a rebound effect whereby growth processes offset incremental
40 environmental improvements (Jänicke, 2008; Bailey et al., 2011).

41
42 Sustainable development therefore depends on effective and equitable mechanisms for dealing with inevitable
43 tradeoffs among various social goals, and the development and implementation of climate-resilient pathways are
44 deeply imbedded in such tradeoffs (Boyd et al., 2008). The nature of such tradeoffs varies with different levels of
45 development. Examples of concepts related to tradeoffs are multi-metric valuation and co-benefits:

- 46 • *Multi-metric valuation.* In evaluating development pathways, there are often needs to combine a number of
47 dimensions associated with different valuation metrics and information requirements, such as monetary
48 measures of returns and non-monetary metrics of risk. Fields ranging from aquatic ecology to risk
49 assessment and financial management have developed tools for such complex valuations, including
50 graphical mapping (e.g., Rose, 2010) and the construction of multi-metric indexes (e.g., an index of "biotic
51 integrity": Johnston et al., 2010). More commonly in collective decision-making, however, analytical-
52 deliberative group processes (NRC, 1996) are used to evaluate, weight, and combine different dimensions
53 and metrics qualitatively.

- 1 • *Co-benefits*. An issue in both climate and development policy, related in some cases to access to financial
2 support (e.g., Miller, 2008), is the fact that a specific resilience-enhancing action is often likely to have
3 benefits for both development and for addressing concerns about climate change. Mitigation policy has
4 commonly adopted the concept of “additionality,” which takes the position that financial support should be
5 limited to those climate change response benefits that are *in addition to* what would be happening in
6 development processes otherwise (e.g., Muller, 2009). A co-benefits approach, on the other hand, takes the
7 position that actions which benefit *both* development and climate change responses simultaneously should
8 be encouraged and that a combination of both kinds of benefits should increase the attractiveness of a
9 proposed action (<http://www.kyomecha.org/cobene/e/cobene.html> -- accessed 10/6/11). For example,
10 mechanisms such as REDD are designed to achieve both carbon emissions reduction and to benefit
11 livelihoods of those living in forested areas. However, empirical research shows that the evidence of the
12 correlation between carbon storage and livelihoods benefits is mixed (Chhartre and Agrawal, 2009). Tools
13 for analyzing such issues are associated with research on “externalities” (e.g., Baumol and Oates, 1989),
14 but participative planning and decision-making usually incorporate a co-benefits perspective as a matter of
15 course.

16
17 In practice, tradeoff issues may or not be resolved in coherent ways. In many cases, resolutions emerge through
18 untidy social processes of evolution and attrition, reflecting dynamics of values, power, control, and surprises, rather
19 than through formal analysis. In some cases, tradeoffs are addressed with the assistance of scenario development, the
20 creation of descriptive narratives, and other projections of future contingencies (IPCC SREX: Chapter 8), along with
21 participative vulnerability assessments (NRC, 2010a).

22 23 24 **20.4.4. Assuring Effective Institutions in Developing, Implementing, and Sustaining Resilient Strategies**

25
26 Climate resilience will benefit from institutions that are effective and sustainable in the face of a wider range of
27 challenges for problem-solving and issue resolution as well. Transformative action and change in integrating
28 sustainable development within a framework of climate resilient pathways is in fact rooted in strong and viable
29 institutions and within an institutional context that adaptively manages the allocation of resources and processes of
30 change. Institutions at different levels have for long periods gone through different societal pressures and challenges
31 relating to environmental change. Local institutions are particularly adroit in coping with multiple changes. These
32 changes have forced them to rethink their institutional arrangements and make adjustments that will allow them to
33 cope with the multiple vulnerabilities they face. According to Agrawal et al, organizational mechanisms are central
34 to building linkages between local level adaptation action and national level planning. However, in six cases studies
35 in west and Latin America, they argue that these connections are missing in almost all the countries under study, and
36 external policy support can catalyze adaptation action through three types of intervention mechanisms— information,
37 incentives, and institutions. (Agrawal A., R. Mearns, and N. Perrin, 2011). The assumption is that fundamental
38 social transformation is often needed in order to achieve sustainable development and processes of maladaptation
39 (Eriksen and Brown, 2011), The term “institutions” is not necessarily limited to formal structures and processes, but
40 can also refer to the rules of the game as well as the norms and cultures that underpin environmental values and
41 belief systems. Ostrom (1986) defines institutions as the rules defining social behavior in a particular context, the
42 action arena. Institutions define roles and provide social context for action and structure social interactions
43 (Hodgson, 2003). Definitions of sustainability are largely shaped by institutional values, cultures and norms.
44 Institutions also critically define our ability to govern and manage the resources and systems that shape adaptation,
45 mitigation and sustainable development. Adopting an adaptation and mitigation pathway requires strong institutions
46 that are able to foster an enabling environment through which adaptive and mitigative capacities can be built.

47
48 Institutions for integrated climate-resilient pathways are therefore not limited to governmental institutions; in fact, in
49 many cases a majority of the key decisions are made and implemented by non-governmental actors, from the private
50 sector to communities and families. For instance, in projects supported by the Climate Change Adaptation in Africa
51 Programme (CCAA), in both Tanzania and Morocco, local governments are providing improved seeds that are
52 drought resistant to vulnerable groups and financially supporting initiatives at community level. Consequently,
53 embarking on a climate resilient pathway may necessitate including local institutions as part of the governance
54 regime. Local institutions tend to know what is needed for effective adaptation. Similarly, as local communities

1 become more and more exposed to climate extremes and variability, they are already adapting to the negative
2 impacts of climate variability and change. However, a sustainable route depends largely on the organisational
3 capacity of vulnerable groups and their ability to translate challenges into opportunities. For instance, in Morocco,
4 where local communities have strong institutions, such as in the Tabant mountain community, they were found to be
5 adapting collectively; but where institutions were less effective and weak, as in the arid plain of Lamzoudia,
6 adaptation action was characterised by individual initiatives (Denton et al., forthcoming 2013)

7
8 Integrating across adaptation, mitigation, and sustainable development requires multilevel governance systems that
9 involve decision-making processes and actors at multiple levels (local, regional, national and global) and ‘hybrid’
10 forms of governance such as public-private partnerships, public-social partnerships (across market and communities)
11 and co-management (across state and communities) (Figure 20-3; Lemos and Agrawal, 2006; Betsill and Bulkeley,
12 2006; Paterson, 2009). Weak governance can affect the viability of political instruments such as National Adaptation
13 Programme of Actions (NAPAs). NAPAs are the most tangible political instruments vis a vis adaptation action,
14 policy and measures in least developing countries. They give national governments the license to be part of the
15 institutional “game” and to contribute to its overall design. However, in spite of this plurality of institutional actors
16 for effective governance in adaptation and mitigation, it would seem that the capacity to co-ordinate and harmonise
17 activities at several levels needs in many cases a strong state sponsored formal institution/s to support and enable
18 adaptation and mitigation initiatives.

19
20 [INSERT FIGURE 20-3 HERE

21 Figure 20-3: A Notional Depiction of Alternative Climate-resilient Sustainable Development Pathways (lower left).
22 Regarding SSP’s see Box 20-3; SSPs are representations of alternative socioeconomic pathways within which
23 climate change responses might evolve.]

24
25 Scholars have suggested that response to climate change may require a new concept of policy transitions that
26 includes “policy integration, long-term thinking for short-term action, keeping multiple options open and learning-
27 by-doing and doing-by-learning.” (Kemp and Rotmans, 2009: 303). Finally, recent literature also suggests that
28 polycentric forms of governance may be more robust and adaptable than policies implemented by a single unit of
29 government (Ostrom, 2005) and thus better suited to adaptive risk management. Understanding what relevant
30 institutional capacities exist is an important requirement for framing and supporting both adaptation and mitigation.
31 Similarly, inherent institutional weaknesses can also affect the potential for good adaptation and mitigation action to
32 take root, particularly where knowledge gaps and climate expertise are missing (Michonski and Levi, 2010).

33
34 In particular, local institutions crucially influence the ability of communities to adapt and benefit from adaptation
35 and mitigation programs in rural and urban settings (Agrawal, 2008; Chharte and Agrawal, 2009; Corbera and
36 Brown, 2008). For instance, institutions tend to play an influential role in shaping farmers’ decisions and helping
37 them make strategic choices with several implications for livelihoods and sustainable development (Agrawal, 2008).
38 However, institutional dynamics tend to ignore informal institutions and the role they play in enabling societies to
39 adapt. Informal institutions are custodian of knowledge and knowledge generation. However, often in developing
40 countries, particularly in Africa, traditional knowledge is not valorized as a reference point for managing climate
41 risks and emerging threats. In Kenya, the importance of indigenous knowledge, given increased uncertainty and
42 climate related risks have compelled national agencies such as the Kenyan Meteorological Agencies and vulnerable
43 groups such as the indigenous communities commonly known as rainmakers to form strategic reciprocal links. Both
44 groups were able to work closely together to calibrate their forecasts and test the efficacy of the results against
45 climate change impacts on agricultural productivity. Hence, the two groups have been able to demonstrate the
46 benefits of western science and traditional knowledge systems to ensure maximum (Ziervogel and Opere, 2010).
47 Integrating meteorological and indigenous knowledge-based seasonal climate forecasts in the agricultural sector. In
48 addition, participatory processes which call for a deliberative form of decision making amongst stakeholders are
49 well suited to the governance culture necessary for effective adaptation and mitigation. Scholars such as Benn have
50 found that deliberative processes of democracy provide greater efficacy in decision-making and lead to more
51 sustainable outcomes. They argue that some deliberative democracy methods can bring diverse stakeholders
52 together- lay, expert and indigenous knowledge - thus putting in place a more communicative model of science
53 (Benn, Dunphy, and Martin, 2009).

1 In addition, the complexity of different resource flows and distributional effects related to adaptation and mitigation
2 is at the heart of the sustainable development debate with numerous implications for equity and justice (O'Brien and
3 Leichenko, 2003; Roberts and Parks, 2006). Institutions are also needed to handle the large flows of funds and other
4 resources that are associated with managing and improving the delivery systems that will allow people and
5 organizations to take advantage of opportunities that will trigger a set of actions to combat the negative impacts of
6 climate change. The nature and dynamics of climate change call for institutions that are able to facilitate the
7 enhancement of adaptive capacity and 'allow society to modify its institutions at a rate commensurate with the rapid
8 rate of environmental change' (Gupta et al., 2008). Institutional 'renewal' is essential in some case to achieve a
9 degree of social cohesion and transformation. A case study in Morocco, under the Climate Change Adaptation in
10 Africa (CCAA), showed that the 'Cellule de Littoral', created to serve as a consultative committee on coastal
11 development in Morocco, has gained some recognition at both local and national levels as it is integrated formally
12 into the institutional framework for the implementation of ICZM Plans of Action (Denton et al., forthcoming 2013).
13 Similarly, assessing vulnerability calls for an understanding of institutions, their evolutionary context, and their roles
14 in the creation and distribution of wealth. In a great many respects, poverty and uses of resources are mediated by
15 institutional factors (Kelly and Adger, 2000). For example, property rights are defined, controlled, and enforced by
16 formal institutions and structures; and institutional structures are especially important where common pool resources
17 are concerned. However, in less developed regions, vulnerability is seldom the result of single stressors, rather most
18 poor communities are double exposed to climate impacts and globalizations processes that shape their overall
19 vulnerability and adaptive capacity (O'Brien et al., 2004).

20
21 Common problems with institutional roles include:

- 22 • (An) incompatibility of current governance structures with many of those that are likely to be necessary for
23 promoting social and ecological resilience' and the fact that 'adaptive ecosystem management overturns
24 some major tenets of traditional management styles which have in many cases operated through exclusion
25 of users and the top-down application of scientific knowledge in rigid programmes.' (Tompkins and Adger,
26 2003: 10).
- 27 • A need for stronger political will within nations and at the international level' 'to initiate and further
28 sustainable development' and overcome 'the classic "free-rider" problem'(Veeman and Politylo, 2003:
29 331).
- 30 • A lack of experience with and/or confidence in approaches to adaptive planning that incorporate rich bodies
31 of knowledge and experience regarding risk management and decision-making under uncertainty (IPCC,
32 SREX; NRC, 2010a).

33 34 35 **20.4.5. *Enhancing the Range of Choices through Innovation***

36
37 Finally, climate resilience will in most cases depend on innovation, developing new ideas and options or adapting
38 robust familiar ideas and options to meet emerging new needs and to respond to surprises. Integrated strategies for
39 climate-resilient strategies need not be limited to currently available policies, practices, and technologies. In many
40 cases, as indicated in the previous section, they can benefit from considering possibilities to develop new options
41 through social, institutional, and technological innovation. For example, if a climate-resilient pathway for a
42 particular region calls for coping with greater water scarcity, innovations might consider changes in water rights
43 practices, improving the understanding of groundwater dynamics and recharge, improving technologies and policies
44 for water-use efficiency improvements, and in coastal areas the development of more affordable technologies for
45 desalination (NRC, 2010a). One key issue for risk management, therefore, is assessing needs for and possible
46 benefits from targeting innovation efforts on critical vulnerabilities.

47
48 Innovations can include both technological and social changes, which in many cases are closely related (Rohracher,
49 2008; Raven et al., 2010), as technology and society evolve together (Kemp, 1994). An important characteristic of
50 such socio-technical transitions are the interactions and conflicts between new, emerging systems and established
51 regimes, with strong actors defending business as usual (IPCC, SREX; Kemp, 1994; Perez, 2002).

52
53 Effective use of innovations depends on more than idea and/or technology development alone. Unless the options,
54 the skills required to use them, and the institutional approaches appropriate to deploy them are effectively

1 transferred from providers to users (e.g., “technology transfer”), effects of innovations – however promising – are
2 minimized (IPCC, SREX). Challenges in putting science and technology to use for sustainable development, in
3 particular, have received considerable attention (e.g., Nelson and Winter, 1982; Patel and Pavit, 1995; NRC, 1999;
4 International Council for Science, 2002; and Kristjanson et al., 2009), emphasizing the wide range of contexts that
5 shape both barriers and potentials. If obstacles related to intellectual property rights can be overcome, however, the
6 growing power of the information technology revolution could accelerate the transfer of technologies and other
7 innovations (linked with local knowledge) in ways that would be very promising (Wilbanks and Wilbanks, 2010).

10 **20.5. Toward Climate-Resilient Pathways**

11
12 In looking toward what to do in response to concerns about climate change impacts, it is useful to think both about
13 how to frame climate-resilient pathways, and about attributes that such pathways are likely to share, and about the
14 degree to which alternative pathways are available.

17 **20.5.1. Framing Climate-Resilient Pathways**

18
19 Climate-resilient pathways recognize that impacts are certain, because climate change can no longer be avoided.
20 Ignoring this source of stress will endanger sustainable development. As a result, vulnerability assessments and risk
21 management strategies are important, considering both possible/likely climate effects – extremes as well as average
22 – and also development conditions such as demographic, economic, and land use patterns and trends; institutional
23 structures; and technology development and use (IPCC, SREX).

24
25 In most cases, vulnerabilities and appropriate risk management approaches will differ from situation to situation,
26 calling for a multi-scale perspective built solidly on fine-grained contextual realities (IPCC SREX: Chapter 8). But
27 most situations share at least one fundamental characteristic: threats to sustainable development are greater if
28 climate change is substantial than if it is moderate (Wilbanks et al., 2007). With more substantial change, resilience
29 is more likely to require *transformational* adaptations: responses that change the nature, composition, and/or
30 location of threatened systems in order to sustain development (Smit and Wandel, 2006; Stringer et al., 2009; NRC,
31 2010a; Pelling, 2010; IPCC, SREX). For near term time horizons, responses are likely to emphasize climate change
32 mitigation and relatively low-cost adaptations with development co-benefits (e.g., Van Aalst, Cannon, and Burton,
33 2008; NRC, 2010a). For longer-term time horizons, responses are likely to combine the monitoring of emerging
34 impacts and threats with evaluation, learning, and contingency planning for possible needs for transformational
35 adaptations (NRC, 2010a; IPCC, SREX). But the more rapidly climate change emerges, the more likely it is that
36 actions will be needed sooner rather than later in order to assure resilience and sustainability (Stafford et al., 2010).

39 **20.5.2. Attributes of Climate-Resilient Pathways**

40
41 Climate-resilient pathways of development deliberately minimize the negative impacts of climate change. Such
42 pathways acknowledge the relationship between greenhouse gas emissions and climate change impacts, and hence
43 the importance of integrating both climate change mitigation and adaptation into sustainable development strategies.
44 One of the most challenging aspects of climate-resilient pathways is that they are rooted in distinctive local contexts,
45 but at the same time that they are shaped by external linkages that require attention and care. For example, resilience
46 cannot be achieved in a few privileged places if it is not achieved in others, because instabilities in adversely
47 impacted situations will spill over to other situations through such effects as resource supply constraints, conflict,
48 migration, or disease transmission (Wilbanks, 2009).

49
50 Consequently, if climate change continues on its current path toward relatively significant changes and impacts
51 (NRC, 2010b), resilient pathways for sustainable development will become increasingly challenging, requiring
52 explicit attention to climate change responses in virtually all regions, sectors, and systems. Sustainable development
53 will depend fundamentally on changes in social awareness and values that lead to innovative actions and practices,
54 including increased attention to both disaster risk management and climate change adaptation in anticipation of (and

1 in response to) changes in climate extremes (IPCC SREX). In most cases, such a new climate-resilient development
2 paradigm is likely to benefit from bottom-up engagement in risk management and evolving problem-solving and
3 from human development to enhance capacities for risk management and adaptive behavior (Tompkins, Lemos, and
4 Boyd, 2008).

5
6 One of the most challenging aspects of climate-resilient pathways is that they are rooted in distinctive local contexts,
7 but at the same time that they are shaped by external linkages that require attention and care. For example, resilience
8 cannot be achieved in a few privileged places if it is not achieved in others, because instabilities in adversely
9 impacted situations will spill over to other situations through such effects as resource supply constraints, conflict,
10 migration, or disease transmission (Wilbanks, 2009).

11
12 With these perspectives in mind, Box 20-6 lists a number of attributes of climate-resilient pathways for sustainable
13 development. Taken as a whole, this characterization of climate-resilient pathways may appear daunting, but in fact
14 each of the items is amenable to strategy development in appropriate national, regional, and local contexts; and
15 notable, measurable progress should be possible in a great many cases.

16 _____ START BOX 20-6 HERE _____

17 **Box 20-6. Attributes of Climate-Resilient Pathways for Sustainable Development**

18 *Awareness and capacity*

- 19 • A high level of social awareness of climate change risks
- 20 • A demonstrated commitment to contribute appropriately to reducing global net GHG emissions, integrated
21 with national development strategies
- 22 • Institutional change for more effective resource management through collective action (Tompkins, Adger,
23 2003)
- 24 • Human capital development to improve risk management and adaptive capacities
- 25 • Leadership for sustainability that effectively responds to complex challenges (Brown, 2012)

26 *Resources*

- 27 • Access to scientific and technological expertise and options for problem-solving
- 28 • Access to financing for appropriate climate change response strategies and actions
- 29 • Information linkages in order to learn from experiences of others with mitigation and adaptation

30 *Practices*

- 31 • Continuing, institutionalized vulnerability assessments and risk management strategy development and
32 refinement based on emerging information and experience
- 33 • Monitoring of emerging climate change effects and contingency planning for possible significant impacts
34 and needs for transformational responses
- 35 • Policy, regulatory, and legal frameworks that encourage and support distributed voluntary actions for
36 climate change risk management
- 37 • Effective programs to assist the most vulnerable populations and systems in coping with impacts of climate
38 change

39 _____ END BOX 20-6 HERE _____

40 **20.5.3. Alternative Climate-Resilient Pathways**

41 Does climate resilience imply one and only one pathway for sustainable development or are there alternative
42 pathways, any one of which will be resilient? Given that there are a great many alternative sustainable development
43 pathways, how does one evaluate which one or ones meet a criterion of climate resilience?

1 The concept of Shared Socioeconomic Pathways (Box 20-3) offers one framework of thought for considering this
2 question. SSPs consider alternative socioeconomic pathways according to dimensions related to both the resource
3 intensity of economic growth and the effectiveness of institutions in resolving tradeoffs (Kriegler, et al., 2012).
4 These dimensions, fundamental to sustainable development, can then be related to socioeconomic challenges
5 surrounding climate change mitigation and adaptation, with lesser or greater challenges depending on
6 socioeconomic conditions. For example, in Figure 20-3, an SSP 1 pathway has relatively limited challenges to both
7 mitigation and adaptation, while an SSP 3 pathway has very substantial challenges to both. SSP 2 has moderate
8 challenges to both adaptation and mitigation, while SSP4 is described as having high challenges to adaptation and
9 low challenges to mitigation. SSP 5 combines high challenges to mitigation with low challenges to adaptation. Any
10 pathway characterized by limited challenges to both is likely to be climate-resilient, while any pathway facing high
11 challenges is likely not to be climate-resilient. It is reasonable to suggest, then that a variety of possible pathways in
12 the lower-left portion of the figure might very well be climate-resilient, where a heavy emphasis on either mitigation
13 or adaptation capacity might somewhat reduce requirements for the other, although both would have to be
14 represented substantially in the pathway.

15
16 This view is, of course, more likely to frame climate-resilient pathways at a global or large-regional scale than at a
17 local or small-regional scale, because many localities and small regions have limited capacities to contribute to
18 climate change mitigation because their greenhouse emissions and carbon sinks are limited in magnitude. In other
19 words, at a large scale, climate-resilient pathways will include actions that promote both adaptation and mitigation
20 in a sustainable manner. At a relatively small scale, however, climate-resilient pathways will involve a range of
21 actions appropriate to differences in potentials for vulnerability and risk reduction, contributing to the cumulative
22 effect of local efforts on larger-scale aggregates.

23 24 25 **20.5.4. Implications for Current Sustainable Development Strategies and Choices**

26
27 Although payoffs from specific long-term pathways may be uncertain at this time, such uncertainties need not
28 preclude actions now. Climate-resilient development pathways are not about actions taken in the future, but rather
29 about the strategies and choices that are taken today. The range of potential climate outcomes, discussed in Box 20-
30 3, will have dramatically different implications for human security, as well as for the health and status of species and
31 ecosystems (IPCC WGII, AR5). Increasingly, the literature linking climate change to greenhouse gas concentrations
32 shows that the emissions in the coming decades will be decisive for future climate outcomes (Anderson and Bows,
33 2008; Meinshausen et al., 2009; Solomon et al., 2009). In fact, waiting to take action may reduce the range of
34 choices for climate resilient pathways in the future (NRC, 2011). The IPCC Special Report on Special Report on
35 Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX), 2012, makes
36 the case that a “solution space” exists now for considering possible strategies that would increase climate resilience
37 while at the same time helping to improve human livelihoods and social and economic well-being (Figure 20-4). It
38 suggests that a process of iterative monitoring, evaluation, learning, innovation, and contingency planning will
39 reduce climate change disaster risks, promote adaptive management, and contribute significantly to prospects for
40 climate-resilient pathways. The solution space emphasizes the linkages between different strategies, recognizing that
41 no single approach alone is likely to be sufficient. In discussing approaches to sustainability in the context of climate
42 extremes, the SREX report draws attention not only to the role of incremental change, but also to transformation,
43 which is defined as “the altering of fundamental attributes of a system (including value systems; regulatory,
44 legislative, or bureaucratic regimes; financial institutions; and technological or biological systems) (IPCC SREX, p.
45 564). Climate-resilient development pathways that deliberately address mitigation and adaptation through both
46 incremental and transformative strategies are likely to present more options for sustainable development than those
47 pathways that reactively respond to the challenges of climate change.

48
49 [INSERT FIGURE 20-4 HERE

50 Figure 20-4: The Solution Space for Current Strategies (SREX, 2012).]
51
52
53

20.6. Priority Research/Knowledge Gaps

Simply stated, the fact is that what is known about integrating climate change mitigation, climate change adaptation, and sustainable development is dwarfed by what is not known. If national and global decision-makers care about realizing potentials from a fusion of these three imperatives, then research should be a very high priority indeed. The most salient research need is to improve the understanding of how climate change mitigation and adaptation can be combined with resilient sustainable development pathways in a wide variety of regional and sectoral contexts (Wilbanks, 2010). One starting point is simply improving the capacity to characterize benefits, costs, potentials, and limitations of major mitigation and adaptation options, along with their external implications for equitable development, so that integrated climate change response strategies can be evaluated more carefully (Wilbanks et al., 2007). What are the major tradeoffs? What are the potential synergies? How do implications of integrated mitigation/adaptation strategies vary with location, climate change risks and vulnerabilities, scale, and development objectives and capacities?

Related to this general priority are at least three specific research needs:

1. Research on how to reconcile the importance of co-benefits from climate change adaptation and mitigation actions with widespread use of the concept of additionality, e.g., how to establish criteria for access to financial support for adaptation that incorporates the development importance of co-benefits.
2. Advances in conceptual and methodological understandings of, and tools to support research on, multiple drivers of development pathways and climate change impacts; possible feedback effects among mitigation, adaptation, and development; and possible thresholds/tipping points that could cause particular challenges for development (NRC, 2009, 2010a).
3. Advances in knowledge about how to respond sustainably to climate change extremes and extreme events, when and where they pose development challenges that would appear to require transformative changes in impacted human and/or environmental systems. What might the options be, and how can they be facilitated where they should be considered? (e.g., Pelling, 2010).

Further research needs include:

1. Research attention to potentials for technological and institutional innovations to ease threats to sustainable development from climate change impacts and responses. In other words, how might climate change responses represent opportunities for innovative development paths? How might technological development be part of a strategy for development/climate change response integration? (Wilbanks, 2010)
2. Research on strategies for institutional development, including improving understandings of how social institutions affect resource use (NRC, 2009), improving understandings of risk-related judgment and decision-making under uncertainty (NRC, 2009), and best practices in creating institutions that will effectively integrate climate change responses with sustainable development outcomes such as participation, equity, and accountability
3. Research on strategies for the implementation of adaptive management strategies for development. Examples of important research needs include improving the understanding of respective roles and interactions between autonomous response behavior and policy initiatives, improving the body of empirical evidence about how to implement changes that are judged to be desirable: e.g., adaptive management and governance capacity, and improving the understanding of differences between retrofitting older infrastructures (the challenge in many industrialized countries) and designing new infrastructures (the challenge in many rapidly developing countries) (IPCC SREX, Chapter 8).
4. Research on how to resolve differences between adaptation and development in ways that enable the flow of financial resources to support adaptations: e.g., how to acknowledge co-benefits in allocating investment resources without inviting every party seeking development investment to use climate change as an opportunity (NRC, 2010a).
5. Research to improve the understanding of how to build social inclusiveness into development/climate change response integration. As suggested above, research is needed on issues of social values/climate justice/equity/participation and how they intersect with the deployment of mitigation, adaptation interventions and sustainable development policy in different regional/sociopolitical contexts (IPCC SREX, Chapter 8).

6. Research on factors that influence deliberate transformations that are ethical, equitable, and sustainable (O'Brien, 2012; Kates, Travis, and Wilbanks, 2012).
7. The development of structures for learning from emerging integrated climate change response/development experience: e.g., approaches and structures for monitoring, recording, evaluating, and learning from experience, identifying “best practices” and their characteristics (NRC, 2010a; IPCC, SREX, Chapter 8).

Finally, it is very possible that progress with global climate change mitigation will not be sufficient to avoid relatively high levels of regional and sectoral impacts, and that such conditions would pose growing challenges to the capacity of adaptation to avoid serious disruptions to development processes. If this were to become a reality later in this century, one response could be a rush toward geo-engineering solutions. In preparation for such a contingency, and perhaps as an additional way to show how important progress with mitigation is likely to be in framing prospects for sustainable development in many contexts, there is a very serious need for research on geo-engineering costs, benefits, a wide range of possible impacts, and fair and equitable structures for global policymaking and decision-making (UK Royal Society, 2009; Kates, Travis, and Wilbanks, 2012).

But a fundamental aim of research to improve capacities for climate-resilient pathways for sustainable development is to avoid such an unfortunate outcome. It seeks to do so by strengthening the base of knowledge that underlies and supports effective actions by viewing climate change mitigation, climate change adaptation, and sustainable development in an integrative and mutually-supportive way.

Frequently Asked Questions

FAQ 20.1: What difference is climate change likely to make for sustainable development?

Climate change can no longer be avoided; and, added to other stresses on sustainable development, its effects – temperature increases, precipitation changes, changes in storm behavior, and sea-level rise – will make sustainability more difficult to achieve for many locations, systems, and affected populations. The challenges presented by climate change vary widely according to threat, the sensitivities of vulnerable systems, and coping capacities; but projected impacts – especially from climate extremes and extreme events – are serious for enough locations, systems, and populations to present dangers for all in this interlinked, interdependent world.

FAQ 20.2: Is it possible to find climate-resilient sustainable development pathways?

If climate change is moderate rather than substantial, climate-resilient sustainable development pathways will be possible for most locations and systems, although perhaps not for all (for instance, some especially vulnerable areas and climate-sensitive endangered species). If climate change is substantial, the threats to resilience are far more problematic, and resilience is much more likely to require transformational adaptations: responses that change the nature, composition, and/or location of threatened systems in order to sustain development.

FAQ 20.3: What are the main characteristics of a climate-resilient sustainable development pathway?

A climate-resilient sustainable development pathway combines flexibility, innovativeness, and capacities for participative problem-solving with effectiveness in mitigating and adapting to climate change. Although this is a significant challenge for any location or system, it is profoundly exacerbated by the fact that different locations and systems are often so linked with each other that a sustainable development pathway cannot be climate-resilient in its own context unless other pathways with which it is connected are also climate-resilient.

FAQ 20.4: What are the main roles of climate change mitigation and adaptation in climate-resilient sustainable development pathways?

The main role of climate change mitigation is to keep climate change and its impacts as moderate as possible. The main role of climate change adaptation is to enable a potentially impacted system to reduce its sensitivities to impacts and/or to improve its capacity to cope with stresses and disruptions. Mitigation is necessary because adaptation is more feasible with moderate climate change than with severe climate change. Adaptation is necessary because impacts are already emerging and will increase in coming decades, even if mitigation is relatively successful. But climate change responses cannot assure climate-resilient pathways unless they are accompanied by sustainable development pathways that enable effective resolution of complex nature-society tradeoffs.

1
2 **FAQ 20.5: Are there things that we can be doing now that will put us on the right track toward climate-resilient**
3 **sustainable development pathways?**

4 Although payoffs from specific long-term pathways may be uncertain, such uncertainties should not preclude
5 actions now. Doing nothing now reduces the range of choices of climate-resilient pathways in the future. Actions at
6 the present time will emphasize co- benefits (i.e., actions that reduce vulnerabilities to climate change impacts in the
7 future and that, at the same time, reduce stresses on sustainable development now) and iterative learning (i.e.,
8 monitoring emerging information about climate change effects and efforts to reduce them), with risk management
9 strategies refined continually on the basis of growing bases of knowledge and experience.

10
11
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15

Table 20-1: Examples of national plans for low carbon growth (Araya, 2010).

Country	Vision	Innovation
China	Low carbon zones to provide a laboratory for large-scale low carbon private and public investment. Europe-China collaboration to pioneer approaches compatible with Chinese institutions and development.	Low Carbon Zones build on 1980s Special Economic Zones (SEZs)
Maldives	Carbon neutrality by 2020 Climate change central development priority for government	Island with focus beyond adaptation
Mexico	Emissions peaking in 2012 and 50 percent reduction below 2000 levels by 2050 Establishment of low carbon development scenarios and priorities	2050 time horizon; peaking objectives; investment platform
South Korea	Plan to guide transition to low carbon economy 80 percent of economic stimulus package going into low carbon measures	Green recovery; public resources commitment
Japan	25% reduction in 2020 compared with 1990 level 80% reduction in 2050 compared with 1990 level Development of mid- and long-term roadmap	Mid- and long-term roadmap Subcommittee, Global Environmental Committee, Central Environmental Council

Table 20-2: Effectiveness of water-saving irrigation dealing with climate change (Zou et al., 2011).

	2007	2008	2009
Water saved (Bm ³)	19.37-40.86	19.86-41.55	22.58-47.25
Energy saved (Mt)	2.92-6.39	3.08-6.72	3.58-7.73
CO ₂ emission reduction (Mt)	6.66-14.58	7.02-15.31	8.15-17.59

Table 20-3: The link between scarcity of resources, environmental degradation, and migration for resource dependent communities.

Country	Impacts of climate change	Coping mechanism to climate variability
Ethiopia	Frequent droughts	Temporary and <i>permanent migration in search of employment.</i>
Mali	Drought	Migration from north to south within the country and towards coastal countries and the west as a spontaneous adaptation strategy.
Cape Verde	Devastating famines, frequent torrential rains	Emigration
Bangladesh	High depth of standing water which prevents crop cultivation during the Kharif season.	Migrate to cities for jobs.
Cambodia	Increased crop losses have led to increased food shortages and poor health,	Rural-urban migration and cross-border migration
Gambia	Unpredictable rainy seasons and dry spells result in lower crop yields, reduced availability of forest products, and poor animal pasture	Rural-urban migration
Guinea-Bissau	Increased pressure on the uplands as the longer dry season, particularly in countryside regions (eastern part of the country).	Displacement of whole villages
Haiti	Poverty, population growth and environmental problems.	Migration of large numbers of people from rural areas to Port au Prince.
Mauritania	Loss of livestock as result of decreased rainfall.	Massive rural exodus among livestock herders and their cessation of a nomadic lifestyle
Tanzania	Erosion and rising sea levels leading to a loss of settlements in coastal areas.	Potential adaptation activity being the relocation of these vulnerable communities to other areas

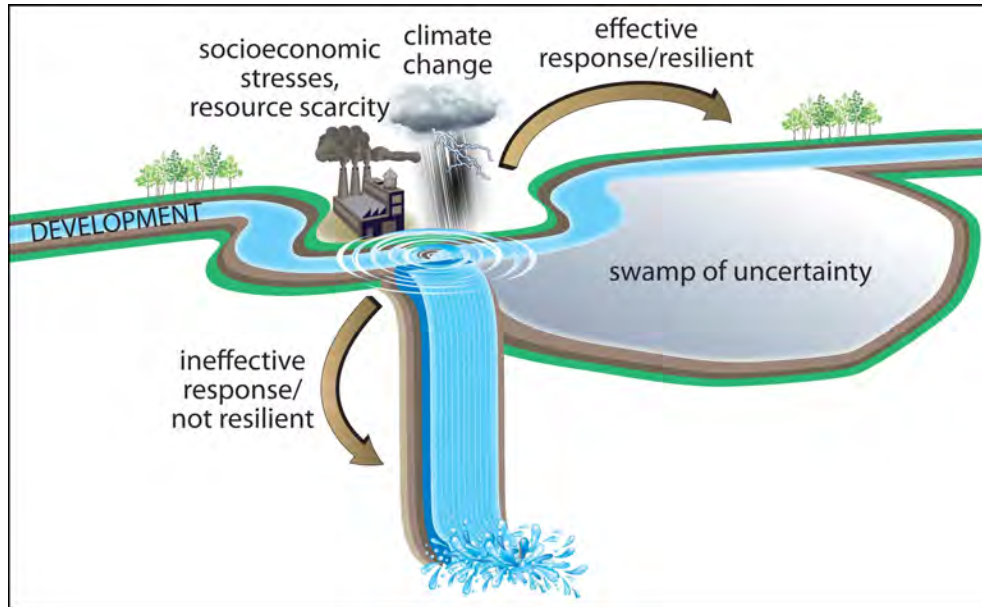
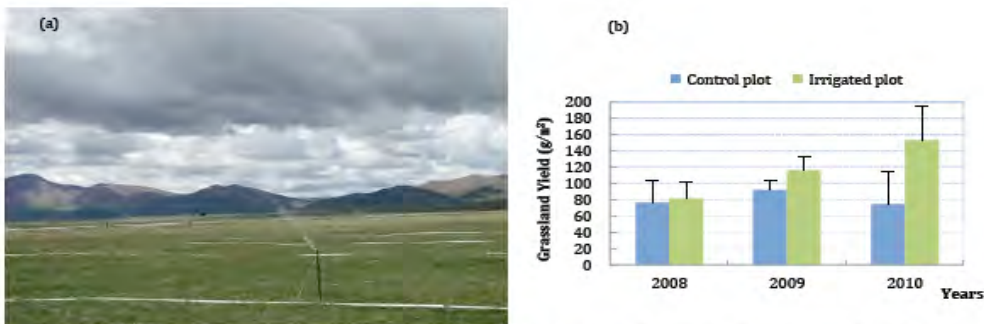


Figure 20-1: Sustainable development depends on effective responses to climate change and other stresses.



In this figure, (a) is the demonstration photo of alpine grassland water-saving irrigation; (b) is the grassland yield changes after irrigation

Figure 20-2: The demonstration of alpine grassland water-saving irrigation measures for adaptation to climate change in Northern Tibet.]

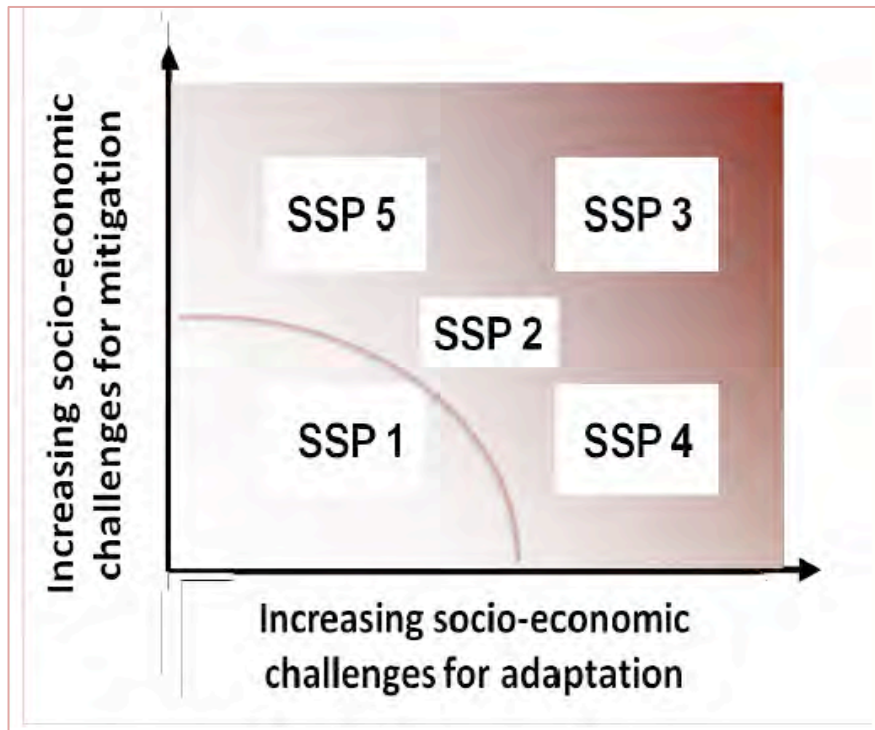


Figure 20-3: A Notional Depiction of Alternative Climate-resilient Sustainable Development Pathways (lower left). Regarding SSP’s see Box 20-3; SSPs are representations of alternative socioeconomic pathways within which climate change responses might evolve.

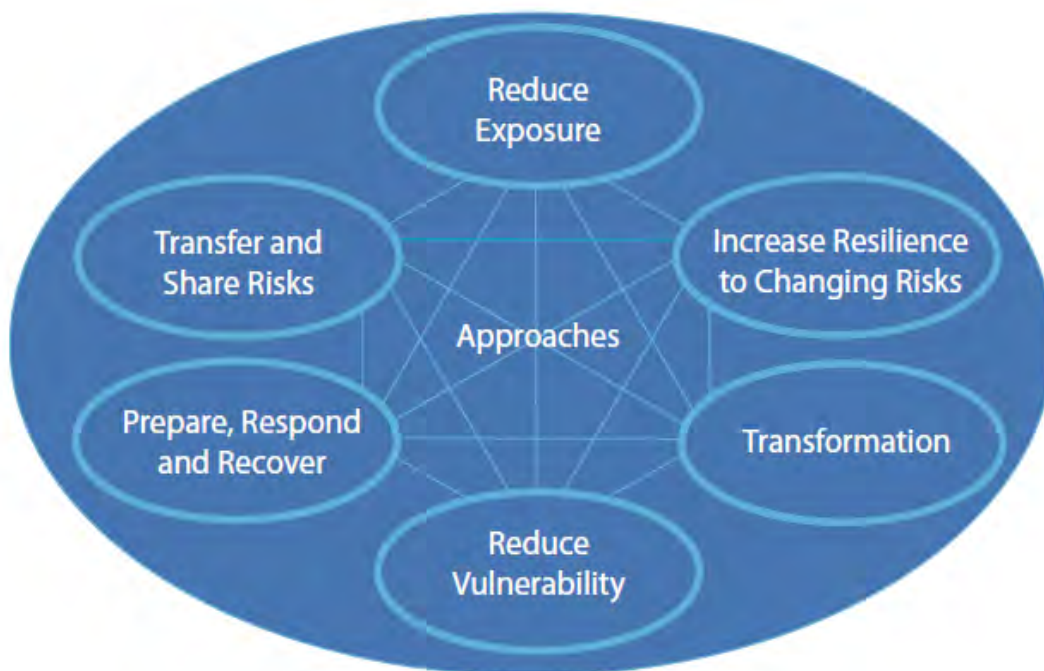


Figure 20-4: The Solution Space for Current Strategies (SREX, 2012).