

Chapter 9. Rural Areas**Coordinating Lead Authors**

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14 15 16 **Executive Summary**

17
18 There is a lack of clear definition of what constitutes rural areas, and definitions that do exist depend on definitions
19 of the urban. [9.1.2] Across the world, the importance of peri-urban areas and new forms of rural-urban interactions
20 are increasing. [9.1.3] Notwithstanding this, rural areas still account for almost half the world's population, about
21 75% of the developing world's poor people and 80% of the world's hungry. [9.1.1] Rural areas therefore are
22 important for assessing the impacts of climate change and the prospects of adaptation in these areas, constituting a
23 dynamic, spatial category. [9.1.1] A lack of focus on the rural sector in policy making increases its vulnerability to
24 climate change. [9.2]

25
26 Climate change in rural areas in developing countries will take place in the context of many important economic,
27 social and land-use trends. In different regions, rural populations have peaked or will peak in the next few decades.
28 [9.3.1] The proportion of the rural population depending on agriculture is extremely varied across regions, but
29 declining everywhere. Poverty rates in rural areas are falling more sharply than overall poverty rates, and
30 proportions of the total poor accounted for by rural people are also falling: in both cases with the exception of sub-
31 Saharan Africa, where these rates are rising. Hunger and malnutrition is prevalent among rural children in South
32 Asia and Sub-Saharan Africa. Processes of commercialisation and diversification in developing countries, and inter
33 linkages between land tenure and food policy are important drivers. Rural people are subject to multiple non-climate
34 stressors, including under-investment in agriculture (though there are signs this is improving), problems with land
35 policy, and processes of environmental degradation. In industrialized countries, there are important shifts towards
36 multiple uses of rural areas, especially leisure uses, and new rural policies based on the collaboration of multiple
37 stakeholders, the targeting of multiple sectors and a change from subsidy-based to investment-based policy. [9.3.1,
38 Table 9-1]

39
40 Cases in the literature of observed impacts on rural areas often suffer from methodological problems of attribution
41 [9.3.2], but evidence for observed impacts, both of extreme events [9.3.2.1] and other categories [9.3.2.2], is
42 increasing. Heat waves and droughts can cause severe impacts while saline intrusion, storm surges, and other coastal
43 climatic events can affect rural livelihood systems. [9.3.2.1] Climate volatility can increase poverty in developing
44 countries. [9.3.2.1]

45
46 Future impacts of climate change on the rural economic base and livelihoods, land-use and regional interconnections
47 are at the latter stages of complex causal chains that flow through changing patterns of extreme events and/or effects
48 of climate change on biophysical processes in agriculture and less-managed ecosystems. This increases the
49 uncertainty associated with any particular projected impact. [9.3.3]

50
51 Major impacts of climate change in rural areas will be felt through impacts on water supply, food security [9.3.3.1]
52 and agricultural incomes. [9.3.4.1] Migration patterns will be driven by multiple factors of which climate change is
53 only one, and projections of migration can only be tentative. [9.3.3.2.1] There will be secondary impacts of climate
54 policy, such as policies to encourage cultivation of biofuels. [9.3.3.3] In certain countries shifts in agricultural

1 production may be seen. [9.3.4.1] Price rises, which may be induced by climate shocks apart from other factors
2 [9.3.3.2.2], have a disproportionate impact on the welfare of the poor in rural areas, such as female headed
3 households and those with limited access to modern agricultural inputs, infrastructure and education. [9.3.3.1]
4

5 Valuation of climate impacts needs to draw upon both monetary and non-monetary indicators. Most studies on
6 valuation highlight that climate change impacts will be significant especially for the developing regions, due to their
7 economic dependence on agriculture and natural resources, low adaptive capacities, and geographical locations.
8 [9.3.4] The valuation of non-marketed ecosystem services [9.3.4.6] and the limitations of economic valuation
9 models which aggregate across multiple contexts [9.3.4] pose challenges for valuing impacts in rural areas.
10

11 There are low levels of agreement on some of the key factors associated with vulnerability or resilience in rural
12 areas [9.3.5.2], including rainfed as opposed to irrigated agriculture [9.3.5.2.1], small-scale and family-managed
13 farms [9.3.5.2.2], and integration into world markets. [9.3.5.2.4] There is greater agreement on the importance for
14 resilience of access to land and natural resources [9.3.5.2.5], flexible local institutions [9.3.5.2.6], and knowledge
15 and information [9.3.5.2.7], and the association of gender inequalities with vulnerability. [9.3.5.2.9]
16

17 There is a growing body of literature on successful adaptation in rural areas, including both documentation of
18 practical experience [9.4.3], and discussion of preconditions. Prevailing development constraints, such as low levels
19 of educational attainment, environmental degradation and armed conflict create additional vulnerabilities which
20 undermine rural societies' ability to cope with climate risks. [9.4.4] The supply of information for decision-making,
21 and the role of social capital in building resilience, are key issues. [9.4.1]
22
23

24 **9.1. Introduction**

25 **9.1.1. Rationale for the Chapter**

26 Rural areas, even after significant demographic shifts, still account for almost half the world's population (UN
27 2011). They also account for about 75% of the developing world's poor people (Ravallion *et al.*, 2007) and 80% of
28 the world's hungry (UNDP, 2005), important points given the association of climate vulnerability with poverty and
29 food insecurity. At the same time, changes in land-use and livelihoods in rural areas make it less straightforward to
30 associate rural areas with agriculture or food production.
31
32

33
34 The Fourth Assessment Report (AR4) of the IPCC contains no specific chapter on "rural areas". Material on rural
35 areas and rural people is found throughout the AR4, but rural areas are approached from specific viewpoints and
36 through specific disciplines. Agriculture and food production, the impacts of which are assessed by Easterling *et al.*
37 (2007), clearly take place mainly in rural areas, but that chapter was not able to cover impacts on other human
38 activities taking place in rural areas or of significance to rural people. Many rural people follow livelihoods directly
39 dependent on unmanaged or less-managed ecosystems, such as forests. However, the AR4 chapter on ecosystems
40 (Fischlin *et al.*, 2007) was not able to cover the indirect impacts of ecosystem change on such livelihoods. The
41 chapter on industry, settlement and society (Wilbanks *et al.*, 2007) reaches important conclusions about specific
42 vulnerabilities of both urban and rural systems to climate change, but much of the literature reviewed and the most
43 important conclusions, on high-density settlements, industry and infrastructure, are implicitly concerned with urban
44 areas.
45

46 This chapter, under the general heading of "Human Settlements, Industry, and Infrastructure" will assess the impacts
47 of climate change on, and the prospects for adaptation in, rural areas, seen as diverse patterns of settlement,
48 infrastructure and livelihoods, in complex relations of interdependence with urban areas. Some of the key
49 considerations will be as follows.

- 50 • Rural areas are largely defined in contradistinction to urban areas, but that distinction is increasingly seen
51 as problematic.
- 52 • Rural areas are a spatial category, associated with certain patterns of human activity, but with those
53 associations being subject to continuous change.

- 1 • Rural populations have, and will have, a variety of income sources and occupations, within which
2 agriculture and the exploitation of natural resources have privileged but not necessarily predominant
3 positions.
- 4 • Rural areas suffer from specific vulnerabilities to climate change, both through their dependence on natural
5 resources and weather-dependent activities, and through their relative lack of access to information,
6 decision-making, investment and services.

7
8 The chapter will address issues also dealt with in Chapter 7 “Food Production Systems and Food Security” and
9 Chapter 4 “Terrestrial and Inland Water Systems”, but will primarily look at how biophysical impacts of climate
10 change on agriculture and on less-managed ecosystems translate into impacts on human systems. It will also address
11 issues dealt with in Chapter 12 “Human Security” and Chapter 13 “Poverty and Livelihoods”, but primarily from the
12 point of view of rural areas as spatial categories with particular characteristics.

13 14 15 **9.1.2. Definitions of the Rural**

16
17 “Rural” and “rural areas”, in both policy-oriented and scholarly literature are terms often taken for granted or left
18 undefined. IFAD (2010) states that the definitions of rural and urban are fraught with difficulties. Hart *et al.* (2005)
19 set out the multiple and sometimes contradictory official definitions used in the United States. Some definitions
20 depend on the scale of the area or settlement being defined. They conclude that choice of a definition depends on
21 purpose, data availability and its place within an appropriate taxonomy. Ultimately, however, in developing
22 countries as well as developed countries, the rural is defined as the inverse or the residual of the urban (Lerner and
23 Eakin, 2010).

24
25 The U.S. Bureau of the Census defines rural areas as consisting of all territory outside of Census Bureau-defined
26 urbanized areas and urban clusters, that is open country and settlements with fewer than 2,500 residents. Such areas
27 can in practice have population densities as high as 999 persons per square mile (386 persons/km²) (Womach, 2005).

28
29 The UK Department for Environment, Food and Rural Affairs (Defra, 2011) uses two definitions of rural areas. In
30 national statistics areas are defined as rural if they fall outside urban areas defined as having 10,000 or more
31 inhabitants. Some urban areas of between 10,000 and 30,000 inhabitants, serving a wider rural hinterland and
32 meeting certain service criteria are defined as Large Market Towns. These Towns and their populations are therefore
33 classified as rural for the purposes of classifying local government areas. Districts with at least 50 per cent of their
34 population living in rural settlements and larger market towns are defined as “predominantly rural”. These two
35 examples demonstrate both the variation of definitions of the rural between countries and the dependence of those
36 definitions on definitions of the urban.

37
38 In India urban areas are defined essentially as those with populations of 5,000 or more, or where least 75% of the
39 male working population is non-agricultural, or having a density of population of at least 400 people per km² (GOI
40 2012)

41
42 Human settlements in fact exist along a continuum from ‘rural’ to ‘urban’, with ‘large villages’, ‘small towns’ and
43 ‘small urban centres’ not clearly fitting into one or the other. The populations of these ambiguous settlements tends
44 to range from a few hundred to approximately 20,000 inhabitants, with 20 to 40 percent of the population in many
45 nations living in settlements in this category (Satterthwaite, 2006).

46
47 Definitions of the rural are therefore variable between countries, increasingly seen as problematic, and increasingly
48 subject to various attempts at refinement and sub-classification. While remaining aware of these issues, this chapter
49 will in general assess literature on current trends in rural areas, and on climate impacts, adaptation and vulnerability,
50 using whatever definitions of the rural are used in that literature.

9.1.3. *Between ‘Rural’ and ‘Urban’: the Peri-Urban Interface*

Authors have increasingly recognized that the simple dichotomy between ‘rural’ and ‘urban’ has “long ceased to have much meaning in practice or for policy-making purposes in many parts of the global South” (Simon *et al.*, 2006:4; Simon, 2008). Because of this, attempts to refine rural-urban classifications have included the concept of “peri-urban areas”, reviewed by Lerner and Eakin (2010). Webster (2002:5) writes of a process of peri-urbanisation as rural areas around cities “become more urban in character” but equally “households may be pursuing peri-urban incomes while still residing in what appears to be largely rural landscapes” (Lerner and Eakin 2010:1). Other conceptualisations stress that peri-urban areas should be seen as more than just the “urban periphery”, but rather as locations in which rural and urban land uses coexist, whether in contiguous or fragmented units (Bowyer-Bower, 2006). Although assessments of “land degradation” and “sustainability” in peri-urban areas exist (e.g. Allen, 2006; Diaz-Chavez, 2006; Gough and Yankson, 2006; Binns and Maconachie, 2006), these have not yet focused on how these areas will be affected by climate change, or how the process of peri-urbanization will shape vulnerability or resilience.

The widening use in academic literature of the Bahasa Indonesian term *desakota* (starting with McGee, 1991) is intended to include more than the peri-urban (Moench and Gyawali, 2008). It recognizes that diversified economic systems exist across the urban-rural spectrum, and focuses on the closely interlinked, co-penetrating rural/urban livelihoods, communication, transport and economic systems (Desakota Study Team, 2008). Desakota areas are seen to be increasing in importance as “push” factors – including climate change (Desakota Study Team, 2008) – drive people out from both rural areas and urban centres. Ecosystem services are particularly important in these areas, and environmental degradation – again, including the impacts of climate change (Desakota Study Team, 2008) will influence ecosystem services and their role as a foundation for livelihood systems across developing countries in these systems, with particularly important consequences for the poor who are often the most directly dependent on water-dependent ecosystem services.

9.2. Findings of Recent Assessments

This section will review AR4 findings of relevance to rural areas (IPCC, 2007), as well as those findings of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2009) that are related both to climate change and rural areas. Easterling *et al.*, (2007) focus on productivity and production of crops, livestock and forests, which clearly have impacts in rural livelihoods, but are only one of many other aspects to be considered. Wilbanks *et al.*, (2007), on human settlements, focus strongly on urban areas. They also state that “research on vulnerabilities and adaptive potentials of human systems has lagged behind research on physical environmental systems, ecological impacts and mitigation (p.385)” and for that reason uncertainties are very prominent in their treatment of the topic. These include uncertainties associated with identifying impacts at small geographical scale, with secondary impacts on human systems of primary effects, with the potential for adaptation to reduce impact, and with the socio-economic and technical trends that will be the context for climate change.

Easterling *et al.*, (2007) state that any assessment of climate change impacts on agriculture has to be undertaken against a background of global demographic and economic trends in rural areas (p.280). These factors determine how rural populations can cope with changing climate conditions, and how climate will affect food security. Different development paths may increase or decrease vulnerabilities to climate-change impacts (Wilbanks *et al.*, 2007: 384). Global numbers of people at risk from hunger will be affected by climate change, but more by socioeconomic trends as captured in the difference between the SRES scenarios (Easterling *et al.*, 2007: 298-299). The significance of climate change needs to be considered in the multi-causal context of its interactions with other non-climate sources of change and stress (Wilbanks *et al.*, 2007: 364). That is, climate change is not the only stress on human settlements, other stresses, such as water scarcity, governance structures, institutional and jurisdictional fragmentation, limited revenue streams for public sector roles, or inflexible land use patterns, which are inadequate even in the absence of climate change, also need to be considered (Wilbanks *et al.*, 2007: 373).

1 In terms of rural livelihoods linked to agriculture, AR4 concludes that subsistence and smallholder livelihood
2 systems suffer from a number of stressors apart from climate change. But these systems are also characterized for
3 having certain resilience factors: efficiencies associated with the use of family labour, livelihood diversity to spread
4 risks, and indigenous knowledge that facilitates coping with crises (Easterling *et al.*, 2007: 281-282). Agricultural
5 knowledge that favours an optimization of resources use to produce food can be of major relevance in this context.
6 Traditional knowledge related to agriculture and natural resource management is assessed as a valuable individual
7 and social asset (IAASTD, 2009). The combinations of stressors and resilience factors gives rise to complex positive
8 and negative trends in livelihoods, that are very locally-specific (293-294) and resistant to aggregate modelling
9 (Wilbanks *et al.*, 2007: 359, 376).

10
11 Forestry is also assessed in AR4 from the viewpoint of timber production by Easterling *et al.* (2007), but forests are
12 also important for millions of people in providing ecosystem services other than timber or the forestry industry, such
13 as food, medicines or fuel. In many rural Sub-Saharan Africa communities, Non-Timber Forest Products (NTFPs)
14 may supply over 50% of household cash income and provide the health needs for over 80% of the population (FAO,
15 2004a). Yet little is known about the possible impacts of climate change on NTFPs. Fires, disease outbreaks, general
16 deforestation trends are all expected to affect the contribution of NTFPs to rural livelihoods. In general terms,
17 Easterling *et al.*, (2007: 291) suggest that the loss of forest resources may directly affect 90% of the 1.2 billion
18 forest-dependent people who live in extreme poverty.

19
20 In terms of systems assessed, tourism, water supplies (demand and availability), insurance, sanitation, and
21 infrastructure, including transport, power and communication, all affect rural settlement. It is recognised that neglect
22 of the rural sector, and rural women in particular, by policy makers and service providers has favoured a lack of
23 investment in infrastructure, water systems, education and health services, and the dismantling of public extension
24 systems, which have all left their mark on rural areas and their inhabitants (IAASTD, 2009). In terms of climate
25 change, these services in rural areas might be less affected than in urban areas precisely because of the lower
26 provision of infrastructure, but the lack of services can limit rural peoples' ability to cope with extreme climate
27 events. Specifically, water supply is important since most water in the world is used for agricultural purposes.

28
29 Wilbanks *et al.* (2007: 375) noted the difficulty of finding valuations of climate change for human settlements. It
30 states that estimates based on aggregate macroeconomic costs of climate change at a global scale are not directly
31 useful while other types of social and environmental costs are poorly captured by monetary metrics. The IAASTD
32 confirmed this finding suggesting other forms of non-monetary valuations, such as energy-related valuations.

33
34 A general adaptation trend highlighted for rural communities is the diversification of livelihoods strategies, moving
35 livestock, harvesting water, shifting crop mixes and migration (Easterling *et al.* 2007: 293). All these require
36 adequate institutional support for longer-term livelihood sustainability. The IAASTD (2009) puts strong emphasis
37 on adaptation and research strategies promoting participation, social learning and empowering rural people. Yet,
38 prospects for adaptation depend on the magnitude and rate of climate change, adaptation strategies being inseparable
39 from increasingly strong and complex global linkages. Adaptation actions can be effective in achieving their specific
40 goals, but they may have other (positive or negative) effects as well. Special attention will have to be given to the
41 access to resources in adaptation measures. As climate change exacerbates and adaptation becomes a common need,
42 there is likely to be competition for resources, whether financial or physical resources, like water or land,
43 exacerbating risks of conflict over resources and further increase inequity, particularly in developing countries
44 (IAASTD, 2009).

45
46 AR4 suggests that mitigation and adaptation policies are in many cases, and certainly for agriculture, settlements
47 and industry, closely linked (Klein *et al.*, 2007; Easterling *et al.*, 2007; 283, 284; Wilbanks *et al.*, 2007: 359, 384). A
48 growing body of literature confirms this statement.

9.3. Assessing Impacts, Vulnerabilities, and Risks

9.3.1. *Current and Future Economic, Social, and Land-Use Trends in Rural Areas*

Climate change in rural areas will take place against the background of the trends in demography, economics and governance which are shaping those areas. While there are major points of contact between the important trends in developing and industrialized countries, and the analytical approaches used to discuss them, it is easier to discuss trends separately for the two groups of countries. In particular there is a close association in developing countries between rural areas and poverty. Table 9-1 summarizes and compares the most important trends across the two groups of countries. Figure 9-1, Table 9-2, and Figure 9-2 focus on two specific trends in developing countries: demographic trends and trends in poverty indicators.

[INSERT TABLE 9-1 HERE

Table 9-1: Major demographic, poverty-related, economic, governance, and environmental trends in rural areas of developed and developing countries.]

[INSERT FIGURE 9-1 HERE

Figure 9-1: Key demographic indicators in rural areas of developing countries.]

[INSERT TABLE 9-2 HERE

Table 9-2: Poverty indicators for rural areas of developing countries.]

[INSERT FIGURE 9-2 HERE

Figure 9-2: Poverty indicators for rural areas of developing countries, by region.]

9.3.2. *Observed Impacts*

Documentation of observed impacts of climate change on rural areas involves major questions of detection and attribution. Much discussion of vulnerability and adaptive capacity in rural areas, especially work based on qualitative fieldwork at community level, reports local perceptions of climate change, or uses local meteorological data without systematic attempts to distinguish between decadal trends and manifestations of long-term global climate change (see for example chapters in Ensor and Berger, 2009, and Castro *et al.*, 2012). Similarly, impacts, vulnerability and adaptive capacity are frequently discussed in the context of extreme events, and perceived increases in their frequency, without systematic discussion of the difficulties of attributing extreme events to climate change (see Paavola, 2008 as an example), difficulties that have been further highlighted by the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (IPCC 2012, Seneviratne *et al.*, 2012). Implied equivalence between perceptions, local decadal trends and global change is not a problem in the context of detailed social-scientific analysis of vulnerability, adaptive capacity and their determinants, but creates problems if such work is used as evidence for observed impact.

The impacts of climate change on patterns of settlement, livelihoods and incomes in rural areas will be the result of multi-step causal chains of impact. Typically, those chains will be of two sorts. One sort will involve extreme events, such as floods and storms, as they impact on rural infrastructure. The other sort will involve impacts on agriculture or on ecosystems on which rural people depend. These impacts may themselves stem from extreme events, from changing patterns of extremes due to climate change, to changes in mean conditions. The detection and attribution of extreme events is discussed by IPCC (2012). The detection and attribution of impacts on ecosystems and on agriculture are dealt with in Chapters 4 and 7 of this report. Both exercises are complex.

With these provisos, observed impacts in the literature can be considered under the headings of impacts of extreme events and impacts of more incremental changes in climate parameters, though there is no clear divide between the two.

9.3.2.1. Impacts of Extreme Events

Seneviratne *et al.* (2012) give a detailed and critical assessment of the detection and attribution of observed patterns of extreme events, which shows greatly varying levels of confidence in the attribution to climate change of global and regional trends. For example they state that it is *likely* there has been a worldwide increase in extreme high water events, and it is *likely* that there has been an anthropogenic influence on this. They have *medium confidence* in detecting trends towards more intense and frequent droughts in some parts of the world (Southern Europe and West Africa) while noting that opposite trends exist, and that there is *low confidence* in any trend in dryness in, for example, East Africa. They assign *low confidence* to any observed long-term increases in tropical cyclone activity, or attribution of any changes in cyclone activity to anthropogenic influence. They state that “attribution of single extreme events to anthropogenic climate change is challenging” (2012:112).

These conclusions, and the evolving literature on attribution of extreme events must be taken into account when discussing the impacts of extreme events on human systems, which are clear. Handmer *et al.*, (2012) summarize the evidence of such impacts. Although no specific analysis is given for rural areas, the main conclusions for human settlements are valid in our context. Extreme events can produce severe distress in societies. For example, Hurricane Stan in October 2005 affected nearly 600,000 people on the Chiapas coast as a consequence of flooding and sudden river overflows (Saldaña-Zorrilla, 2008). Natural disasters produce adverse impact on the macro-economy. Developing countries, and smaller economies, experience larger declines following a disaster of similar relative magnitude than do developed countries or bigger economies. Martine and Guzman (2002) analyze the consequences of Hurricane Mitch (the most powerful hurricane of the 1998 season) on the underlying vulnerability of Central America. They concluded that poverty can act as a magnifier of the threat of natural hazards.

Heat waves are one of the climate shocks that can substantially affect human comfort and even produce mortality. Although there are differences between urban and rural areas regarding the magnitude of extreme high temperatures, there is evidence pointing towards the fact that human populations seem to be equally vulnerable among urban and rural areas (Loughan *et al.*, 2010). Despite the direct impacts on human systems, droughts produce severe economic distress on rural areas. Employment reduction as a consequence of lower agricultural productivity and ultimate migration are two of the most common responses (Gray and Muller, 2012). Other examples of climate related stressors that can produce major impacts on rural areas are sea level rise that can worsen saline intrusions, inundation, storm surges, erosion, and other coastal hazards in island communities, and glacier melt that affects major agricultural systems in Asia (Warner *et al.*, 2009).

Extreme events have a strong influence on poverty levels. Ahmed *et al.* (2009) found that under the present climate, extreme events (referred to as climate volatility) increase poverty in developing countries with clear impacts in Bangladesh, Mexico, Indonesia, and Africa. Literacy rate, better institutions, higher per capita income, higher degree of openness to trade, and higher levels of government spending are conditions that reduce disaster shock and prevent further spillovers into the macro-economy (Noy, 2009).

Raleigh *et al.* (2008) present a comprehensive paper with regionally specific data and a break out of extreme events by type and frequency. Even though they recognize the influence of climate drivers on migration, their analysis differs from “environmental refugee” assessments as they emphasize the role of human reaction and adaptation. Raleigh and Urdall (2007) also state that population growth and density are factors that increase risk and that socioeconomic and political factors have generally outweighed environmental stressors in the past.

Preliminary assessments often analyze the observed impacts of climate stressors such as droughts, floods, and heat waves to obtain response functions. These functions are then used to generate estimates of the impacts of climate change in rural areas.

9.3.2.2 Other Observed Impacts

Glacial retreat in Latin America (Orlove, 2009) is one of the least ambiguous current impacts on rural areas. In highland Peru there have been rapid observed declines since 1962 in glacier area and dry-season stream flow, on

1 which local livelihoods, which accord well with local perceptions of changes that are necessitating adaptation. There
2 is also a rich specialized literature on the impacts of shrinking sea-ice and changing seasonal patterns of ice
3 formation and melt on Inuit in circumpolar regions (Ford, 2009).

4
5 Poverty indicators can be considered as a result of climate impacts as well as a key component of vulnerability.
6 Migration is another relevant impact that can be observed and attributable directly to climate. Black *et al.* (2011), in
7 work that seeks to understand how and why existing flows from and to specific locations may change in the future,
8 recognizing the complexity of the phenomenon and exploring climate drivers that act on it, present two examples. In
9 Ghana, rainfall variability increases seasonal migration in good years, and reduces migration in drought years.
10 However, the growing variability and uncertainty associated with rainfall patterns have resulted in more anticipatory
11 migration. When addressing migration, Reuveny (2007) uses the term “ecomigrant” to show how environmental
12 change can trigger migration. The Dust Bowl is an example where drought was one (but not the only) cause of this
13 disaster. It is argued that environmental degradation removed the basis for the agricultural-based lifestyle, setting the
14 stage for ecomigration.

15 16 17 **9.3.3 Future Impacts and Vulnerabilities**

18
19 This section will examine the major impacts of climate change identified or projected for rural areas, under the
20 headings of: economic base and livelihoods; landscape and regional interconnections, including migration, trade,
21 investment and knowledge; and second-order impacts of climate policy. The following section, 9.3.4, assesses
22 literature on impact through a different and specific lens, that of economic valuation, though there is some overlap.
23 The biophysical impacts of climate change on food crops are dealt with primarily in Chapter 7; but also here and in
24 section 9.3.4 insofar as they affect rural economies. Issues relating to biophysical impacts on non-food cash crops
25 are illustrated in Box 9-1 with reference to coffee.

26
27 As with the observed impacts in section 9.3.2, the future impacts of climate change described here, and quantified in
28 section 9.3.4, are at the latter stages of complex causal chains that flow through changing patterns of extreme events
29 and/or effects of climate change on biophysical processes in agriculture and less-managed ecosystems. This
30 increases the uncertainty associated with any particular impact on the economic base, on land-use or on regional
31 interconnections.

32 33 34 **9.3.3.1. Economic Base and Livelihoods**

35
36 Climate change will affect rural livelihoods, or “the capabilities, assets (stores, resources, claims and access) and
37 activities required for a means of living” (Chambers and Conway, 1992). This is because many rural livelihoods are
38 dependent on natural resources (e.g. agriculture, fishing and forestry), and their availability will vary in a changing
39 climate. This may have effects on human security and wellbeing (Kumssa and Jones, 2010).

40
41 Morton (2007), adapting findings from AR4, suggests that the impacts of climate change on smallholder and
42 subsistence farmers can be conceptualized as a combination of: biological processes affecting crops and animals at
43 organism or field level; environmental and physical processes affecting production at a landscape, watershed or
44 community level; and other impacts, including those on human health and on non-agricultural livelihoods. This
45 schema is developed by Anderson *et al.* (2010), with a cross-cutting dimension of extreme events, increased
46 variability and shifts in average temperature and rainfall, as well as introducing indirect impacts, for example
47 through trade and food prices, and through climate mitigation policies.

48
49 An additional dimension is effects of climate change on water supply which in turn affect rural livelihood bases,
50 whether through a decrease or increase. In South Africa, for example, most of the climate change models predict a
51 reduction in freshwater availability by 2050, and a computable general equilibrium approach shows that this will
52 adversely affect household welfare (Juana *et al.*, 2008). In the Mount Kenya region, in contrast, the NRM3
53 Streamflow Model under the TGICA climate change projection will result in an increase of annual runoff by 26%,
54 with a severe increase in flood flows, and a reduction of the lowest flows to about a tenth of the current value

1 (Notter *et al.*, 2007). Changing rainfall levels will also affect groundwater levels, which play a role in rural
2 livelihoods. At the continental level in Africa, analysis of existing rainfall and recharge studies suggests that climate
3 change is unlikely to lead to widespread catastrophic failure of improved rural groundwater supplies (Macdonald *et*
4 *al.*, 2009). However, at higher resolution groundwater resources are threatened (e.g. in South Africa, Knüppe, 2011),
5 and water crises are expected to multiple resulting from the increasing demand, and this will further affect the
6 people in rural areas who fetch water (Nkem *et al.*, 2011).

7
8 Water availability plays a key role in the viability of agricultural livelihoods, alongside changes in temperature.
9 Climate change is expected to impact water resources in the Asian region in a major way. A study by the World
10 Bank (2010a) argues that diminishing Himalayan glaciers would impact water requirement and food security of
11 more than one billion people in Asia. There are some regional and country studies, which support this view.
12 Likewise, Immerzeel *et al.* (2010) in a study of major river basins of the region viz. Indus, Ganges, Brahmaputra,
13 Yangtze and Yellow rivers conclude that different river basins would have different impacts on water availability
14 and food security due to climate change. They further argue that the Brahmaputra and Indus basins would be more
15 susceptible to water availability affecting food security of 60 million people (ibid). ADB (2009a) argues that climate
16 change would increase water stress in four south East Asian countries of Indonesia, Philippines, Thailand and
17 Vietnam.

18
19 In assessing the impacts of climate change on water resources in rural areas of Europe, it is predicted that
20 Mediterranean climates will experience more pressure on water resources from reduced rainfall and melt water from
21 glacial ice and snow. Schroter *et al.* (2005) predict that in the Mediterranean region summer water supply could fall
22 by 20 to 30% following global warming of 2°C and 40 -50% for 4°C . These declines would increase the costs of
23 production and living in the South (Falloon and Betts, 2010). Drought could threaten biodiversity and traditional
24 ecosystems particularly in Southern Europe with problems exacerbated by declining water quality. Decline in
25 economic activity is likely to increase rural depopulation and harm the development of rural communities in
26 Southern Europe (Westhoek *et al.*, 2006). According to MacDonald *et al.* (2009) climate change will not lead to a
27 widespread failure of improved rural groundwater supply in Africa, but it could affect a population of up to 90
28 million people, as they live in rural areas where annual rainfall is between 200 and 500mm per year, and where
29 decreases in annual rainfall, changes in intensity or seasonal variations may cause problems for groundwater supply.

30
31 Various studies conclude a decline in crop yield and water availability of agriculture due to climate change over the
32 next three to four decades in different parts of the world (Section 7.2.1, Chapter 7, AR5). For the Asia –Pacific
33 region several studies have concentrated on impacts emanating from the agricultural sector (ADB & IFPRI, 2009;
34 ADB, 2009a; Srivastava *et al.*, 2010; De Silva *et al.*, 2007; Xiong *et al.*, 2009, 2010; Ramirez-Villegas *et al.*, 2011)
35 Similarly, studies on the adverse impacts of climatic changes on yields in different parts of North America, Australia
36 and Europe have been conducted (Warren *et al.*, 2006; Olesena *et al.*, 2011; Anwar *et al.*, 2007; COPA COGECA,
37 2003; Schlenker and Roberts, 2009; Roberts and Schlenker, 2010; Niemi *et al.* 2009; Wolfe *et al.* 2008). The
38 impacts of climate change on the smallholder and rain-fed dominated (96% of all agricultural land is rain-fed)
39 agricultural sector are considered to be very significant to the economies and livelihoods in Africa (Müller *et al.*,
40 2011; Kotir, 2011; Collier *et al.*, 2008; Hassan, 2010). These results emerge across a range of scenarios. Several
41 other studies also map declines in net revenues from crops and the associated links with food security and poverty
42 (Molua, 2009; Thurlow *et al.*, 2009; Reid *et al.*, 2008; World Bank, 2010a; Thurlow and Wobst, 2003. Yield
43 patterns are expected to present spatial differences in South America, as projected by various studies with some
44 losing such as bean growers in Central America and some gaining such as sugarcane cultivators in Brazil. Such
45 country case studies are based on climate projections for SRES A2 and B2 scenarios derived by Hadley Center
46 HadRM3P model (Pinto and Assad, 2008; ECLAC, 2009; ECLAC, 2010a). Adverse impacts on yield derived on the
47 basis of simulations of the above mentioned scenarios imply that since bean growers in Central America are small,
48 low-income farmers, climate change may have large repercussion throughout the region, endangering the food
49 security of large segments of the population (ECLAC, 2010b).

50
51 There will also be impacts on non-food cash crops, on which many rural people depend. The case of tropical
52 beverage crops, in particular coffee, is discussed in Box 9-1, and projected changes in area suitable for all three
53 tropical beverage crops are set out in Table 9-3.

1 ____ START BOX 9-1 HERE ____

3 **Box 9-1. Impacts of Climate Change on Tropical Beverage Crops**

4
5 The major traded beverage crops coffee, tea and cocoa support the livelihoods of several million small-scale
6 producers. Coffee production has long been recognized as sensitive to climate variability with global production and
7 prices sensitive to occasional frosts in Brazil – the world’s largest producer. Likewise the livelihoods of millions of
8 small producers are dependent both on stability of production and stability in world prices. During the last crash in
9 coffee prices from 2000–2003 poverty levels in the coffee growing regions of Nicaragua increased, while they fell in
10 the rest of the country (World Bank, 2003); subsequently during the drought associated with El Nino in 2005 coffee
11 productivity fell to between a third and half of normal similarly leading to severely reduced income for small
12 producers (Haggar, 2009).

13
14 Analysis of the effects of recent climate change on coffee producing areas in Mexico by Gay *et al.* (2006) show that
15 in Veracruz between 1969 and 1998 rainfall has decreased by 40mm per year and temperatures have increased by
16 0.02°C per year. Extrapolating these changes to 2020 they find that coffee production could decline by 34%, but
17 most importantly this decline in production takes producers from making net profits of on average around US\$200
18 per acre, to less than \$20 per acre. This has led to a series of studies projecting the effects of climate change on the
19 distribution of Arabica coffee growing areas of the coming decades.

20
21 For Brazil, Pinto *et al.*, (2004) have mapped the changes in area suitable for coffee production in the four main
22 coffee producing states. Major changes in the distribution of coffee producing zones are foreseen in Minas Gerais
23 and Sao Paulo with the potential area for production declining from 70–75% of the state to 20–25%, production in
24 Goyas being eliminated but only a 10% reduction in area in Parana. New areas suitable for production in Santa
25 Catarina and Rio Grande do Sul will only partially compensate the loss of area in other states (Pinto and Assad,
26 2008). The economic impacts of a rise in temperature of 3°C would cause a 60% decline coffee production in the
27 state of Sao Paulo equal to nearly 300 million dollars income (Pinto *et al.*, 2007).

28
29 Models developed by CIAT predict the distribution of coffee under climate scenarios averaged from 21 different
30 models by parameterising current distribution using 19 climatic variables and mapping where those conditions may
31 occur in the future. This method has been applied to coffee distribution in Kenya (CIAT 2010), Central America and
32 Mexico (Laderach *et al.*, 2010), tea production in Kenya (CIAT, 2011b) and Uganda (CIAT, 2011b), and cocoa
33 production in Ghana and Ivory Coast (CIAT, 2011c) (Table 9-3). Only one similar study appears to have been done
34 for Robusta coffee (Simonett, 2002) in Uganda, which appears to show similarly drastic changes in both distribution
35 and total area suitable for coffee production. At minimum climate change will cause considerable changes in the
36 distribution of these crops disrupting the livelihoods of millions of small-holder producers, in many cases the total
37 area suitable for production would decrease considerably with increases of temperature of only 2–2.5°C.

38
39 ____ END BOX 9-1 HERE ____

40
41 [INSERT TABLE 9-3 HERE

42 Table 9-3: Projected changes in areas suitable for production of tropical beverage crops by 2050.]

43
44 Food security is now known to reflect a broader range of factors than merely food production (Sen, 1992), and in
45 three countries in African which suffered mass mortality food crises since 2000 – Ethiopia, Malawi and Niger -
46 these crises were triggered by a moderate decline in crop and/or livestock production, exacerbated by “exchange
47 entitlement failures” – food price spikes and asset price collapses (Devereux, 2009).). For example, the food crisis
48 of 2007–2008 exposed the vulnerability of rural livelihoods to external price shocks. Review of the evidence shows
49 that price rises have a disproportionate impact on the welfare of the poorest of the poor in rural areas - female-
50 headed households (which tend to be poorer than male-headed households) and those who have limited access to
51 land, modern agricultural inputs, infrastructure and education (Ruel *et al.*, 2009: 3). This has illustrated that the
52 vulnerability of rural livelihoods is affected by not only ecological, but also social and economic factors that mediate
53 or hinder people’s access to different assets and capacities to adapt (Ericksen, 2008a, b; Ellis, 2000: 290–91).

1 However, changes in production will play a role in affecting food security and resultant increases in malnutrition
2 (Ringle, 2010).
3

4 Agricultural livelihoods are not restricted to crops, but also involve livestock. On the African continent, pastoralists
5 have developing strategies for responding to climate variability, for example in the Afar region of Ethiopia (Davies
6 and Bennett, 2007). Data from over 9000 African livestock farmers in 10 countries shows that farmers are more
7 likely to have livestock as temperatures increase and as precipitation decreases, based on logit analysis to estimate
8 whether farmers adopt livestock, followed by three econometric models (a primary choice multinomial logit, an
9 optimal portfolio multinomial logit and a demand system multivariate probit) to determine species choice. The
10 climate scenarios predict a decrease in the probability of beef cattle and an increase in the probability of sheep and
11 goats, and more heat-tolerant animals will dominate the future in Africa (Seo and Mendelsohn, 2007a). A
12 development of the Ricardian method shows that these choices relate to the net income of different animal species.
13 On this basis, large-scale commercial beef cattle farmers are most vulnerable to climate change in Africa,
14 particularly since they are less likely to have diversified (Seo and Mendelsohn, 2007b). Six SRES scenarios
15 generated by six GCMs were used by Hein *et al.* (2009) for the Ferlo Region in Northern Senegal, where livestock
16 keeping is the main economic activity of the rural population. A modest reduction in rainfall of 15% in combination
17 with a 20% increase in rainfall variability could have considerable effects on livestock stocking density and profits,
18 reducing the optimal stocking density by 30%. Livestock is also important to the livelihoods of many citizens of
19 Kenya (Kabubo-Mariara, 2009), a country where more than 77% of its people live in rural areas (UN, 2010). A
20 recent study shows that livestock production is highly sensitive to climate change, whereby increased mean
21 precipitation of 1% could reduce revenues by 6% (Kabubo-Mariara, 2009).
22

23 Livelihoods dependent on fisheries will also experience vulnerability to climate change. Impacts of climate change
24 on aquatic ecosystems will have adverse consequences for the world's 36 million fisherfolk as well as the nearly 1.5
25 billion consumers who rely on fish for more than 20% of their dietary animal protein (Badjeck *et al.*, 2010). The
26 linkage between various fish populations, such as black hake, and climate dynamics has been shown using
27 correlations with indices such as the North Atlantic Oscillation (Meiners *et al.*, 2010). Climate change will cause
28 increasing sea surface temperatures, ocean acidification, sea level rise, increasing storm intensity and altered ocean
29 circulation, and rainfall patterns. All of these will affect target species through a range of direct and indirect
30 mechanisms. The sensitivity of fish stocks to these changes will determine the range of potential impacts to life
31 cycles, species distributions, community structure, productivity, connectivity, organism performance, recruitment
32 dynamics, prevalence of invasive species, and access to marine resources by fishers (Johnson and Welch, 2010). An
33 indicator approach showed that economies with the highest vulnerability of capture fisheries to climate change were
34 in Central and Western Africa (e.g. Malawi, Guinea, Senegal, and Uganda), Peru and Colombia in north-western
35 South America, and four tropical Asian countries (Bangladesh, Cambodia, Pakistan, and Yemen)(Allison *et al.*,
36 2009). This vulnerability arises from the combined effect of predicted climate change on fish stocks, the relatively
37 high share of fisheries as a source of income (including export earnings) and diets, and limited societal capacity to
38 adapt due to the prominence of poverty in these societies (Allison *et al.*, 2009). In another study of changes in
39 climate and social systems in north eastern Asia on fisheries development, Kim (2010) argues that in countries like
40 China, Japan and South Korea these changes could have a negative impact on fisheries adversely affecting
41 livelihoods and food security of the region.
42

43 Climate change may in different regions accelerate or retard the processes of livelihood diversification away from
44 agriculture. Although it is also determined by other factors such as poverty, income distribution, farm output,
45 gender, labour and credit markets, diversification into non-farm incomes might accelerate if climate-related risks of
46 farm income failure increase as a result of climate change (Ellis, 2000:294). Such diversification would help
47 households achieve low risk correlations between their livelihood components (Ellis, 2000:294)
48

49 The livelihoods framework allows analysis of livelihoods outcomes as embedded within an external context of
50 multiple stresses and dynamics, all of which change over time (Kepe, 2008; Morton, 2007). Climate variability and
51 change interacts with, and sometimes compounds, existing livelihood pressures in rural areas, such as economic
52 policy, globalization, environmental degradation and HIV/AIDS, as has been shown in Tanzania (Hamisi *et al.*,
53 2012), Ghana (Westerhoff and Smit, 2009), South Africa (O'Brien *et al.*, 2009; Ziervogel and Taylor, 2008; Reid
54 and Vogel, 2006), Malawi (Casale *et al.*, 2010), Kenya, (Oluoko-Odingoa, 2011), Senegal (Mbow *et al.*, 2008) and

1 India (O'Brien et al, 2004). In the Kenya example, analytical techniques such as multiple correlation and regression
2 analysis, principal components analysis, factor analysis and cluster analysis showed that poverty was the main
3 contributor to food insecurity, although climate complicated the issue (Oluoko-Odingo, 2011). In other examples,
4 climate change is deemed the most critical stress, for example in the Ruaha Valley of Tanzania, where about 42% of
5 variation in cereal production is described by the rainfall amount variability, in addition to changes in wildlife
6 diversity and hydroelectric power generation (Malley *et al.*, 2007). Vulnerability to climate change is often
7 exacerbated by factors such as poverty, poor health, unemployment and inadequate village infrastructure in rural
8 areas (Jones and Thornton, 2009; Tschakert, 2007).

9
10 Especially for agriculture and other traditional livelihoods in developing countries, the concept of the “centrality of
11 the social” (Fairhead and Leach, 2006) is important: social relations within households (particularly gender
12 relations) and between households, profoundly affecting production decisions, management of knowledge, and
13 marketing (Morton, 2007). Similarly access to diversification as adaptations to climate extremes depends on gender,
14 age, governance institutions based on studies in South Africa, Tanzania and Uganda (Goulden *et al.*, 2009).
15 Vulnerability within rural areas is gendered. Women’s water security relative to men already places them at a
16 disadvantage in a context of changing availability (Tandon, 2007). Gendered and unequal patterns of participation in
17 decision-making and politics, labour, resource access and control, and possession of knowledge and skills.
18 shape the ability of men and women to adapt to climate risks (Rossi and Lambrou 2008).

19 20 21 9.3.3.2. *Landscape and Regional Interconnections*

22
23 As well as economic livelihoods, climate change will have implications for landuse and landscape in rural areas.
24 Around one-sixth of the world’s population is living in arid and semi-arid regions, which are mostly formed by rural
25 areas. More than 250 million people are directly affected by desertification, while another one billion are at risk. The
26 world’s major arid regions are in the developing world, where the population growth rate is high, and socio-
27 development levels are low (Jiang and Hardee, 2011). Some of the agricultural shifts described above can also be
28 viewed as landscape changes which may, in turn, feed back into local changes to the climate system. Olson *et al.*
29 (2008) suggested that the seemingly subtle land use change from savannas to cropping in East Africa may have a
30 significant regional climate impact. Spatial pattern is also important, for instance, different socioeconomic scenarios
31 can have the same urbanisation trend, but the spatial pattern may differ, reflecting alternative development
32 processes, e.g. periurbanisation versus counter urbanisation (Rounsevell *et al.*, 2007).

33
34 In both developing and developed countries, rural areas have been increasingly integrated with the rest of world. The
35 main channels through which this rapid integration process takes place are migration (permanent and cyclical),
36 commuting, transfer of public and private remittances, regional and international trade, inflow of investment and
37 diffusion of knowledge through new information and communication technologies (IFAD, 2010). In this context,
38 changes in the occurrence of some types of extreme events due to climate change, increased variability, and
39 changing mean climate parameters are likely to have significant implications for regional and global integration
40 trends in rural areas.

41
42 Desakota systems represent a change in the type of relationships between human society and ecosystems, and
43 therefore create shifts in the geographical and social distribution of risk and vulnerability (Pelling and Mustafa,
44 2010: 3). Because of this, the characteristics of desakota regions can both increase and decrease disaster and climate
45 risk, and can pose both opportunities and challenges for disaster response and reconstruction (Pelling and Mustafa,
46 2010). For example, increased transport connectivity in desakota regions can reduce disaster risk by providing a
47 greater diversity of livelihood options and improving access to education, but can also encourage land expropriation
48 to enable commercial development (hence increasing vulnerability of those who are made landless). Similarly, the
49 expansion of local labour markets and wage labour in these areas can reduce disaster risk and improve disaster
50 response through providing new livelihood opportunities and more effective risk management through the
51 management and financial capacity of the formal sector but can simultaneously increase disaster risk as reliance on
52 wage labour can increase dependence on the external economy and exposure to systemic shocks (Pelling and
53 Mustafa, 2010: 7, Figure 2).

9.3.3.2.1. Migration

One of the consequences of changing economic livelihoods and landscapes in rural areas due to climate change is an impact on migration. Typically out-migration to urban areas by the semi-skilled and low-skilled has been the predominant migration flow out of rural areas, particularly in developing countries, although the rates vary from country to country (IFAD, 2010). Other countries show greater trends of rural-rural migration (e.g. India).

Growing efforts are researching environmental migration, building on the AR4 conclusion that extreme events will lead to changed patterns of migration (Boko *et al.*, 2007). Though the impacts of climate change are likely to affect population distribution and mobility, it is difficult to establish a causal relationship between environmental degradation and migration, which is still termed “complex and unpredictable” (Brown, 2008). The link between internal migration in response to environmental stresses is contested. One school of thought shows internal (and particularly rural out-migration increasing during times of environmental stresses (e.g. Afifi, 2011; Gray and Mueller, 2012), with projections that these trends will continue under climate change (Kniveton *et al.*, 2011). Growing vulnerability to environmental change may also lead to an increase in abandonment of settlements (McLeman, 2011). Another body of literature shows that migration rates are no higher under conditions of environmental or climate stress (Black, 2011; van der Geest, 2011; van der Geest and de Jeu, 2008; Tacoli, 2009). Whilst rural-urban migration was once the dominant flow, there is now also a trend for migration to small and medium-sized towns (Sall *et al.*, 2010). Increased migration due to climate change may also affect human security (Brown and Crawford, 2008).

9.3.3.2.2. Trade

The volume of global agricultural trade has substantially increased over recent decades. Between 2000-2008, the value of global agricultural exports rose from US\$ 551 billion to US\$ 1 342 billion, representing an average annual growth of 5 percent (WTO, 2009). In addition to trade in primary crops, trade in processed food, fish and forest products has also been expanding (WTO, 2009). Growing volumes of international trade indicate that an increasing number of producers and consumers of agricultural goods are connected to global markets (IFAD, 2010). However, the fundamentals of agricultural trade have changed significantly in the late 2000s. There was a major agricultural price spike, and historically high degree of price volatility towards the end of the period. Some cyclical and structural factors – such as droughts in Australia and Ukraine creating shortage of cereals in international markets, the expansion of bio-fuels at the expense of food crop production, export controls, and growing demand by emerging economies for secondary agricultural products such as meat, energy and feed crops – have led to a volatile and unpredictable trading environment (FAO, 2008; Timmer, 2010; Schmidhuber and Matuschke, 2010; Karapinar and Haberli, 2010).

Against this backdrop, climate change is expected to affect the pattern and volume of international trade flows. At the sectoral and product levels, it may alter the comparative advantage of countries and regions through its potential impacts on their agricultural supply capacities. These effects will be reflected on agricultural prices – which are the signals of economic scarcity or abundance. Based on a limited number of studies that were available at the time, AR4 concluded that the effects of moderate increases in global mean temperatures (GMTs) (between 2-3°C) on food prices might lead to a small rise or decline (10-15 percent) in food (cereals) prices, while GMT increases in the range of 5.5°C or more might result in an increase in food prices of, on average, 30 percent. However, more recent studies produce more pessimistic projections which are differentiated at the crop level. For example, simulations results of two climate models – the National Centre for Atmospheric Research, US (NCAR) and the Commonwealth Scientific and Industrial Research Organization, Australia (CSIRO) – based on A2 scenario inputs – suggested that climate change might result in additional price increases in 2050, ranging from 30-37 percent for rice, 52-55 percent for maize to 94-111 percent for wheat (Nelson *et al.*, 2009). If CO₂ fertilization is taken into account, the 2050 price increases are expected to be smaller (for example, by 15-17 percent for rice relative to no CO₂ fertilization). It is important to note that these price increases are projected in addition to the price increases (62 percent in rice, 63 percent maize, and 40 percent in wheat) that are expected under no-climate-change scenario,

1 which are largely driven by population and income growth projected to be greater than productivity and area growth
2 (Nelson *et al.*, 2009).

3
4 The prices of beef, pork and poultry are also projected to increase significantly under A2 inputs simulated in CSIRO
5 and NCAR models. Accordingly, in addition to the projected price increases, under no-climate-change scenario, of
6 33, 36, 35 percent for beef, pork and poultry respectively, 20, 18, 21 percent increases are projected under climate
7 change scenario for these three commodities respectively, without taking into account CO₂ fertilization ((Nelson *et*
8 *al.*, 2009).

9
10 Other studies, using different models and scenario combinations, produce significantly different results in relation to
11 price projections. For example, a study undertaken by IFPRI using another model (called IMPACT) estimates
12 additional price increases (relative to no-climate change) of 32- 34 percent for maize (with baseline and pessimistic
13 socioeconomic scenarios), 18-20 percent for rice (with optimistic and pessimistic socioeconomic scenario) and 23-
14 24 percent for wheat (with baseline and pessimistic socioeconomic scenarios) ((Nelson *et al.*, 2010).

15
16 The projected production and price changes across regions will affect trade flows substantially. Without climate
17 change, net developed-country exports (of rice, wheat, maize, millet, sorghum, and other grains) to developing
18 countries are expected to increase by 22.4 million mt, from 83.4 million mt to 105.8 million mt between 2000 and
19 2050, representing a growth of 27 percent (Nelson *et al.*, 2009). Climate change might lead to an additional export
20 volume of 0.9 million mt (with wetter NCAR scenario) to 39.9 million mt (with drier CSIRO scenario) (Nelson *et*
21 *al.*, 2009). Developed-country exports are projected to increase by an additional 12 to 18 percent relative to no
22 climate change if CO₂ fertilization is taken into account (Nelson *et al.*, 2009). Regions such as South Asia, East
23 Asia and Pacific are projected to increase their imports substantially over this period. For example, South Asia
24 which exported around 15 million mt in 2000 is expected to import up to 54 million mt (with drier CSIRO scenario)
25 (Nelson *et al.*, 2009). By 2050, the Middle East and North Africa region and Sub-Saharan Africa which are already
26 net importers of cereals are estimated to increase the volumes of cereals imports by 29 and 30 percent, respectively
27 (Nelson *et al.*, 2009). In addition, due to climate impacts on prices, trade flow values will increase even at higher
28 rates than trade volumes.

29
30 However, there are other models producing substantially different projections for developed country cereals exports.
31 For example, MIROC scenario (produced by the Center for Climate System Research, University of Tokyo) with
32 A1B-induced production effects on U.S. maize production project a radical decline in net maize exports by up to 70
33 percent by 2050 (Nelson *et al.*, 2010). This is in sharp contrast to the projection that U.S. exports would double
34 under no-climate change scenario (Nelson *et al.*, 2010). These different projections underline the high degree of
35 uncertainty in the climate scenarios and the potential role of international trade in mitigating the effects of climate
36 change on agricultural productivity.

37
38 It is projected that additional food deficits caused by climate change will be supplied, fully or partly, through trade
39 and food aid from surplus regions (Nelson *et al.*, 2009; Huang, et al., 2011:12; Jankowska, et al 2012) This would
40 place additional pressure on food aid agencies, which have already been struggling to deliver aid in an environment
41 of growing scale of poverty and malnutrition due to the recent price hikes and of historical volatility in food aid
42 supplies (Barrett and Maxwell, 2006; Harvey, et al. 2010)

43
44 The potential role that trade could play in mitigating the impacts of climate change will also be affected by
45 countries' trade policies. In the period of the 1980s and 1990s, global agricultural trade was largely shaped by
46 market distortions caused by border protection measures (in the form of tariff barriers) imposed by both developing
47 and developed countries, and by export subsidies and domestic support measures of OECD countries (OECD,2010;
48 Aksoy and Ng, 2010). However, with the recent price hikes, agricultural trade regulation has entered a new era of
49 lower domestic price support, lower applied tariffs, and increasingly frequent export restrictions (Anderson and
50 Martin 2011; Huang, et al., 2011; Karapinar 2010). For example, during the 'food crisis' of 2007–2008, dozens of
51 countries imposed various forms of export restrictions on food staples, in order to maintain domestic availability of
52 supplies, which created additional volatility in global markets (FAO, 2008; Anderson and Nelgen, 2012; Headey,
53 2011; Karapinar, 2011, 2012). The emerging literature on the subjects illustrates that deepening agricultural markets
54 through trade reform and improved market access as well as by investing in additional supply capacity of small-

1 scale farms in developing countries could help reduce market volatility and mitigate supply shortages which might
2 be caused by climate change (UNEP, 2009; WTO, 2009).

5 9.3.3.2.3. *Investment*

7 Climate change may also affect investment patterns in rural areas. On the one hand, countries, regions and sectors
8 that are expected to be affected adversely by climate change may have difficulty attracting investment. On the other
9 hand, ecological zones that will become favourable due to climate change are expected to see increasing inflow of
10 investment. For example the recent price hikes in agricultural commodities have led to new initiatives of foreign
11 direct investment (FDI) in the form of large-scale crop production in poor countries (Anseeuw *et al.*, 2012; World
12 Bank, 2010). This type of FDI seems to follow a new pattern whereby capital-endowed countries with high imports
13 of food or feed crops are preparing to invest in large production projects in low-income countries endowed with
14 low-cost labour force, land and water resources. Climate change may lead to similar investment patterns. However,
15 there is a risk that these new investments might not be integrated into local structures and the local populations
16 becoming increasingly vulnerable as they might lose access to vital assets such as land and water (Anseeuw *et al.*,
17 2012). On the other hand, if FDI comes with a basket of new technology, business connections, infrastructure and
18 human capital, and if such investments lead to local business development and employment generation, they could
19 bring substantial benefits to the host country (World Bank, 2010).

21 Climate change will also lead to investment in clean energy technologies. Investments in renewable energy sources,
22 such as wind and solar, are often located in rural areas which may create employment opportunities for rural areas
23 (second order impact) (del Río and Burguillo, 2008).

26 9.3.3.2.4. *Knowledge*

28 Rural areas, as never before, are exposed to diffusion of knowledge through migration, trade and investment flows,
29 technology transfers, and improved communication and transport facilities (IFAD, 2010). Future impacts of climate
30 change on these channels of integration will affect the pace and intensity of knowledge transfers. For example,
31 increased transport and communication connectivity can reduce disaster risk by providing a greater diversity of
32 livelihood options and improving access to education (Pelling and Mustafa 2010). Similarly, if trade, migration and
33 investment flows will be intensified as a result of climate change, this will inevitably have a positive impact on
34 knowledge transfer to rural areas.

37 9.3.3.3. *Second-Order Impacts of Climate Policy*

39 Climate policies, both for mitigation and adaptation, will have secondary and often unforeseen impacts on rural
40 people.

42 One example is the possibility of use of GMOs as an adaptive strategy in agriculture. Where GMOs are considered
43 as a plausible strategy for rural areas, choices about biotechnology will play a defining role in shaping the future of
44 rural places. This future might be characterised by increased differentiation among commodity sectors and between
45 large and small farms, spatial differentiation between GM and non-GM areas, increased economic vulnerability of
46 producers if consumer resistance to GMOs continues, and increasing social tensions between GM and non-GM
47 producers (Cocklin *et al.*, 2008). All this will impact rural spaces.

49 The promotion of biofuel crops as a source of energy in substitution of fossil fuels will also have impacts on rural
50 areas (land-use change) and agriculture. Calls for future policies to support a switch to biofuel production indicate
51 how current concern about climate change will manifest as future landscape change (Dockerty *et al.*, 2006).

52 Concerns already expressed about the impact of biofuel production on food security due to increase in food prices,
53 increasing land concentration (and land grabs), and competition for water (Eide, 2008; also Müller *et al.*, 2008).

54 Model potential production and implications of a global biofuels industry: estimate production at the end of the

1 century will reach 220-270 exajoules in a reference scenario, and 320-370 exajoules under a global effort to mitigate
2 greenhouse gas emissions. They recognise the need for a high land conversion rate to achieve this (Gurgel *et al.*,
3 2007). The need to work towards increasing energy supply from renewable resources as responses to climate
4 change, will in time manifest themselves in landscape changes, whether it be through the granting of planning
5 consents for wind farms, the creation of a market for energy crops, structural changes in coastal defences, etc.
6 (Dockerty *et al.*, 2006).

9 9.3.4. Valuation of Climate Impacts

11 This section assesses literature on climate change impacts through studies that have adopted various economic
12 methods for valuation of impact. The impacts of climate change are expected to be unequally distributed across the
13 globe, with developing countries at a disadvantage, given their geographical position, low adaptive capacities (Stern,
14 2007; World Bank, 2010a) and the significance of agriculture and natural resources to the economies and people
15 (World Bank, 2010b; Collier *et al.*, 2008). Both direct and indirect impacts have been projected, such as lower
16 agricultural productivity, increase in prices for major crops and rise in poverty (Hertel *et al.*, 2010), which have
17 implications for rural areas and rural communities. This section discusses literature on the valuation of impacts as
18 relevant for rural areas and arising from climate change, with reference to agriculture, fisheries and livestock, water
19 resources, GDP and rural economy, extreme weather events and sea level rise and health. There are various channels
20 through which changes in economic values may occur in rural areas, such as through changes in profitability, crop
21 and land values and loss of livelihoods of specific communities through changes in fisheries and tourism values.
22 Losses and gains in health status and nutrition, and wider economy-wide impacts such as changes in job availability
23 and urbanization also impact economic values that accrue to rural communities, the opportunities and the constraints
24 that rural communities experience and changes that rural landscapes undergo. The impact on availability of fresh
25 water resources is another major area of concern for the developing regions in particular. Climate change can
26 adversely impact poverty through multiple channels (Section 10.9, chapter 10, AR5).

28 Viewing impacts regionally, despite the ongoing debates around the uncertainty and limitations of valuation studies,
29 scholars generally agree that African countries could experience relatively high losses compared to countries in
30 other regions (World Bank, 2010b; Watkiss *et al.*, 2010; Collier *et al.*, 2008). These conclusions emerge across a
31 range of climate scenarios and models used by researchers. For instance, Watkiss *et al.* (2010) use the FUND model
32 for a business as usual scenario and a mitigation 450ppm 2 degrees scenario as generated by using the PAGE2002
33 model, while the World Bank uses a range of country specific models for calculating costs. Overall negative
34 consequences are seen for Africa and Asia, due to changes in rainfall patterns and increases in temperature (Müller
35 *et al.*, 2011). Though climate change would impact a range of sectors, water and agriculture are expected to be the
36 two most sensitive to climatic changes in Asia (Cruz *et al.*, 2007, Chapter 3 AR5). In South American countries,
37 higher temperatures and changes in precipitation patterns associated with climate change affect the process of land
38 degradation, compromising extensive agricultural areas in LAC countries. Research on climate change impacts in
39 rural North America has largely focused on the effects on agricultural production and on indigenous population,
40 many of whom rely directly on natural resources. Developed countries in Europe will be less affected than the
41 developing world (Tol *et al.*, 2004), with most of the climate sensitive sectors located in rural areas.

43 Valuation and costing of climate impacts, draws upon both monetary and non-monetary metrics. Most studies use
44 models that estimate aggregated costs or benefits from impacts to entire economies, or to a few sectors, expressed in
45 relation to a country's gross domestic product (GDP) (Stage, 2010; Watkiss, 2011). Values which are aggregated
46 across sectors generalise across multiple contexts and could mask particular circumstances that could be significant
47 to specific locations, while expressing outcomes in aggregated GDP terms. This is a matter of concern for
48 economies in Africa and Asia, where subsistence production continues to play a key role in rural livelihoods.
49 Valuation of non marketed ecosystem services poses further methodological and empirical concerns (Dasgupta,
50 2008; Dasgupta *et al.*, 2009; Watkiss, 2011; Stage, 2010).

52 Illustrative regional and sub-regional estimates for the value of impacts of climate change are presented here.
53 Estimates for agriculture in most cases relate directly to rural lives. A range of other impacts on which available
54 information exists is also considered, since these values and costs concern significant proportions of livelihoods and

1 assets in rural areas. It is also to be noted that available literature concentrates on certain sectors and a few countries.
2 For instance, research on specific rural populations is less developed than for particular sectors that are largely
3 located in rural spaces such as agriculture. Limited information is available on West Asia and Pacific islands, on
4 health impacts for both Africa and Asia, small and poor communities of the Arctic (Furgal and Seguin 2006, Furgal
5 and Prowse, 2008; Ford and Pearce, 2010).

6 7 8 9.3.4.1. *Agriculture* 9

10 Changes in agricultural production will have corresponding impacts on incomes and wellbeing of rural peoples. The
11 largest known economic impact of climate change is upon agriculture because of the size and sensitivity of the
12 sector, particularly in the developing world. A large number of studies to evaluate the impacts on the agricultural
13 sector and its ramifications for communities have been conducted at various scales, ranging from micro level farm
14 models to large scale regional and country level climate cum socio- economic scenario modeling exercises. Some of
15 these also report values for associated economic losses. Since models are simplifications of complex real world
16 phenomena, different models tend to highlight different aspects of impacts and their consequent economic values.
17 For instance, in estimating economic losses the Ricardian method has been used widely to study climate change
18 impacts in agriculture and inbuilt adaptation. However, often such analysis does not incorporate features like
19 technological progress, relative price changes, agricultural policy and other dynamic characteristics. Similarly on the
20 bio-physical impacts side, changes in the El Niño/Southern Oscillation (ENSO) statistics may also have serious
21 economic implications for the agricultural sector in certain countries such as in Latin America. However, ENSO
22 responses differ strongly across climate models, and at the current stage of understanding do not allow conclusions
23 to be drawn on how global warming will affect the Tropical Pacific climate system (Latif and Keenlyside, 2009). A
24 sample of the available studies is provided in Table 9-4, since it is beyond the scope of the chapter to present the
25 entire literature.

26
27 [INSERT TABLE 9-4 HERE

28 Table 9-4: Illustrative sample of studies on economic value and changes in value from climate change.]
29
30

31 9.3.4.2. *Fisheries, Livestock, Mining* 32

33 Fisheries are significant ecosystems that are vulnerable to climate change impacts and have implications for rural
34 livelihoods and food security (Section 7.3.2.5, Chapter 7, AR5, Allison *et al.*, 2009, Section 9.3.3.1 current chapter).
35 Climate change can also have significant impacts on livestock keeping (Section 9.3.3.1 current chapter).

36
37 Some relatively less researched areas which may impact the livelihoods of rural communities include mining and
38 ranching. Pearce *et al.* (2011) highlight the current and ongoing vulnerability of mining and mining communities in
39 Canada, often rural and with few other economic activities, to climate change. Current and past infrastructure for
40 mines was built under a no-climate change presumption and economic and ecological vulnerabilities as a result are
41 substantial, and industry actors are unprepared to deal with this. Findings (Franco *et al.*, 2011) reveal significant
42 declines in forage for ranching under all climate scenarios (B1 and A2) considered for California. The dairy sector in
43 California is predicted to lose \$287-902 million annually to climate impacts by the end of the century (Lal *et al.*,
44 2011).

45 46 47 9.3.4.3. *Water Resources* 48

49 The changes in valuation of water resources due to climate change arise from expected impacts on populations
50 dependent on these water resources and these will be felt in several parts of the world (Sections 3.4.9, 3.5 and 3.8,
51 Chapter 3, AR5). While monetary estimates of the losses are few and not generalisable, estimates are available on
52 the number of people that are expected to be adversely impacted in terms of direct access to water resources by
53 communities and also indirectly on food security (Section 9.3.3.1, current chapter).
54

1
2 9.3.4.4. *GDP and Economy-Wide Impacts*
3

4 All the sub regions of Asia-Pacific are expected to become warmer due to climate change. Incidence of extreme
5 weather events is also expected to increase which would reduce the agricultural GDP of all countries in the region
6 especially in South and Southeast Asia (ADB and IFPRI, 2009). In a regional review of economics of climate
7 change in four south East Asian countries of Indonesia, Philippines, Thailand and Vietnam, ADB suggests that
8 climate change would result in a mean annual loss of 2.2% of GDP by 2100 if only market related impact is
9 accounted. If non market impacts related to health and ecosystems are also accounted for, then it would result in
10 5.7% annual loss of GDP for the same period (ADB, 2009a). Bigano *et al.* (2008) suggest that the predicted 25cm
11 rise in sea level alone would result in a GDP loss of 0.1% in southeast Asia by 2050. Another estimate suggests that
12 four Asian countries of Bangladesh, India, Philippines and Vietnam had a cumulative loss of \$20billion due to
13 natural disasters in the last decade, which makes them quite sensitive to climate risks (ADB, 2009 b). In case of
14 Bangladesh, which is extremely vulnerable to climate change because of a large area less than 5 metres above sea
15 level, a single severe cyclone could result in damages worth \$9 billion by 2050 accounting for 0.6% of the country's
16 GDP (ibid.) Most of the impacted regions are rural, and coastal. Thus the implied losses in GDP become relevant
17 for the rural communities in these countries.
18

19 Coastal and island rural communities throughout North America are less able to afford major infrastructure
20 improvements and will thus be more vulnerable to the effects of sea level rise, including waterborne and food borne
21 diseases, water table salinity, and diminished storm protection from affected reefs and wetlands, but detailed costs
22 are very site-specific (Hess *et al.*, 2008). Cordalis *et al.* (2007) discuss the climate vulnerabilities and policy
23 complexities facing Native American tribes and note that moving villages where needed could cost billions of
24 dollars.
25

26 In Arctic Canada and Alaska, infrastructure built for very cold weather will deteriorate as the air and ground warm.
27 Larsen *et al.* (2008) estimate increases in public infrastructure costs of 10-20 percent through 2030 and 10% through
28 2080 for Alaska, amounting to several billion dollars, much of it to be spent outside of urban centers. The climate
29 models used were part of the IPCC's coordinated AOGCM model inter-comparison project and the underlying
30 model assumptions are based on a middle-of-the-road "A1B" emissions and growth scenario defined by the IPCC.
31 Lemmen *et al.* (2007) reports that foundation fixes alone in the largely rural Northwest Territories could cost up to
32 CAN\$420 million, and that nearly all of Northern Canada's extensive winter road network, which supplies rural
33 communities and supports extractive industries which bring billions of dollars to the Canadian economy annually, is
34 at risk. Replacing it with all-weather roadways is estimated to cost CAN\$85,000/km.
35
36

37 9.3.4.5. *Extreme Weather Events, Sea-Level Rise*
38

39 The main climate change related extreme events that can cause changes in economic values in rural areas include
40 heat waves and droughts, storms, inundation and flooding (Stern 2007; Handmer *et al.*, 2012; Section 3.4.9, Chapter
41 3, AR5). A detailed discussion on the costs of climate extremes and disasters is set out by Handmer *et al.*, 2012.
42 Costs can be of two kinds: losses or damage costs and costs of adaptation. While some of the costs lend themselves
43 to monetary valuation (such as infrastructure costs) others cannot be easily estimated such as the value of lives lost
44 and the value of eco system services lost (for discussion on the methodologies for valuing costs refer to Handmer *et al.*
45 *et al.*, 2012: Section 4.5.3).
46

47 Damage costs of floods and droughts (Section 10.3.1, chapter 10, AR5) and from rise in water levels in Europe
48 (Swiss Re, 2009a) demonstrate the cost implications for rural communities in the developed regions of the world.
49 Studies mapping the adverse impacts in UK and Europe show a range of sectors that are impacted in rural areas
50 particularly due to drought in Europe and flooding in UK. For instance, major impacts hit farming and forestry with
51 an estimated \$15 billion production lost through drought, heat stress and fire (Munich Re 2004), the worst effect
52 being on summer crops in Mediterranean regions (Giannakouopoulos *et al.*, 2009). Longer term adaptation could
53 reduce the severity of losses but could include displacement of agricultural and forestry production from Southern
54 Europe to the North. The UK Government's Foresight Programme (2004) estimates that global warming of 3 to 4 °C

1 could increase flood damage from 0.1% up to 0.4% of GDP. In Europe costs could rise from \$10 billion today to
2 \$120-150 billion by 2100. With strengthened flood defences these costs may only double. Much of the investment in
3 flood defences and coastal protection would be in rural coastal areas.
4

5 Several studies from the developing countries provide evidence on the substantial costs rural communities in
6 particular face in these countries. Salinity and salt water intrusion have implications for rural livelihoods as they
7 impact both fisheries and agriculture (Section 5.5.3, Chapter 5, AR5). Sea level rise also leads to wetland loss and
8 coastal erosion. A few illustrations of the range of impacts of relevance for the rural economy are provided here.
9 Loss of agricultural land and changes in the saline-freshwater interface is estimated to impact the economies of
10 Africa adversely (SEI, 2009, S. Dasgupta *et al.*, 2007). Ahmed *et al.*, (2009) suggest that for households,
11 characterized as agricultural self-employed (95% or more income from farm income), climate volatility increases
12 poverty rate in some African countries. They also find that on simulating the effect of climate extremes on poverty
13 in Mexico using the SRES A2 scenario as generated by CMIP3 multi-model dataset, rural poverty increases by 43-
14 52% following a single climate shock. Kronik and Verner (2010) note that some 12% of Mexico's population is
15 indigenous and that these rural subsistence communities are more vulnerable to extreme weather events and often
16 depend on climate-sensitive crops like coffee. Studying extreme events Boyd and Ibarraán (2009) use a CGE model
17 to simulate the effects of a long drought on the Mexican economy and find declines in production of 10-20% across
18 a variety of agricultural sectors.
19
20

21 9.3.4.6. *Recreation and Tourism; Forestry*

22

23 Studies assessing the changes in economic value of recreation and tourism due to climate change are relatively fewer
24 in number (Coastal tourism is discussed in Section 5.4.4.2, Chapter 5, AR5). While some studies locate an increase
25 in values for certain regions others estimate shifts in tourism and losses (Bigano *et al.*, 2007; Hamilton *et al.*, 2005;
26 Beniston, 2010), methodological challenges and contrasting findings for the short and long run pose problems in
27 generalizing findings (economic values for recreation and tourism are discussed in Section 10.6, Chapter 10, AR5).
28 Change in economic values will impact rural communities (Lal *et al.*, 2011), with the linkages between biodiversity,
29 tourism and rural livelihoods and rural landscapes being an established one both for developing and developed
30 countries (Nyaupane and Poulde 2011, Scott *et al.*, 2007, Hein *et al.*, 2009).
31

32 It has been argued that climate change would have adverse impacts on various ecosystems, including forests and
33 biodiversity in many regions of the world (AR4; Stern, 2007; Eliasch, 2008; Ogawa-Onishi *et al.*, 2010; ADB,
34 2009a; Tran *et al.*, 2010; Preston *et al.*, 2006) and these will have implications for rural livelihoods and economies
35 (Chopra and Dasgupta, 2008; Safranyik and Wilson, 2006; Kurz *et al.*, 2008; Walton, 2010). However, monetary
36 valuation of changes in non-marketed ecosystem services due to climate change continue to pose a challenge to
37 researchers.
38
39

40 9.3.4.7. *Health*

41

42 Some studies have looked at the health impacts in various regions of the world, however for the most part these do
43 not by and large distinguish the rural from the urban sector. Studies have examined the linkages between health and
44 climate change terms of the implications for vector-borne and waterborne diseases for Asia and Africa. No
45 comprehensive assessment of climate change effects on health in Africa or Asia has been conducted so far, and there
46 remain considerable gaps in knowledge (Costello *et al.*, 2009; Byass, 2009). In general it appears that the region of
47 Africa could be seriously affected if counter measures are not put in place (Byass, 2009; Costello *et al.*, 2009; Ebi,
48 2008; SEI, 2009) and that most climate change related health impacts are in children of rural areas in Sub-Saharan
49 Africa and Asia. As there is a lack of studies which consider rural areas specifically, the interested reader is referred
50 to chapter 11 for current sources of vulnerability (Section 11.3.1, Chapter 11, AR5) and major climate sensitive
51 health outcomes (section 11.2, Chapter 11, AR5). A discussion on the additional costs of treatment due to climate
52 related health outcomes is available in Section 10.8.2, chapter 10, AR5.
53
54

9.3.5. Key Vulnerabilities

9.3.5.1. Competing Definitions of Vulnerability

Discussions on climate vulnerability in rural areas is necessarily related to discussion on competing conceptualizations and terminologies of vulnerability, much of which arises from research based on case-studies located in rural areas. Different conceptualizations are important, because the policy prescriptions for rural areas derived from each are different (O'Brien *et al.*, 2007), if not contradictory. Two main type of vulnerability analysis/concepts/approaches exist (O'Brien *et al.*, 2007; Nelson *et al.*, 2010; Füssel, 2007):

- Vulnerability viewed as a combination of exposure to hazards, sensitivity and adaptive capacity (as in the AR4 Glossary), also called end-point or outcome vulnerability. The resulting policy options derived strongly emphasise new technologies as options to reduce vulnerability and enhance adaptive capacity. One important constraint of this approach is that vulnerabilities related to factors such as gender (Nelson *et al.*, 2002) or the status of indigenous people, tend to remain hidden (O'Brien *et al.*, 2009)
- Vulnerability viewed as pre-existing socio-economic factors that make populations vulnerable to extreme events (or climate change more broadly), also called starting-point interpretation or contextual vulnerability, emphasizing climate change interactions with multiple processes of change and thus widening the boundaries of the research. It is assumed that vulnerability arise less from physical sensitivities of the resource base that supports the human system than from the social, economic and political facts that affect how the human system interacts with the resource base. The resulting policy options have a strong focus on diversity and local knowledges (Brondizio and Moran, 2008). This type of assessment has grown in the last few years.

In line with these interpretations, to measure vulnerability both inductive and deductive methods exist (Nelson *et al.* 2010) and approaches vary from what is called a vulnerability variable, unicriterial or econometric assessment, e.g. centered on examining changes in agricultural yield; or a vulnerability indicator or multicriterial approach, (Gbetibouo *et al.*, 2010). The selection of the type of indicators is also affected by these two approaches, since a number of judgments have to be made when translating the concepts into estimates of vulnerability (Heltberg and Bonch-Osmolovskiy, 2011). For instance, wealth has been widely used to define human vulnerability, but an indicator of equity in income distribution has recently been suggested as a more important factor (Lioubimtseva and Henebry, 2009).

9.3.5.1.1. Vulnerability or resilience

Recent discussions in this field relate to whether studies should be centered in the analysis of vulnerability or resilience. Here again the focus is different, since vulnerability implies a key role for targeted international development assistance in helping the rural poor while resilience research enhances more bottom-up forms of assistance that allow adaptive capacities and flexible governance structures. Resilience research considers that conventional development assistance can exacerbate vulnerability before and after shocks (McSweeney and Coomes, 2011). In that manner, sources of vulnerability at one point in time can be sources of resilience in another.

9.3.5.2. Vulnerability in Rural Areas: Debates

The stresses that climate change hazards will create for rural livelihoods will have two major aspects: reduction of existing livelihood options, and greater volatility and unpredictability in streams of livelihoods benefits, especially in semi arid, mountainous, polar, and coastal ecological environments (Agrawal and Perrin, 2008). It is widely agreed that rural areas are among the most vulnerable to climate changes since two thirds of the world's poor live in rural areas, they lack access to important goods, services (including health (Horton *et al.*, 2010) and education) and information (Casillas and Kammen, 2010), a big proportion of their livelihoods derive from nature-dependent activities. On the other hand, because rural communities have always been exposed to climate risk they are often highly adapted to it (R. Nelson *et al.*, 2010). For instance, Ruel *et al.*, (2009) suggest that the urban poor are

1 disproportionately more vulnerable to recent food, fuel and financial crises, of which climate change is an
2 exacerbating factor.

3
4 Vulnerability in rural areas can be aggravated by non-climate factors, such as:

- 5 • physical geography, e.g. desert or semi-desert conditions (Lioubimtseva and Henebry, 2009), remoteness
6 (Horton, *et al.*, 2010), level of dependence on climate conditions (Brondizio and Moran, 2008));
- 7 • economic constraints and poverty (Ahmed *et al.*, 2011; Macdonald *et al.*, 2009; Mertz *et al.*, 2009; Mertz
8 *et al.*, 2009);
- 9 • gender inequalities (V. Nelson *et al.*, 2002);
- 10 • social, economic and institutional instability and changes (e.g. urbanization, industrialization, female-
11 headed households, landlessness, short-time policy horizons, low literacy, high share of agriculture in
12 GDP), demographic changes, HIV/AIDS, access and availability of food, density of social networks,
13 memories of past climate variations, knowledge and long-term residence in the region (Macdonald *et al.*,
14 2009; Mougou *et al.*, 2011; Ruel *et al.*, 2010; Sallu *et al.*, 2010; Simelton *et al.*, 2009; Mertz *et al.*, 2009;
15 Parks and Roberts, 2006; Gbetibouo *et al.*, 2010; Ahmed *et al.*, 2011; Cooper *et al.*, 2008; Brondizio and
16 Moran, 2008)).

17
18 These factors can operate at both individual and community levels (Eakin and Wehbe, 2009).

19
20 However, the adoption of different approaches in the analysis of vulnerability and the acknowledgment that
21 vulnerability is in many cases an extremely local circumstance, results in contradictory findings with regard to
22 vulnerability in rural areas. For instance, although poverty has always been considered a clear factor increasing
23 vulnerability to climate change, McSweeney and Coomes (2011) found that climate-related disasters can change the
24 structural factors, fostering local capacities for endogenous institutional changes that enhance community resilience,
25 increasing intergenerational equity and long-term ecological sustainability. Also Brouwer *et al.* (2007) found that
26 vulnerability to flooding in Bangladesh in terms of damage suffered was lower for households that fully depended
27 on natural resources than those who did not fully depend on natural resources. Osbahr *et al.* (2008) found that
28 diversification in rural areas does not always reduce vulnerability and can increase inequity in one community if
29 they are not accompanied by reciprocity.

30
31 In general, there are low levels of agreement on some of the key factors associated with vulnerability or resilience in
32 rural areas, including rainfed as opposed to irrigated agriculture, small-scale and family-managed farms, and
33 integration into world markets. There is greater agreement on the importance for resilience of access to land and
34 natural resources, flexible local institutions, and knowledge and information, and the association of gender
35 inequalities with vulnerability.

36 37 38 9.3.5.2.1. *Irrigation*

39
40 Past research has tended to agree that rain-fed agriculture is more vulnerable to climate change (Bellon *et al.* 2011)
41 and that irrigation is needed to decrease that vulnerability (Gbetibouo *et al.*, 2010). More recent findings suggest that
42 this is context-dependent and irrigation has been found to increase vulnerability in certain cases (Lioubimtseva and
43 Henebry, 2009; Eakin, 2005). Cooper *et al.* (2008) concluded that in rainfed Sub-Saharan Africa the focus should be
44 on improving productivity of rain-fed agriculture instead of irrigation as irrigation schemes are also being threatened
45 by drought, and Ahmed *et al.* (2011) emphasise the role of drought-tolerant crops.

46 47 48 9.3.5.2.2. *Scale of farming systems*

49
50 Some authors suggest that high reliance on small-scale farming increases the vulnerability of communities in rural
51 areas (Bellon *et al.*, 2011; Gbetibouo *et al.*, 2010) although it is suggested that their resilience capacity (stemming
52 from factors such as indigenous knowledge, family labour, livelihood diversification) should not be underestimated.
53 On the contrary, Brondizio and Moran (2008) indicate that small farmers are less vulnerable than large,
54 monocropping farmers when climatic variations make an area inappropriate for a particular crop, because they tend

1 to cultivate multiple crops. However, they recognize that small farmers tend to suffer from technological limitations,
2 low access to extension services, and market disadvantages. Mertz *et al.* (2009) suggest that small farmers are highly
3 resilient as they have shown along history facing numerous changes and suggest that the value of local knowledge in
4 climate change studies has received little attention. To Eakin (2005), the shift in support agriculture from
5 subsistence to commercial agriculture suffered in Mexico reduced smallholders resilience for climatic variations.
6
7

8 9.3.5.2.3. *Livestock and pastoralism*

9

10 Although the intersection of climate change with livestock systems and pastoralism has been a relatively neglected
11 research area (Thornton *et al.*, 2009), it is widely recognized that pastoralists face specific constraints that make
12 them particularly vulnerable (Macdonald *et al.*, 2009; Cooper *et al.*, 2008). On one hand, mobility is claimed to be
13 an excellent strategy to reduce vulnerability to certain climate stressors. Jones and Thornton (2009) suggest that in
14 marginal areas of Africa where agriculture is becoming increasingly difficult, livestock may become a future
15 alternative, and to Sallu *et al.* (2010) investment in and accumulation of physical assets, including land and
16 livestock, is a form to decrease vulnerability. Brooks *et al.* (2009) suggest that in semi-arid environments mobile
17 pastoralism could be rehabilitated. According to Lioubimtseva and Henebry (2009) and Fraser *et al.*, (2011) the
18 decline of livestock and traditional practices such as mobility increases vulnerability of people in arid and semiarid
19 regions. On the other hand, a range of social, economic, environmental and political changes threaten the activity or
20 makes it more vulnerable. For instance, the lack of recognition of grazing rights, land privatization (and grabbing)
21 processes, increased rainfall variability, drought and flooding or the perception that pastoralists are backward, are
22 important barriers to this activity (Dougill *et al.*, 2010). Furthermore, the lack of other alternatives in certain
23 marginal areas where animals are the only secure assets can lead to overstocking and overgrazing, and thus, to
24 increase the vulnerability of the pastoral activity (Cooper *et al.*, 2008).
25
26

27 9.3.5.2.4. *Development strategies, trade, external market integration*

28

29 Another point of discussion is the linkages between development trends, market integration and climate change and
30 how they impact vulnerability. In terms of trade, some authors argue that opening markets to international trade
31 increases vulnerabilities of small farmers and poor people. Market integration reduced the capacity of indigenous
32 systems for dealing with climate risk in Bolivia (Valdivia *et al.*, 2010) and Mozambique (Eriksen and Silva, 2009),
33 and shifting towards cash-cropping a narrow range of commodities has favoured dryland degradation in the Sahel
34 (Fraser *et al.*, 2011) and Honduras (McSweeney and Coomes, 2011), by accelerating socioeconomic stratification or
35 focusing incomes in a single crop. Ruel *et al.* (2010) suggest that excessive dependence of cash income increases
36 vulnerability of the urban poor compared with the rural poor, who can have access to other type of assets. On the
37 other hand, Jones and Thornton (2009) estimated that rainfed mix crop/livestock areas in sub-Saharan Africa which
38 are far from large markets have higher poverty rates and thus, conclude they are more vulnerable to climate change.
39 Also Gbetibou *et al.* (2010) proposed increased market participation as a valid measure to reduce vulnerability of
40 vulnerable regions in South Africa as calculated by a vulnerability index.
41

42 According to Brooks *et al.* (2009) the dominant development paradigm favoring transitions from tradition to
43 modernization, economic growth and globalization, does not favor action under uncertainty, a point also relevant in
44 agricultural activities (Rivera-Ferre and Ortega-Cerdà, 2011). Climate change is mostly seen as something that
45 *affects* development, tackling environmental considerations onto policies. Brooks *et al.* (2009) suggest the need of
46 new models of development built *around* environmental constraints and opportunities which search for a balance
47 between productivity and resilience. McSweeney and Coomers (2011) suggest development priority should aim at
48 ensuring a favorable context for the emergence of informal networks and endogenous solutions. Enhancement of
49 social networks is also an important element to tackle vulnerability.
50

51 Also relevant is the discussion about famine relief as a controversial strategy that increases vulnerability of poor
52 people. Food relief favors sedentarization, which constrains mobile livelihoods and also makes it more difficult for
53 women access resources such as fuelwood and water (V. Nelson *et al.*, 2002). Also, MacDonald *et al.* (2009) state
54 that “the ‘food-first’ culture that dominates vulnerability assessments and emergency response in most African

1 countries ignores the impact of water insecurity on livelihoods, and the role that water interventions can play in
2 reducing immediate and longer-term vulnerability”.

3
4
5 9.3.5.2.5. *Access to resources*

6
7 Lack of access to assets, among which land is an important one, is accepted to be an important factor increasing
8 vulnerability in rural people. The breakdown of traditional land tenure systems increases vulnerability (Fraser *et al.*
9 2011). Dougill *et al.* (2010) suggest that although land privatization in Botswana has increased vulnerability of
10 poorer communal pastoralist, it has helped the wealthier farmers, remaining a route to enhance resilience as this
11 private land-owning group has become less vulnerable.

12
13
14 9.3.5.2.6. *Vulnerability and institutions*

15
16 Vulnerability and livelihood security are closely linked to the institutional environment. Institutions can increase
17 (Eakin, 2005) or reduce vulnerability to climate change. For that reason it is important to foster research on the role
18 of local institutions in vulnerability and the way in which local and external institutions can be articulated (Agrawal
19 and Perrin, 2008; Berman *et al.*, 2012). Anderson *et al.* (2010) associate flexible local institutions in dryland
20 societies, primarily for resource management, with resilience to climate change.

21
22
23 9.3.5.2.7. *Knowledge and information*

24
25 Lack of information and knowledge of rural people is suggested as a factor that increases vulnerability, mostly
26 among poor people. What is not so much agreed in the literature is what type of knowledge is best to reduce
27 vulnerability. Valdivia *et al.*, (2010) suggest the need for local responses and indigenous knowledge to reduce
28 vulnerability, while Bellon *et al.*, (2011) state that local knowledge and traditional institutions are too local, and in
29 some contexts gathering information from further away is important. They find that to face the forecasted climatic
30 changes, the geographical area of exchange of seeds should be larger than the one covered by the traditional systems
31 of seed exchange. Access to information is not always a guarantee of success either. Coles and Scott (2009) found
32 that in Arizona, despite ample access to weather forecasting, ranchers did not rely on such information, implying
33 that changes are required to make more attractive information to users.

34
35
36 9.3.5.2.8. *Migration*

37
38 The issue of migration relates to vulnerability in two ways, depending on the context and situations. Vulnerable
39 people tend to migrate, and this is both a coping and adapting strategy, depending on the temporal scale of that
40 migration. The places they leave can reduce the vulnerability if migrants send remittances, or can increase it if the
41 burden of work, usually for women, also increases. Social networks, essential to reduce vulnerability, are also
42 affected reducing the transmission of traditional knowledge (Valdivia *et al.*, 2010). Furthermore, those places
43 receiving migrants change their population pattern which in some cases can also affect their vulnerability, or
44 experience an excessive demographic growth, which increases pressure over scarce resources, as it is being
45 experienced in the semiarid tropics (Cooper *et al.*, 2008). Brondizio and Moran (2008) found that in-migration in the
46 Amazon brought people with knowledge that is ill-adapted to the local environment.

47
48
49 9.3.5.2.9. *Gender*

50
51 Gender issues were a “latecomer” to the climate debate (Denton, 2004), but vulnerability reflects gender-related
52 inequalities that pervade in the developing world (Denton, 2002; Vincent *et al.*, 2010; Nelson and Stathers, 2009).
53 Gender differences in roles, responsibilities and capabilities mean that climate change may actually reinforce
54 disparities between men and women (Vincent *et al.*, 2010). These points are demonstrated by cases from rural

1 Africa. In the context of climate change-induced conflicts among the Turkana pastoralists of Kenya, women are
2 likely to be more adversely affected than men (Omolo, 2011). Female-headed households in drought-prone rural
3 Zimbabwe are disadvantaged in terms of access to land, access to markets, and access to productive labour (given
4 women's time sharing with reproductive labour), hence more vulnerable than their male-headed counterparts
5 (Huisman, 2005). African women farmers have typically not benefited from government interventions to increase
6 production, such as support for cash cropping and non-farm enterprises – since cash income is seen as a male
7 activity – hence reinforcing their vulnerability (Gladwin *et al.*, 2001). Climate change increases vulnerability
8 through male out-migration that increases the work to women; cropping and livestock changes that affect gender
9 division of labor; increased difficulty in accessing resources (fuelwood and water) and increased conflicts over
10 natural resources. Also health impacts increase work for women as carers (V. Nelson *et al.*, 2002).

13 9.4. Adaptation and Managing Risks

15 9.4.1. Framing Adaptation

17 Adaptation is required where vulnerabilities are high and projected impacts severe. As the previous sections
18 outlined, rural areas in both developed and developing countries need to adapt to climate change. This process of
19 adaptation, and building capacity to adapt, is a dynamic process and should be linked to other development
20 initiatives aiming for poverty reduction or improvement of rural areas (Nielsen *et al.*, 2012; Hassan, 2010; Eriksen
21 and O'Brien, 2007). An analysis in Mali showed that policy support now for agriculture in a changing climate would
22 yield an annual gain of \$252million in economic benefits, as opposed to a \$161million loss without policy
23 adjustment (Tanveer *et al.*, 2006). Likewise in Ethiopia “low regrets” measures to respond to current variability are
24 important to shift the trajectory from disaster-focused to longer-term vulnerability reduction (Conway and Schipper,
25 2011). Economic and institutional development, improvements in health, education and infrastructure, growing
26 interconnectedness and technology transfers help rural societies develop their human and social capital which allows
27 them to deal with a range of risks including climate change.

29 Many adaptations build on examples of responses to past variability in resource availability, and it has been
30 suggested that the ability to cope with current climate variability is a prerequisite for adapting to future change
31 (Cooper *et al.*, 2008). At the same time, however, it cannot be assumed that past response strategies will be
32 sufficient to deal with the range of projected climate change. In some cases, existing coping strategies may increase
33 vulnerability to future climate change, by prioritising short-term resource availability (O'Brien *et al.*, 2008; Adepetu
34 and Berthe, 2007). Evidence of adaptation is found in agriculture, water, biodiversity and fisheries.

36 Agricultural societies have a history of responding to the impacts of change in exogenous factors, including (but not
37 limited to) weather and climate (Mertz *et al.*, 2009). They undertake a range of adjustment measures relating to their
38 farming practices (e.g. planting, harvesting and watering), crop and livestock varieties that they use, investment
39 decisions in relation to infrastructure, technologies and livelihoods, and such examples have been observed in
40 Nigeria and Mali (Adepetu and Berthe, 2007), Burkina Faso (Barbier *et al.*, 2009), Ghana (Gyampoh *et al.*, 2008),
41 Botswana (Dube and Sekhela, 2007), Ethiopia and South Africa (Bryan *et al.*, 2009; Baiphethi *et al.*, 2008; Thomas
42 *et al.*, 2007). Adaptations are also evident among livestock farmers, who use new varieties of fodder crops suited to
43 the changing conditions (Salema *et al.*, 2010), choose their animals based on the prevailing conditions (Kabubo-
44 Mariara, 2009, 2008), or modify grazing patterns, as has been observed in East Africa (Eriksen and Lind, 2009) and
45 southern Africa (O'Farrell *et al.*, 2009). Conservation agriculture shows promising results and can be used as an
46 adaptation (Nyala *et al.*, 2011) and for sustainable intensification of production (Pretty *et al.*, 2011), with significant
47 yield productions observed in South Asia and southern Africa (Erenstein *et al.*, 2012). In other cases, the potential
48 effectiveness of adaptation under future climate scenarios has been modeled, for example in Cameroon (Tingem and
49 Rivington, 2009), and for the African continent (Seo, 2011a). Water management for agriculture is also critical in
50 rural areas under climate change, for example the use of rainwater harvesting (Biacin *et al.*, 2011; Kahinda *et al.*,
51 2010, Vohland and Barry, 2009), and more efficient irrigation, particularly in rural drylands (Thomas, 2008).
52 Diversified farms are more resilient than specialized ones (Seo, 2010); but rural societies also diversify their income
53 sources beyond agriculture, which allows them to reduce their risk exposure. Examples include the exploitation of
54 gums and resins in Kenya (Gachathi and Eriksen, 2011). There may be some rural areas, however, where limits to

1 agricultural adaptation are reached, and thus the only option that remains is to migrate or diversify away from
2 farming (Mertz *et al.*, 2011).

3
4 As well as being an important input to agriculture, adaptation in water resources in general is critical in rural areas.
5 Given projected reductions in water availability, improved management is required. This can include demand- and
6 supply-side measures, for example through the use of dams, as has been proposed in the Volta River in Ghana (van
7 de Giesen *et al.*, 2010). The extent to which such adaptation measures have been implemented to date varies: in a
8 study from Europe, Africa and Asia, the Elbe and Rhine basins had the highest level of water resource management
9 measures in place, followed by the Orange and Guadiana, with lower levels in the Amu Darya and Nile Equatorial
10 Lakes (Krysanova *et al.*, 2010). In the Middle East and North Africa, whilst supply-side measures are advanced,
11 little attention has been paid to the demand-side measures that will be critical in a changing climate (Sowers *et al.*,
12 2010). In the cases of transboundary basins additional barriers exist to adaptive management measures, particularly
13 in Africa (Goulden *et al.*, 2009a), although examination of potential institutional designs has been undertaken
14 (Huntjens *et al.*, 2012). Where appropriate water management institutions exist and are effective, their role in
15 improving rural livelihoods has been demonstrated, for example in Tanzania's Great Ruaha basin (Kashaigili *et al.*,
16 2009). The need for effective water management for adaptation therefore exists not only at the basin level, but at a
17 higher resolution, for example in human settlements and towns (Mukheibir, 2008). Some potential for recharge of
18 groundwater as an adaptation measure has also been shown, for example in India (Sukhija, 2008).

19
20 Effective management is also essential for adaptation of forests and biodiversity to climate change. As with water
21 resources, forests can adapt through management of forest fires, silvicultural practices, and the conservation of
22 forest genetic resources. In Africa, the systematic analysis of current policies and practices in order to understand the
23 nature and extent of intervention required is often lacking (Fobissie *et al.*, 2009). Forest resources can play a role in
24 enabling adaptation during extreme events in Zambia, Mali and Tanzania, although should take place within a
25 managed context to ensure sustainability (Robledo *et al.*, 2011). As the climate changes, part of adaptive
26 management may entail modification of existing biodiversity management practices. In addition to land and water
27 management and law and policy, direct species management is important (Mawdsley *et al.*, 2009). In terms of
28 managing protected areas, to maintain appropriate habitats a network approach may be effective (Hole *et al.*, 2011).

29
30 Adaptation in marine ecosystems is also of relevance to rural areas. Bleaching of coral reefs through rising
31 temperatures causes habitat loss which, in turn, affects fisheries. Management through selective use of gear is a
32 recommended management measure, based on 15 global sites (Cinner *et al.*, 2009). As with other ecosystems, the
33 extent to which adaptation is required will depend on existing capacity. Of 5 countries in the southwestern Indian
34 Ocean, the environmental sensitivity in Mauritius is offset by the higher adaptive capacity, although the more
35 environmentally-sensitive parts of Madagascar will be priorities for intervention assistance (McClanahan *et al.*,
36 2009).

37
38 It is often the case that adaptation measures are implemented to address climate conditions as part of risk
39 management strategies of individuals, societies or governments. Government-provided safety nets lead to adaptive
40 social protection and can be used to scale up to meet unanticipated circumstances, such as those caused by climate
41 hazards (Alderman and Haque, 2006). There are possibilities of using social protection (cash transfers, asset
42 transfers and conditional cash transfers) to manage and reduce the risks of forced displacement resulting from
43 climate change by increasing the threshold for distress migration, as opposed to economic migration that is
44 voluntary (Johnson and Krishnamurthy, forthcoming). According to data from Suriname and French Guiana, when
45 shocks are extreme, irreversible, cumulative and co-variate, as in climate change, public welfare systems
46 complement informal risk-sharing arrangements. Government-provided safety nets reduce climate risks by
47 alleviating poverty, enabling new risk management strategies, and promoting human capital development
48 (Heemskerk *et al.*, 2004).

49
50 Integration across various types of schemes, such as for drought insurance, microfinance and social protection
51 programmes can prove effective as risk management strategies (Osgood and Warren, 2007; Conway and Schipper,
52 2011). Index based insurances are largely characterized by pilot schemes of limited areal extent, yet spatial pooling
53 of micro-insurance schemes reduce capital requirements and encourage micro-insurers to cover drought-related
54 losses (Meze-Hausken *et al.*, 2009). Index insurance has been trialled in a number of rural locations, including in

1 Malawi (Hochrainer *et al.*, 2009; Osgood *et al.*, 2008) and Ghana (Molini *et al.*, 2010). Microfinance can improve
2 delivery of adaptation financing to the grassroots, as in the case of Bangladesh and Nepal (Agrawala and Carraro,
3 2010).

4
5 In rural areas worldwide, with agriculture still playing an important role as the main source of livelihood, adaptation
6 and mitigation strategies are often inter-linked, and managing climate change related risks can simultaneously lead
7 to adaptation and mitigation (bearing in mind the greenhouse gas emissions from rural dwellers). Some authors
8 emphasize the role of new energy technologies as mitigation and adaptation strategies within agriculture and
9 forestry, with special relevance in rural areas (Povellato *et al.* 2007). For example, in western Kenya small-scale
10 experiments on agricultural production practices and domestic energy efficiency (the “smokeless kitchen”) can
11 mitigate climate change while increasing energy efficiency, health standards, food security, and community-based
12 adaptive capacity (Olsson and Jerneck, 2010).

13
14 Social capital, meaning the various networks and links that connect people, have been shown to play a major role in
15 resilience to climate change (as well as other idiosyncratic and covariate risks). In KwaZulu Natal, South Africa,
16 social capital-related failures, such as a breakdown in two-parent families, divergences between religious groups,
17 ambiguous leadership characterised by conflict, and changes in cultural norms have been linked to food insecurity
18 (Misselhorn, 2009). In Mexico, Guatemala and Honduras the existence and development of local networks among
19 farmers, service providers and information sources facilitates adaptation, particularly in the context of economic
20 liberalisation (Eakin *et al.*, 2006). That said, there are limits to the role of social capital in bringing about resilience,
21 particularly in the case of covariate shocks which affect a large proportion of the population. The scale of the 2000
22 Mozambique floods, for example, surpassed the response capacity in Limpopo basin communities not helped by
23 external aid – although supporting local support mechanisms was identified as appropriate to assist recovery
24 (Brouwer and Nhassengo, 2006).

25
26 Social capital has also been identified as critical to facilitate adaptation. Farmers’ decisions to adopt new crops
27 relates to the adoption choices of farmers in their social network, particularly within a religious network (Bandiera
28 and Rasul, 2006). However, the importance of social capital in facilitating adaptation varies among different groups
29 within the population, depending on their education levels and gender. A study of sunflower adoption in northern
30 Mozambique showed that adoption decisions of farmers with better information are less sensitive to the adoption
31 choices of others (Bandiera and Rasul, 2006). Women typically amass more social capital, and use this to manage
32 livelihood risks, including those from climate, and sometimes are successful in empowering themselves
33 economically (Goulden *et al.*, 2009; Vincent *et al.*, 2010).

34
35 Whilst social capital can be useful in supporting adaptation, it does not provide a panacea, and several cautionary
36 notes have arisen regarding its social differentiation. The sustainability of social capital-related adaptation actions is
37 scale-dependent. Research in Mozambique and South Africa showed that collective action adaptation options can
38 enhance livelihood resilience to climate change but others have negative spillover effects to other scales of analysis
39 – meaning that defining whether or not adaptation is successful is scale-dependent (Osbaht *et al.*, 2010). At the same
40 time there is evidence that the political dimensions of social capital are important in influencing adaptation. In
41 Kenya, for example, livelihood adjustments and adaptations are influenced through forming social relations and
42 political alliances to influence collective decision-making. In the face of drought and conflict, rural pastoralists form
43 relations aimed at retaining or strengthening their power, and adaptations tend to mirror existing power relations,
44 hence can reinforce inequality (Eriksen and Lind, 2009).

45
46 There are important gender dimensions to adaptation. Social institutions — laws, norms, traditions and codes of
47 conduct - have not only a direct impact on the economic role of women but also an indirect one through women’s
48 access to resources like education and health care (Morrison and Juetting, 2004), and are thus essential in promoting
49 adaptation. Computable general equilibrium (CGE) model evidence from Mozambique shows that agricultural
50 technology improvements benefit both men and women within rural households, and technological change in
51 cassava appears to be a particularly strong lever for increasing female and overall household welfare, especially
52 when risk is considered (Arndt and Tarp, 2000). Gender differences in the ability to adapt are also noted in other
53 sectors. Adaptation options such as rainwater harvesting and conservation are not gender-neutral, as they require
54 additional labour which women may not have (Baiphethi et al, 2008). Addressing this requires gender-sensitive

1 analysis of adaptation support, as has been done with water management in the Sister Watersheds project (with
2 Brazilian and Canadian partners), and in Kenya, Mozambique and South Africa (Figueiredo and Perkins, 2012). In
3 Tanzania, public investment in rural infrastructure, in the availability and technically efficient use of inputs, in a
4 good, gender-equal, education system and in the strengthening of social capital, agricultural extension and
5 microcredit services are the best means of improving the adaptation of farmers (Below *et al.*, 2012).
6
7

8 **9.4.2. Decision-making for Adaptation** 9

10 Decision-making for adaptation takes place at a variety of levels, and can be public or private or public. At the
11 national and local levels, law and policies can enable planned adaptation (Stuart-Hill and Schulze, 2010). Proposed
12 adaptation strategies in the water, biodiversity and fisheries sectors above fall within the realm of policies and
13 governance. To improve the robustness of such adaptations, understanding decision-making of rural people is
14 essential (Bryan *et al.*, 2009). For example, in Canada's North, communities use resources from "land and sea" for
15 their nutrition, livelihoods, and cultures (Van Oostdam *et al.*, 2005). Climate change has had a negative impact on
16 health and safety by warming ice in the winter and making it less stable for hunting, fishing, and traveling. Inuit
17 Tapiriit Kantami, Canada's national Inuit organization, has initiated a program with regional Inuit groups and
18 research groups in Canada to document changes in communities and means of adaptation. Similarly the role of
19 indigenous knowledge has been observed in the Sahel (Nyong *et al.*, 2007).
20

21 At the local level, many of the agricultural adaptations outlined above are examples of private decisions for
22 adaptation. These agricultural adaptation decisions are embedded in the inter-relationship of a variety of social
23 factors in which climate drivers are only one consideration (Crane *et al.*, 2011). An example of where public policy
24 can support private adaptation is in index-based insurance schemes. In Africa where understanding of insurance is
25 low, participation rates can be improved by using simulation games, as trialed in Ethiopia and Malawi, or by more
26 conventional training methods (Patt *et al.*, 2010). Data from India, Africa and South America shows that the trust
27 that people have in the insurance product and the organisations involved in selling and managing it may be more
28 important than economic factors, such as the size and timing of the premium and potential payouts (Patt *et al.*,
29 2009). Public policy also has a role to play in supporting gender-sensitive adaptation (Molua, 2009). However,
30 private decisions often take place in the context of national policies and laws, which are not always mutually-
31 supportive (Stringer *et al.*, 2009), especially in the agropastoral sector where settlement is encouraged (Awuor *et al.*,
32 2011).
33

34 One major difference between public and private decision-making is that that latter is typically more responsive. An
35 analysis of agricultural water schemes in South America, for example, found that private irrigation schemes increase
36 in response to a warmer climate, whereas public ones do not, and that they are taken gradually (Seo, 2011b).
37 Participatory stakeholder processes to inform public policy and law can take time. A case study of a resettlement
38 programme in Mozambique showed that farmers and policymakers disagreed about the seriousness of the climate
39 risks, and the potential negative consequences of proposed adaptive measures (Patt and Schroeter, 2008). In
40 Bangladesh, the ambitious national Flood Action Plan (FAP) did not receive support from NGOs, who embarked
41 upon an anti-FAP movement and attained what they perceived to be a more people-oriented national water policy,
42 (Mallick *et al.*, 2005).
43
44

45 **9.4.3. Practical Experiences of Adaptation in Rural Areas** 46

47 There have been a range of measures that facilitate adaption to climate change in rural areas around the world. These
48 include actual and planned adaptation measures to observed and expected changes in mean climate conditions,
49 variability and extreme events.
50

51 In Northern China, the negative effects of climate change such as "drought and ecological degradation," are very
52 serious. As an adaptive measure, China moved "winter wheat northwards" and expanded rice crops to increase
53 yields and the quality of wheat-flower. In order to sustain 'Northeast Rice' with limited water availability, policy
54 efforts have been focused on better irrigation systems, water-management, multiple-cropping systems, and water-

1 saving techniques. This case has shown that the combined efforts of “individual farmers, extension staff, technology
2 institutes and governments,” in conjunction with financial support, may help farmers in efficiently adapting to
3 climate change (Lin *et al.*, 2005).

4
5 In the Mekong Delta in Vietnam, Columbia University’s Center for International Earth Science Information
6 Network has projected that a “one-meter sea-level rise could result in the displacement of more than seven million
7 residents in the delta, and a two-meter rise would double to 14 million- or 50 percent of the delta residents.” An
8 increase in flood frequency and magnitude has threatened residents’ lives and created instability in crop fields. As
9 rapid industrialization has placed stresses on the environment and Vietnam’s natural resources, many people in
10 Mekong have adapted by moving east to cities with rapid economic growth. The government’s “living with floods”
11 program has encouraged rice farmers to shift to aquaculture, while the planned relocation of 20,000 “landless and
12 poor households” has altered social networks and livelihoods (De Sherbinin *et al.*, 2011).

13
14 In Kenya, the dryland areas have experienced over 15 severe droughts since 1950, leading to major losses of crops
15 and livestock. El Nino flooding has “destroyed infrastructure, crops and property,” led to “increased animal and
16 plant diseases,” and killed many people. Government and development partners view assisting Kenya with both food
17 and seed provision to be a superior approach to simply providing food to households affected by climate change,
18 because it could lead to long-term improvements in resilience and agriculture. The seed fairs successfully provided
19 quality seeds and information to farmers at a lower cost than commercial seeds, and the system is now “used in
20 many areas to provide emergency seed relief in response to both climate-related and social disasters” – in Uganda
21 and Sudan as well as Kenya (Orindi and Ochleung, 2005).

22
23 In the highlands of Ethiopia, land management has been unable to meet growing demands for “food, feed, and
24 fiber,” as land degradation and soil infertility have negatively impacted yields. An increasing population and
25 exploitative land use have contributed to this problem. Farmers believed that soil erosion in outfields and soil
26 compaction due to livestock trampling were the most significant causes of low crop yield. Researchers tested the
27 effect of zai, or “small water harvesting pits,” on crop yield and water retention in the Sahel dryland regions, over
28 the course of three years. Both enlarged zai pits and increased inputs increased yields, water retention, and incomes
29 drastically. Contrary to the conventional belief that nutrient deficiencies are limiting plant growth in this area, this
30 study showed that “low soil water holding capacity” was the major factor preventing plant utilization of nutrients
31 and growth. The zai pits helped make this condition more favorable (Amede *et al.*, 2011).

32
33 Over the course of the past decade, floods in Mozambique have displaced hundreds of thousands of people from
34 their homes to temporary shelters, depriving them of their livelihoods, homes, and access to medicine, drinking
35 water, and sanitation. Climate models predict that the north will likely experience increased levels of rainfall while
36 the south will likely experience less, leading to simultaneous drought and floods in Mozambique and leaving the
37 country at the “mercy of increasingly unpredictable weather patterns”. After the 2001 floods, the government
38 created an incentive program to permanently resettle, away from areas prone to dangerous flooding, providing
39 construction materials and assistance in return for brick-making. The government resettlement program has led to
40 dependency on the government due to a lack of infrastructure for a self-sustaining economy and the problem of
41 frequent crop-failure. Additionally, experts suggest that even with outside humanitarian assistance, people in
42 Mozambique may need to migrate further and further to the capital of the country or to neighboring countries (De
43 Sherbinin *et al.*, 2011). Another case study in Mozambique showed that informal institutions, forms of livelihood
44 diversification and collective land-use systems that allow reciprocity, flexibility and the ability to buffer shocks help
45 facilitate adaptation in rural areas (Osbahe *et al.*, 2008).

46
47 An environmental factor that has often been neglected is wind, which erodes soils and thus leads to a decline in
48 agricultural productivity. In Sebikotane, Senegal, “brutal sea winds” hinder vegetation and erode soil. Hence a new,
49 “third-generation agricultural system,” intended to “produce” an environment rather than merely protect or conserve
50 it, was adopted to help adapt to climate change, increase yields, maintain biodiversity, and “improve the lives of
51 women and girls”. The system included natural intensification techniques such as diversification, contour cropping,
52 sprinklers, ploughed furrows, and drop irrigation, “producing the right environment” for optimal production and
53 ecosystem health, targeting local markets and export markets with agricultural production, and training the farmers

1 in future generations. The Sebikotane farms have received substantial international funding and have promoted
2 similar farms throughout Senegal (Seck *et al.*, 2005).

3
4 Adaptation can also occur on a de-centralized level. In Gutu district in Zimbabwe, 405 individuals addressed the
5 community's problem with water shortages, and with the dryness and degradation of their primary water source, the
6 Mutubuki wetland. The objectives of the project were to better protect and manage the wetland. This goal was
7 pursued by seeking donations and funds from UNDP funding for the National Action programme (NAP) in 1999 to
8 form the Mutubuki Chitenderano Development Association (MCDA) and act to prevent damage from livestock
9 through demarcation and fencing. The MCDA established management, advisory, garden, and electrification
10 committees, built dams for harvesting water to be used for gardening in 2000, attained electricity in the village, and
11 promote "income-generating activities for livelihoods provision" that reflected the livelihood priorities of the
12 community, including well construction, rearing small livestock, millet and sorghum seed (Chigwada, 2005). The
13 central governments also help local communities to develop their local adaptation measures. For example,
14 Zimbabwe "Future Change Agents" are being trained by government institutions to support smallholder
15 communities in adapting their agricultural practices to current climate variability, which is also a step in building
16 adaptive capacity to cope with future climate change at the local level (Twomlow *et al.*, 2008).

17
18 Individual farmers also take effective adaptation measures. For example, there is a documented case of a farmer in
19 Burkina Faso, who over the course of 20 years has engaged in the process of adapting to a hotter and drier climate
20 by innovating from existing farming practices. He augmented the practice of "zai," creating shallow pits to collect
21 and concentrate rainfall onto crop roots, by increasing the size of the pits and adding manure to them during the dry
22 season. This led to higher yields and growth of new trees amid his crop rows, which further increased "yields of
23 millet and sorghum [and restored] the degraded soil's vitality," thus providing his family with food security
24 (Hertsgaard, 2011). Scientists refer to the mixture of crops and trees as "farmer-managed natural regeneration," or
25 agro-forestry. The practice of farmer managed natural regeneration or agro forestry benefits agricultural production
26 by providing shade and bulk, which helps mitigate the effects of heat and wind and drastically reduces the amount of
27 sowing required by farmers. Additionally, leaf litter acts as mulch, which increases the fertility of soil, and fodder
28 may be used to feed livestock and, in emergencies, people. This technology and other simple technologies have
29 "enabled more water to infiltrate the soil" and likely contributed to the recharging of once rapidly falling water
30 tables. Additionally, the farmer has sold wood from his trees for cooking, furniture, and construction to diversify his
31 income and used trees as a source for natural medicine. Farmer-managed natural regeneration has since spread
32 throughout the region, mostly through word-of-mouth.

33
34 Improvement of the poor's ability to cope with climate change can be independent from institutional intervention or
35 subsidies- it may be endogenous and occur without strong, targeted institutional action. Before Hurricane Mitch, in
36 Honduras, "beans were grown on the terraced meander opposite the community, often in agroforestry systems
37 including cacao, peach palm, and other fruit and timber trees." Almost 40% of each household's average income
38 was from agriculture. After the 1998 hurricane, indigenous and poor communities were hit most severely with
39 flooding and subsequent tropical storms, which caused over 5,000 deaths, and economic distress. The "subsistence
40 base was crippled" and most of the rice, banana and manioc crops were destroyed, leading to hunger and illness.
41 Hurricane Mitch taught cultivators to "avoid the first floodplain terrace," so no agro forests were lost in severe
42 storms that occurred after Mitch. Additionally, the diversification of sources for income that occurred after Mitch
43 ensured that many households still had the resources to cope with crop losses from later storms. Additionally, the
44 new landholding system "removed incentives for speculative clearing of primary forest," thus improving social
45 equity in Honduras (McSweeney, 2002; McSweeney and Coomes, 2011).

46
47 _____ START BOX 9-2 HERE _____

48 49 **Box 9-2. Drought Adaptation in Rajasthan**

50
51 Rajasthan in India is located in an arid ecological zone and experiences severe droughts, a condition that
52 communities have learned to cope with through conservative use of natural resources. Ways in which communities
53 have adapted to drought include ending production of crops such as wheat and cotton that require a large amount of
54 water, storing fodder for times of drought and scarcity, using savings or borrowing "from cooperatives and banks"

1 for drinking water well construction, bunding fields, digging and deepening ponds and wells to retain water,
2 growing medicinal plants to contribute to revenue, making compost using earthworms for environmentally friendly
3 fertilizer. With the help of a local NGO, women have also formed a self-help group (SHG) to collect money to lend
4 to the needy during emergencies. Additionally, a government Food-for-Work Programme helps provide
5 communities with wheat, cash, and subsidized fodder (Chatterjee *et al.*, 2005).

6
7 _____ END BOX 9-2 HERE _____

8
9 _____ START BOX 9-3 HERE _____

10 11 **Box 9-3. Adaptation to Extreme Events in Jamaica**

12
13 Extreme weather events and severe droughts have badly affected Jamaica's households, communities, and
14 agriculture since the mid 1990's. These changes will likely contribute to poverty and stunt Jamaica's growth and
15 productivity. The adaptation methods that have already been used by farmers in St. Elizabeth, which is considered
16 the breadbasket of Jamaica, include planting methods such as "quick crops and the scaling down of production
17 during the dry season," when they will mature and be ready for the market during the tourist season. This also
18 enables farmers to generate enough income to invest more during the rainy season to grow primary crops. Thus,
19 farmers try to minimize risk because they are especially vulnerable to the dry season- their success during the rainy
20 season is dependent on production during the dry season. Another adaptive strategy is to plant crops with multiple
21 uses and crops that will be more tolerant to dry spells. In southern St. Elizabeth, a dry area, successful crop
22 production depends on moisture retention, which is increase with practices such as "mulching, edging or perimeter
23 planting, drip irrigation and managing the application of water to plants". During droughts, some farmers will
24 "sacrifice a portion of the crops under cultivation," apply thicker mulching, borrow or share money for water, and
25 using fertilizer on leaves. To recover from drought, farmers "scale down" so that their crops are more manageable
26 and can grow successfully (Campbell, *et al.*, 2011).

27
28 _____ END BOX 9-3 HERE _____

29
30 _____ START BOX 9-4 HERE _____

31 32 **Box 9-4. Adaptation Initiatives in the Beverage Crop Sector**

33
34 One of the leading initiatives to prepare small holder producers of beverage crops for adaptation to climate change is
35 the AdapCC project which worked with coffee and tea producers in Latin America and East Africa (Schepp, 2010).
36 This process used risk and opportunity analysis and participatory capacity building (CafeDirect/GTZ, 2010) to help
37 farmers identify changes in management practices to both mitigate their contribution to climate change and adapt to
38 the changes in climate they perceived to be occurring. In general the actions for adaptation were a reinforcement of
39 principles of sustainable production, such as using tree shade.

40
41 The Coffee Under Pressure project of CIAT and Green Mountain Coffee has complemented the models of changes
42 in coffee distribution with models of changes in distribution of 20 other potential crops that may have potential to
43 replace coffee where it will cease to be viable in the future. This has been complemented with detailed studies of the
44 vulnerability of producers in terms of exposition, sensitivity and capacity to adapt to climate change (Baca *et al.*,
45 2010). This indicates that there is a considerable variability in the overall vulnerability to climate change between
46 different communities in the same region and even families within the same community. Facilitating processes of
47 adaptation in this context will be a challenge, but supports the need for participatory community adaptation
48 processes that would enable families to implement strategies appropriate to their own circumstances and capacity.

49
50 Policy recommendations to support adaptation in these sectors (Eakin *et al.*, 2011; Laderach *et al.*, 2011; Schepp,
51 2010; Schroth *et al.*, 2010) have prioritized the follows interventions to support adaptation:

- 52 • Community-based analysis of climate risks and opportunities as a basis for community adaptation strategies
- 53 • Improved recording and access to climate information including medium and long-term predictions

- 1 • Sustainable production techniques including soil and water conservation, shaded production systems,
2 diversification of production systems
- 3 • Development of new varieties with broader adaptability to climate variation, higher temperatures and
4 increased drought tolerance
- 5 • Financial support to invest in adaptation and reduce risks through climate insurance
- 6 • Organization of small producers to improve access to knowledge, financial support and coordinate
7 implementation
- 8 • Environmental service payments and access to carbon markets to support sustainable practices
- 9 • Development of value chain strategies across all actors to support adaptation and increase resilience across
10 the sectors.

11
12 There are possibilities for synergy between adaptation and mitigation. The sustainability standards Rainforest
13 Alliance and Common Code for the Coffee Community are piloting climate-friendly standards for producers that
14 aim to reduce the GHG emissions from agricultural practices, increase sequestration of carbon in soils and trees, but
15 also prepare producers for adapting to climate change (SAN, 2011; Linne, 2010). The later consists of improved
16 understanding of climate impacts and promoting sustainable production practices to increase resilience in the
17 production systems.

18
19 _____ END BOX 9-4 HERE _____
20
21

22 **9.4.4. *Limits and Constraints to Rural Adaptation***

23
24 In highly fragile ecologies and vulnerable rural societies that are highly exposed to severe impacts of climate
25 change, adaptation measures may face significant physical, financial, social and cultural barriers and limitations to
26 adaptation. Lack of access to credit and water are two major factors inhibiting adaptation for farmers in Africa and
27 Asia. A multinomial logit analysis of climate adaptation responses suggested that access to water, credit, extension
28 services and off-farm income and employment opportunities, tenure security, farmers' asset base and farming
29 experience are key to enhancing farmers' adaptive capacity (Gbetibouo *et al.*, 2010). A multinomial choice model
30 fitted to data from a cross-sectional survey of over 8000 farms from 11 African countries showed that better access
31 to markets, extension and credit services, technology and farm assets (labour, land and capital) are critical for
32 helping African farmers adapt to climate change. Hence government policies and investment strategies must support
33 education, markets, credit and information about adaptation to climate change, including technological and
34 institutional methods (Hassan and Nhemachena, 2008). Systematic assessment of rural risk and vulnerability and
35 participatory identification of possible solutions can enable the rural poor to get better access to assets and the
36 services they require to overcome the prevailing barriers to adaptation.

37
38 Rural households' lack of access to technologies and markets is also a major barrier to adaptation. According to a
39 study of adoption of improved, high yield maize in Zambia, production and price risks could render input use
40 unprofitable and prevent rural households from benefiting from technological change which is crucial for adaptation
41 (Langyintuo and Mungoma, 2008). The severe 1997 drought in the Central Plateau of Burkina Faso highlighted that
42 household with a larger resources base took the advantage of distress sales and high prices of agricultural
43 commodities (Roncoli *et al.*, 2001). A nationally representative rural household survey in Mozambique from 2005
44 shows that, overall, using an improved technology (improved maize seeds, improved granaries, tractor
45 mechanization, and animal traction) did not have a statistically significant impact on household income. However
46 when distinguishing between households using improved technologies, especially improved maize seeds and
47 tractors, and those who do not, households who had better market access had significantly higher income (Cunguara
48 and Darnhofer, forthcoming). Social characteristics of households heads and culture both affect access to adaptation
49 options, based on modeled data from the Nile basin of Ethiopia (Deressa *et al.*, 2009) and evidence from Burkina
50 Faso (Nielsen and Reenberg, 2010), respectively.

51
52 Although access to credit, water, technologies and markets are barriers, more fundamental is access to information –
53 in terms of projected changes in climate (and weather conditions). Since adaptation strategies involve dealing with
54 uncertainty, whether stakeholders have access to information for decision making and how they perceive and utilize

1 this information affects their adaptation choices (Sheate *et al.*, 2008; Patt and Schröter, 2008; Dockerty *et al.*, 2006).
2 So far the uptake of information has been suboptimal (Vogel and O'Brien, 2006), but the potential for improved
3 prediction and effective timely dissemination has been noted in South Africa (Archer *et al.*, 2007; Klopper *et al.*,
4 2006) and also in Ethiopia (Bryan *et al.*, 2009). There have been attempts to assess factors influencing uptake and
5 utility of climate forecasts. Agent-based social simulation models show that to be effective in reducing climate risk,
6 trust in forecasts has to be high, and they have to be right 60-70% of the time to benefit smallholder farmers (Ziervogel
7 *et al.*, 2005). As well as trust, the effects of user wealth, risk aversion, and presentational parameters, such as the
8 position of forecast parameter categories, and the size of probability categories, on perceived value of seasonal
9 forecasts have been investigated (Millner and Washington, 2011). An assessment of the extent to which climate
10 change scenarios are currently used in developing adaptation strategies within the agricultural development sector in
11 Africa shows that annual climate information (such as seasonal climate forecasts) is used to a certain extent to
12 inform and support some decisions, yet climate change scenarios are rarely used at present in agricultural
13 development (Ziervogel and Zermoglio, 2009). Although, there is a large and growing literature on the role of
14 seasonal forecasts, in particular on the needs of rural end-user groups, e.g. smallholder farmers in a mountainous
15 village in southern Lesotho (Ziervogel, 2004), the optimal use of seasonal forecasts in risk management by
16 smallholder farmers is largely limited by constraints related to legitimacy, salience, access, understanding, capacity
17 to respond and data scarcity (Hansen *et al.*, 2011).

18
19 The socio-cultural context of participatory processes in the dissemination and use of seasonal forecasts is important
20 and affects who participates and what they gain (Peterson *et al.*, 2010). Rural producers in three ecological zones of
21 Burkina Faso were statistically more likely to understand the probabilistic aspect of the forecasts and their
22 limitations, to use the information in making management decisions and through a wider range of responses than
23 those who had not been part of the participatory processes (Roncoli *et al.*, 2009). Evidence from Malawi shows that
24 forests can be important in reactive coping by providing food during shortages and a source of cash for coping with
25 weather-related crop failure – but households most reliant on forests have low income per person, are located close
26 to the forest, and are headed by individuals who are older, more risk averse, and less educated than their cohorts
27 (Fisher *et al.*, 2010). Gender differences have been observed in preferred dissemination channels in Limpopo
28 province, South Africa, which highlighted that women preferred to hear the forecast from an extension worker,
29 whilst men preferred to hear it on the radio (Archer, 2003). Debates over forecast skill and farmer skill are also
30 common to other parts of the world such as the USA, where interviews with farmers in Georgia showed that the
31 social nature of information processing and risk management bears upon the ways farmers may integrate climate
32 predictions into their agricultural management practices (Crane *et al.*, 2010).

33
34 Stakeholder networks have been used to map forecast dissemination in Lesotho, and are useful for identifying
35 obstacles (Ziervogel and Downing, 2004). There are promising signs for the integration of scientific-based seasonal
36 forecasts with indigenous knowledge systems (Ziervogel *et al.*, 2010). Ensuring improved validity and utility of
37 seasonal forecasts will require collaboration of researchers, data providers, policy developers and extension workers
38 (Coe and Stern, 2011), as well as with end users. Additional opportunities to benefit rural communities come from
39 expanding the use of seasonal forecast information for coordinating input and credit supply, food crisis management,
40 trade and agricultural insurance (Hansen *et al.*, 2011). Attempts to use longer term crop forecasting options based on
41 large-area seasonal crop yield forecasting and, genotypic adaptation based on long-term climate change projections
42 have also been examined (Challinor, 2009). Climate forecasting has also been applied to ecosystem models for use
43 in livestock farming (Boone *et al.*, 2004).

44 45 46 **9.5. Key Conclusions and Research Gaps**

47 48 **9.5.1. Key Conclusions**

49
50 There is a lack of clear definition of what constitutes rural areas, and definitions that do exist depend on definitions
51 of the urban. Across the world, the importance of peri-urban areas and new forms of rural-urban interactions are
52 increasing. Notwithstanding this, rural areas still account for almost half the world's population, about 75% of the
53 developing world's poor people and 80% of the world's hungry. Rural areas therefore are important for assessing

1 the impacts of climate change and the prospects of adaptation in these areas, constituting a dynamic, spatial
2 category. A lack of focus on the rural sector in policy making increases its vulnerability to climate change.
3

4 Climate change in rural areas in developing countries will take place in the context of many important economic,
5 social and land-use trends. In different regions, rural populations have peaked or will peak in the next few decades.
6 The proportion of the rural population depending on agriculture is extremely varied across regions, but declining
7 everywhere. Poverty rates in rural areas are falling more sharply than overall poverty rates, and proportions of the
8 total poor accounted for by rural people are also falling: in both cases with the exception of sub-Saharan Africa,
9 where these rates are rising. Hunger and malnutrition is prevalent among rural children in South Asia and Sub-
10 Saharan Africa. Processes of commercialisation and diversification in developing countries, and inter linkages
11 between land tenure and food policy are important drivers. Rural people are subject to multiple non-climate
12 stressors, including under-investment in agriculture (though there are signs this is improving), problems with land
13 policy, and processes of environmental degradation. In industrialized countries, there are important shifts towards
14 multiple uses of rural areas, especially leisure uses, and new rural policies based on the collaboration of multiple
15 stakeholders, the targeting of multiple sectors and a change from subsidy-based to investment-based policy.
16

17 Cases in the literature of observed impacts on rural areas often suffer from methodological problems of attribution,
18 but evidence for observed impacts, both of extreme events and other categories, is increasing. Heat waves and
19 droughts can cause severe impacts while saline intrusion, storm surges, and other coastal climatic events can affect
20 rural livelihood systems. Climate volatility can increase poverty in developing countries.
21

22 Future impacts of climate change on the rural economic base and livelihoods, land-use and regional interconnections
23 are at the latter stages of complex causal chains that flow through changing patterns of extreme events and/or effects
24 of climate change on biophysical processes in agriculture and less-managed ecosystems. This increases the
25 uncertainty associated with any particular projected impact.
26

27 Major impacts of climate change in rural areas will be felt through impacts on water supply, food security and
28 agricultural incomes. Migration patterns will be driven by multiple factors of which climate change is only one, and
29 projections of migration can only be tentative. There will be secondary impacts of climate policy, such as policies to
30 encourage cultivation of biofuels. In certain countries shifts in agricultural production may be seen. Price rises,
31 which may be induced by climate shocks apart from other factors, have a disproportionate impact on the welfare of
32 the poor in rural areas, such as female headed households and those with limited access to modern agricultural
33 inputs, infrastructure and education.
34

35 Valuation of climate impacts needs to draw upon both monetary and non-monetary indicators. Most studies on
36 valuation highlight that climate change impacts will be significant especially for the developing regions, due to their
37 economic dependence on agriculture and natural resources, low adaptive capacities, and geographical locations. The
38 valuation of non-marketed ecosystem services and the limitations of economic valuation models which aggregate
39 across multiple contexts pose challenges for valuing impacts in rural areas.
40

41 There are low levels of agreement on some of the key factors associated with vulnerability or resilience in rural
42 areas, including rainfed as opposed to irrigated agriculture, small-scale and family-managed farms, and integration
43 into world markets. There is greater agreement on the importance for resilience of access to land and natural
44 resources, flexible local institutions, and knowledge and information, and the association of gender inequalities with
45 vulnerability.
46

47 There is a growing body of literature on successful adaptation in rural areas, including both documentation of
48 practical experience, and discussion of preconditions. Prevailing development constraints, such as low levels of
49 educational attainment, environmental degradation and armed conflict create additional vulnerabilities which
50 undermine rural societies' ability to cope with climate risks. The supply of information for decision-making, and the
51 role of social capital in building resilience, are key issues.
52
53
54

9.5.2. Research Gaps

Research on climate change in rural areas, which truly takes in their nature as areas with shifting combinations of human activity, in which agriculture is important but not necessarily predominant, and with changing patterns of interaction with towns, is only just beginning. Such research will need to be developed, and extended to rural areas throughout the world.

Research is required on the valuation and costing of climate change impacts which take note of the complexity and specificity of rural areas, with special emphasis on non-marketed ecosystem services and specific populations that have not as yet been studied.

More research is needed on vulnerability, to identify the most vulnerable areas, populations and social categories, but it should include research on methodological questions such as conceptualizations of vulnerability, assessment tools, spatial scales for analysis, and the relations between short-term support for adaptation, policy contexts and development trajectories, and long-term resilience or vulnerability.

Research is needed on practical adaptation options, not only for agriculture but for non-agricultural livelihoods. Adaptation research must also look at adaptations to institutions, to better enable them to address lack of access to credit, markets, information, risk-sharing tools and property rights. Research into vulnerability, resilience and adaptation must all improve ways to integrate local and scientific knowledge.

Frequently Asked Questions***FAQ 0.1: Why are rural areas important in the study of climate change impacts, assessments and vulnerability?***

Outline response:

- Importance of rural areas in extent, population, proportion of the world's poor, and pre-existing vulnerabilities
- *Relative* dependence on agriculture and natural resources
- Need to look at impacts on rural areas beyond impacts on agriculture.

FAQ 9.2: What are the differences and similarities relevant to climate change between rural areas in developed and developing countries?

Outline response:

- Major differences: in developing countries rural areas are more sharply characterised by poverty, isolation and low human development. Less the case in developed countries where they are increasingly characterised by close linkages to towns, commuting, and by recreation activities
- *Relative* dependence on agriculture and natural resources is a common factor, and this characterises many of the most important impacts
- In both regions rural areas are increasingly diverse (serving functions beyond agriculture) and that diversity is increasingly recognised
- Distance and marginality are also common factors, which inhibit adaptive capacity

FAQ 9.3: What will be the major categories of climate change impact on rural areas across the world?

Outline response:

Impacts will be experienced through:

- impacts on natural resource-dependent sectors, e.g. agriculture, forestry and fishing – and the livelihoods and incomes that are based on them (both through changing climate means and changing variability);
- impacts on less-managed ecosystems;
- impacts of extreme events on infrastructure and housing;
- as secondary impacts of climate policies;
- and also directly on human health

FAQ 9.4: What are or will be the major forms of adaptation in rural areas?

Outline response:

- Will depend on identifying the relevant risks, and then determining the most appropriate adaptation responses
- For livelihoods and incomes: adaptations to the projected changes in resource availability (altered farming and forestry systems and practices)
- Migration
- Modifications to infrastructure

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Table 9-1: Major demographic, poverty-related, economic, governance, and environmental trends in rural areas of developed and developing countries.

	Developed countries	Developing countries
Demographic Trends	<p>Rural areas account for 75% of land area and 25% of population in OECD countries (OECD 2006).</p> <p>Rural population has peaked (absolute numbers) in Europe and North America.</p> <p>Rural depopulation in some places, but some counter-urbanization elsewhere.</p>	<p>Rural population has already peaked in Latin America and Caribbean, East and South East Asia; expected to peak around 2025 in Middle East, North Africa, South and Central Asia; around 2045 in sub-Saharan Africa.</p> <p>Despite declining growth rates, rural population still a majority in all sub-regions of Asia (72% in South Asia) and 60-70% in Africa (although proportions vary regionally). (IFAD, 2010; World Bank, 2007; and see Figure 9-1)</p>
Dependence on agriculture	<p>Agriculture accounts for only 13% of rural employment in the EU (2006), and less than 10% on average across developed countries; however, has a strong indirect influence on rural economies.</p> <p>Increased competition as a result of economic globalization has resulted in agriculture no longer being the main pillar of the rural economy in Europe. Economic policies are primary drivers. (Marsden, 1999, Lopez-Gelats, 2009)</p> <p>Climate change not expected to cause drastic decrease in agricultural land availability in EU (Mijl <i>et al.</i>, 2006).</p>	<p>Proportion of rural population engaged in agriculture declining in all regions: currently 14% in South America, 23% in Middle East, 71% in Eastern Africa. Driven by growth of small manufacturing and tourism, commuting to towns, dependence on pensions and remittances. Agriculture still provides jobs for 1.3 billion smallholders and landless workers (World Bank, 2008).</p> <p>Non-agricultural including labour-based and migration-based livelihoods increasingly existing alongside (and complementing) farm-based livelihoods.</p> <p>Agricultural initiatives and growth still important for adaptation and for small holders in Africa and Asia; (Osbaahr <i>et al.</i> 2008; Collier <i>et al.</i> 2008; Kotir, 2010; Ravallion and Dutt, 1996; Rao, 2005)</p>
Poverty and Inequality	<p>Per capita GDP in rural areas of OECD countries is only 83% of national average (but significant variation within and between countries): driven by out-migration, aging, lower educational attainment, lower productivity of labour, low levels of public services.</p>	<p>Rates of poverty (percentage of population living on less than US \$ 2/day) and extreme poverty (percentage of population living on less than US \$ 1.25/day) falling in rural areas in most parts of the world; but rural poverty and rural extreme poverty rising in sub-Saharan Africa.</p> <p>Hunger and malnutrition prevalent among rural children in South Asia and Sub-Saharan Africa (UN, 2010; IFAD, 2010; World Bank, 2007). See Figure 9-2 and Table 9-2.</p>
Economic, Policy, Governance Trends	<p>Shift from agricultural (production) to leisure (consumption) activities; focus on broader amenity values of rural landscapes for recreation, tourism, and forests, ecosystem services. (Bunce, 2008; OECD, 2006;</p>	<p>Structural adjustment and economic liberalisation have encouraged shift to commercial agriculture and diversification (Bryceson, 2002).</p> <p>Interlinkages between land tenure, food</p>

	<p>Rounsevell <i>et al.</i>, 2007)</p> <p>Agricultural subsidies under pressure from international trade negotiations and domestic budgetary constraints.</p> <p>‘New rural paradigm’ in OECD countries focuses on investments rather than subsidies, and targets a range of rural economic sectors.</p> <p>Policy and economic changes more important factors than climatic change in shaping rural areas (Audsley <i>et al.</i>, 2006)</p>	<p>security and biofuel policies impact rural poverty (see Chapter 7, section 7.1 and 7.3.2 for further details)</p> <p>Climate, food and fuel prices, environmental resources and diseases create adverse conditions for specific communities (O’Brien <i>et al.</i>, 2009; Casale <i>et al.</i>, 2010; Bunce <i>et al.</i>, 2009)</p> <p>Decentralization of governance in South Asia. Movements towards land reform in some parts of Asia (Kumar, 2010).</p> <p>Emergence of economies in transition, characterised in places by co-existence of leading and lagging regions; political and democratic decentralization expanding leading to increasing complexity of policy (World Bank, 2007).</p>
Environmental Degradation	<p>Different socio-economic scenarios have varying impacts on land use and agricultural biodiversity (Reidsma <i>et al.</i>, 2006).</p>	<p>Resource degradation, environmentally fragile lands subject to overuse and population pressures, exacerbate social and environmental challenges.</p> <p>Multiple stressors increase risk, reduce resilience and exacerbate vulnerability among rural communities from extreme events and climate change impacts (See Chapter 13, Section 13.2.6 for further details).</p>
Rural-Urban Linkages and Transformations	<p>Changes in land-use and land-cover patterns at urban-rural fringe affected by new residential development, local government planning decisions, and environmental regulations (Brown <i>et al.</i>, 2008).</p>	<p>Significant share of manufacturing activities take place in rural areas. Significant share of non-agricultural activities, except in Middle East.</p> <p>Rural-urban migrants tend to be in working age cohort, therefore reducing size of rural workforce, and migration is adopted for escaping poverty (Brown <i>et al.</i>, 2008).</p> <p>Conventional rural to urban migration, except in some cases such as Caribbean where international migrants return to rural areas (Potter., 2005).</p>

Table 9-2: Poverty indicators for rural areas of developing countries.

	Incidence of poverty (%)		Incidence of rural poverty (%)		Incidence of extreme poverty (%)		Incidence of extreme rural poverty (%)		Rural people as % of those in extreme poverty	
	1988	2008	1988	2008	1988	2008	1988	2008	1988	2008
Developing World	69.1	51.2	83.2	80.9	45.1	27.0	54.0	34.2	80.5	71.6

Source: adapted from IFAD, 2010

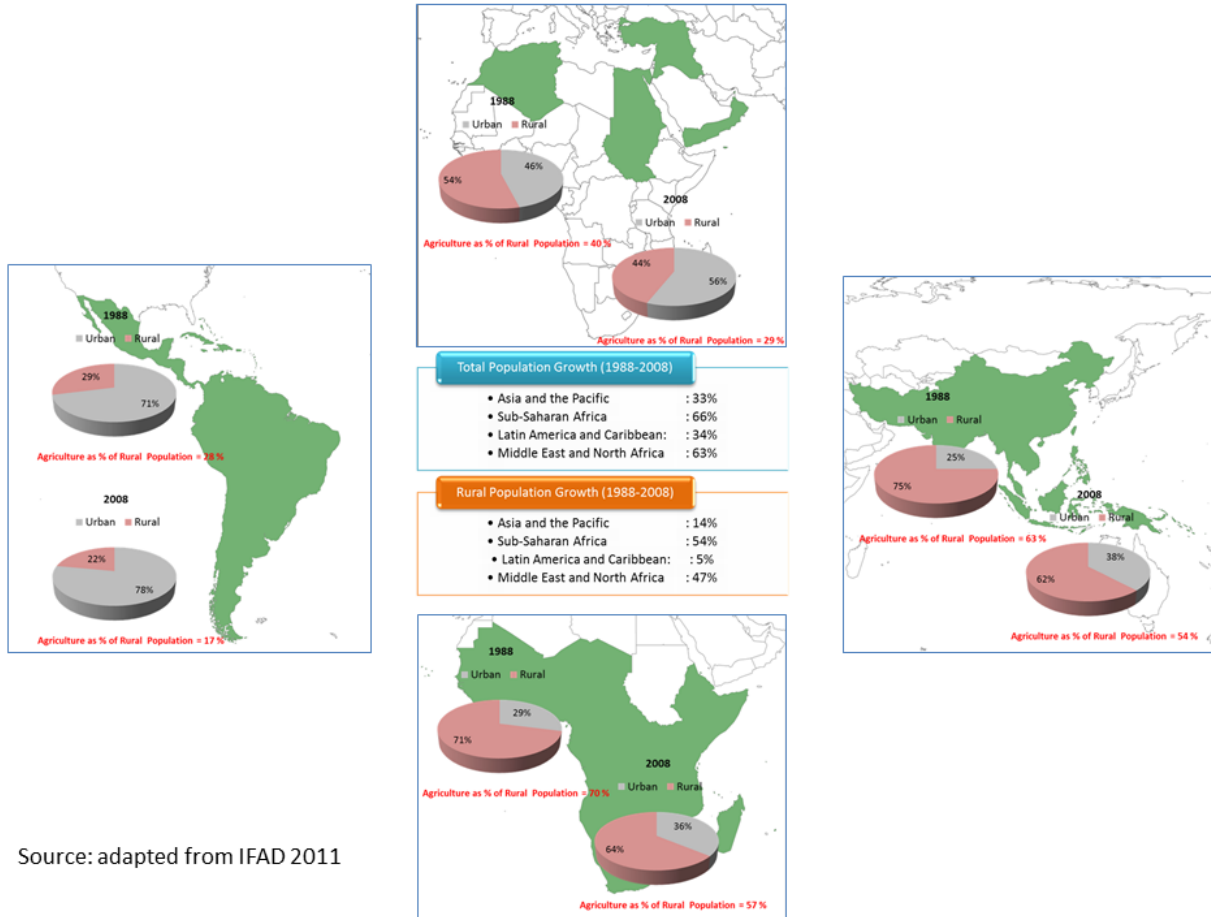
Table 9-3: Projected changes in areas suitable for production of tropical beverage crops by 2050.

Crop	Countries	Change in total area by 2050	Change in distribution by 2050
Coffee	Guatemala, Costa Rica, Nicaragua, El Salvador, Honduras, Mexico	Between 38 and 89% decline in area suitable for production	Minimum altitude suitable for production rises from 600 to 1000 m.a.s.l.
	Kenya	Substantial decline in suitability of western highlands, some decline in area optimal for production in eastern highlands	Minimum altitude for production rise from 1000 to 1400 m.a.s.l.
Tea	Kenya	Majority of western highlands loose suitability, while losses are compensated by gains at higher altitude in eastern highlands	Optimum altitude for production change from 1500-2100 m.a.s.l. to 2000-2300 m.a.s.l.
	Uganda	Considerable reduction in suitability for production across all areas	Optimal altitude change from 1450-1650 m.a.s.l. to 1550-1650 m.a.s.l.
Cocoa	Ghana, Ivory Coast	Considerable reduction in area suitable for production; almost total elimination in Ivory Coast	Optimal altitude changes from 100-250 m.a.s.l. to 450-500 m.a.s.l.

Sources: CIAT, 2010; CIAT, 2011b; CIAT, 2011c; Laderach *et al.*, 2010

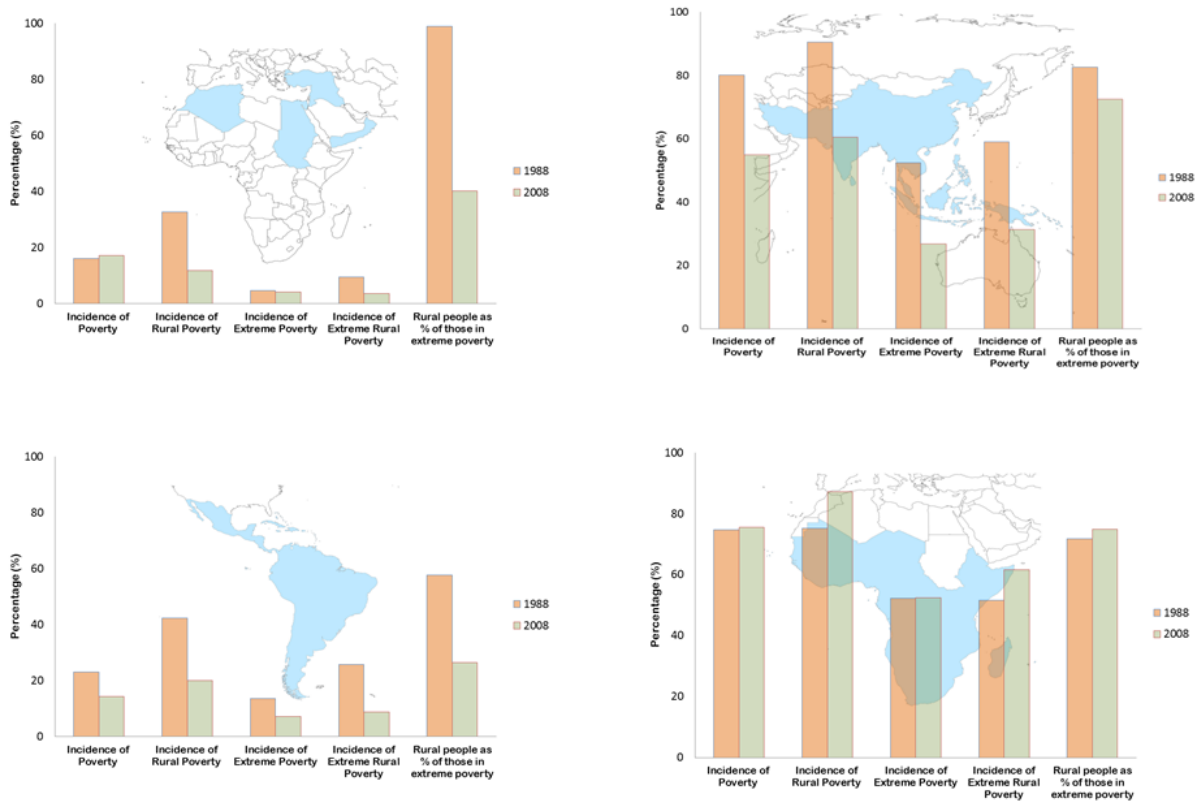
Table 9-4: Illustrative sample of studies on economic value and changes in value from climate change.

Study : Author /s	Country / Region	Findings and Estimates
Vaghefi <i>et al.</i> , 2011	Malaysia (2 degrees C rise in temperature)	Annual economic loss in rice production: \$ 54.17 million
Zhai and Zhuang, 2009	South East Asian countries : Thailand, Vietnam, Philippines	GDP reduction from loss of agricultural productivity by 2080: 1.7-2.4%
Guiteras, 2007	India	GDP reduction from agricultural losses: 1-1.8% Consumption reduction for poor: 18%
ADB and IFPRI, 2009	Asia	Annually spending for coping with adverse agricultural impacts between 2010-2050: \$4.2 - \$ 5 billion
Mendelsohn <i>et al.</i> , 2010	Mexico	Decline in farmland values for each degree of warming: 4-6000 pesos
Mendelsohn <i>et al.</i> , 2007	U.S. A. (10% average increase in temperature)	Fall in crop land values for rural communities: 13%
Mendelsohn and Reinsborough, 2007	Canada (increasing precipitation) U.S.A. (increasing temperature)	Mixed effects with some improved profits Adverse impacts on farming
Wittrock <i>et al.</i> , 2011	Canada (Canadian Global Model 2)	Crop losses under drought: CAN\$ 7-171 per hectare
Franco <i>et al.</i> , 2011	California (B1 – low emissions and A2 – medium emissions scenarios)	Annual Agricultural losses upto \$3billion Flooding increases losses
World Bank, 2010a	Mozambique (Dynamic CGE model)	Damages to agriculture, hydropower and infrastructure (including coastal areas) by 2050: \$7.6 billion
Mideksa, 2010	Ethiopia (Cline, CGCM2 and PCM)	Decline in GDP from agriculture and linked sectors: 10% from benchmark levels
Dinar <i>et al.</i> , 2008	11 African countries (Ricardian analysis; various climate scenarios)	By 2100: Total losses of \$48.2 billion to gains of \$ 90 billion In 2020 for 1.6% warmer and 3.7% dryer climate: net farm revenues decline by upto 25%
Nelson <i>et al.</i> , 2009	Africa (A2 scenario; CSIRO and NCAR models)	Food security impacts Decline in calorie consumption per capita per day by: 500 calories
Schlenker and Roberts, 2010	Africa (A1B scenario; WCRP CMIP3)	Losses for crops except Cassava: likelihood of 95% that losses exceed 7% 5% probability that losses exceed 27%
ECLAC, 2010a, b	Guatemala, Belize, Costa Rica, Honduras (SRES A2 and B2; Regional climate models)	Losses in gross value of production upto 25% (Guatemala, followed by other countries)
Seo and Mendelsohn, 2008	South America (SRES A1; Canadian Climate Centre)	Loss in incomes of farmers by: 2020: 14% 2060: 20%
Sanghi and Mendelsohn, 2008	Brazil (Climate predictions from 14 GCMs)	Annual damages between: 1 – 39%
Fallon and Betts, 2010	Southern Europe (2 degrees C rise in temperature)	Increased costs of agricultural production
Olesena <i>et al.</i> , 2011	Hungary, Serbia, Bulgaria, Romania	Negative impacts for crops in continental climatic zone



Source: adapted from IFAD 2011

Figure 9-1: Key demographic indicators in rural areas of developing countries.



Source: adapted from IFAD 2011

Figure 9-2: Poverty indicators for rural areas of developing countries, by region.