Chapter 9. Rural Areas

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Contents

Executive Summary

There is a lack of clear definition of what constitutes rural areas, and definitions that do exist depend on definitions of the urban. Across the world, the importance of peri-urban areas and new forms of rural-urban interactions are increasing.

Cases in the literature on rural areas of observed impacts on rural areas often suffer from methodological problems of attribution, but evidence for observed impacts, both of extreme events and other categories, is increasing.

Climate change in rural areas in developing countries will take place in the context of many important economic, social and land-use trends. In different regions, rural populations have peaked or will peak in the next few decades, and will be overtaken by urban populations. The proportion of the rural population depending on agriculture is extremely varied across regions, but declining everywhere. Poverty rates in rural areas are falling more sharply than overall poverty rates, and proportions of the total poor accounted for by rural people are also falling: in both cases with the exception of sub-Saharan Africa, where these rates are rising. Rural people are subject to multiple non-climate stressors, including under-investment in agriculture (though there are signs this is improving), problems with land policy, and processes of environmental degradation.

In industrialized countries, there are important shifts towards multiple uses of rural areas, especially leisure uses, and new rural policies based on the collaboration of multiple stakeholders, the targeting of multiple sectors and a change from subsidy-based to investment-based policy.

Major impacts of climate change in rural areas will be felt through impacts on food security and agricultural incomes. Migration patterns will be driven by multiple factors of which climate change is only one, and projections of migration can only be tentative. There will be secondary impacts of climate policy, such as policies to encourage cultivation of biofuels.

Most studies on valuation highlight that climate change impacts will be significant especially for the developing regions, due to their economic dependence on agriculture and natural resources, low adaptive capacities, and geographical locations. The valuation of non marketed ecosystem services and the limitations of economic valuation models which aggregate across multiple contexts pose challenges for valuing impacts in rural areas.

There is a growing body of literature on successful adaptation in rural areas. Prevailing development constraints, such as low levels of educational attainment, environmental degradation and armed conflict create additional vulnerabilities which undermine rural societies' ability to cope with climate risks. The supply of information for decision-making, and the role of social capital in building resilience, are key issues.

9.1. Introduction

9.1.1. Rationale for the Chapter

Rural areas, even after significant demographic shifts, still account for almost half the world's population (UNFPA, 2007). They also account for about 75% of the developing world's poor people (Ravaillon, *et al*. 2007), an important point given the association of climate vulnerability with poverty. At the same time, changes in land-use and livelihoods in rural areas make it less straightforward to associate rural areas with agriculture or food production.

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

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

- Rural areas are largely defined in contradistinction to urban areas, but that distinction is increasingly seen as problematic.
- Rural areas are a spatial category, associated with certain patterns of human activity, but with those associations being subject to continuous change.
- Rural populations have, and will have, a variety of income sources and occupations, within which agriculture and the exploitation of natural resources have privileged but not necessarily predominant positions.
- Rural areas suffer from specific vulnerabilities to climate change, both through their dependence on natural resources and weather-dependent activities, and through their relative lack of access to information, decision-making, investment and services.

9.1.2. Definitions of the Rural

"Rural" and "rural areas", in both policy-oriented and scholarly literature are terms often taken for granted or left undefined. IFAD (2011) states that the definitions of rural and urban are fraught with difficulties. Hart *et al*. (2005) set out the multiple and sometimes contradictory official definitions used in the United States. Some definitions depend on the scale of the area or settlement being defined. They conclude that choice of a definition depends on purpose, data availability and its place within an appropriate taxonomy. Ultimately, however, the rural is defined as the inverse or the residual of the urban (Lerner and Eakin, 2010).

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

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

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

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

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" as "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 ecosystems 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. Relevant Findings of AR4

AR4 chapters 5 and 7 are of high relevance to rural areas. However, AR4 Chapter 5 is focused on production and productivity, which clearly have impacts in rural livelihoods, but are only one of many other aspects to be considered. Chapter 7, on human settlements, has a strong focus on urban areas. It also states that research on vulnerabilities and adaptive capacities of human systems has lagged behind research on physical environmental systems, ecological impacts and mitigation, and for that reason uncertainties are very prominent in its treatment of the topic. A key task for the present chapter is to determine whether uncertainties, with regard to rural areas, have been reduced.

AR4 suggests that any assessment of climate change impacts on agro-ecological conditions has to be undertaken against a background of declining global population growth, rapidly rising urbanisation, shrinking shares of agriculture in the overall formation of incomes and fewer people dependent on agriculture. It suggests that within rural areas there will be continued diversification away from agriculture and that rural to urban migration will continue to be important (Ch5). These factors determine how rural populations can cope with changing climate conditions. Although these trends are important, how they progress will differ with different socioeconomic scenarios.

Other important findings which have been confirmed since AR4 is that the impact of socioeconomic scenarios on the numbers of people at risk of hunger (but also other risks in rural areas) is significantly greater than the impact of climate change (Ch.5) and that different development paths may increase or decrease vulnerabilities to climate-change impacts (Ch7). Furthermore, the significance of climate change (positive or negative) lies in its interactions with other non-climate sources of change and stress, and its impacts should be considered in such a multi-causal context (Ch.7). Thus, climate change is not the only stress on human settlements, but rather it coalesces with other stresses, such as scarcity of water, governance structures, institutional and jurisdictional fragmentation, limited revenue streams for public sector roles, and inflexible patterns of land use that are inadequate even in the absence of climate change (Ch7).

In terms of rural livelihoods linked to agriculture, AR4 (Ch.5) concludes that subsistence and smallholder livelihood systems experience a number of stressors apart from climate change and that they also possess certain important resilience factors: efficiencies associated with the use of family labour, livelihood diversity allowing to spread risks and indigenous knowledge that allows exploitation of risky environmental niches and coping with crises. The combinations of stressors and resilience factors gives rise to complex positive and negative trends in livelihoods. Land degradation and loss of biodiversity are exacerbated as a result of climate trends and the pressure to cultivate marginal land or adopt unsustainable cultivation practices.

AR4 suggests that mitigation and adaptation policies are in many cases, and certainly for agriculture, settlements and industry, closely linked (Ch.5 and 7). A growing body of literature confirms this statement.

In terms of landscape, AR4 found that different temperature changes will have different impacts on grasslands. Grasslands cover approximately 26% of the land surface and 70% of agricultural lands (FAO, 2005; WRI, 2000). Drylands occupy 41% of the land area, and are home to more than 2 billion people (UNEP, 2006). Thus, this has important effects on rural areas, including land uses, landscapes and productivity, affecting more to those whose livelihoods depend on livestock.

Forestry is also assessed in AR4 from the viewpoint of timber production in chapter 5, but forests are also important for millions of people in providing ecosystem services other than timber or the forestry industry, such as food, medicines or fuel. In many rural Sub-Saharan Africa communities, Non-Timber Forest Products (NTFPs) may supply over 50% of household cash income and provide the health needs for over 80% of the population (FAO, 2004a). Yet little is known about the possible impacts of climate change on NTFPs. Fires, disease outbreaks, general deforestation trends are all expected to affect the contribution of NTFPs to rural livelihoods. In general terms, AR4 suggests that the loss of forest resources may directly affect 90% of the 1.2 billion forest-dependent people who live in extreme poverty.

AR4 suggested that the very young, the very old and the very poor, indigenous people and recent immigrants tend to be more vulnerable to climate impacts than the general economy and population, in particular those concentrated in relatively high-risk areas. This is generally the population profile in rural areas, increasing the vulnerability of these areas. Also, specific sectors, as tourism or agroindustry, also highly located in rural contexts, will be more affected than others, with impacts in rural land-use and livelihoods.

In terms of systems assessed, tourism, water supplies (demand and availability), insurance, sanitation, and infrastructures, including transport, power and communication, all affect rural settlement. However, due to economies of scale, rural areas are often less well equipped in terms of infrastructures, communication, transport, and social services. This has two sides, on the one hand, rural areas might be less affected than urban areas because they already do not have these infrastructures, but on the other hand, this lack of infrastructures can limit their ability to cope with extreme climate events. Specifically, water supply is important since most water in the world is used for agricultural purposes.

AR4 noted the difficulty of finding valuations of climate change for human settlements. It states that estimates of aggregate macroeconomic costs of climate change at a global scale were not directly useful and that many types of costs – especially to society – are poorly captured by monetary metrics.

One issue that is addressed in different manners by different chapters in AR4 is that adaptation strategies can also be considered from the perspective of the development of policies that support changes in current consumption habits (UNEP, 2010). Adaptation also includes spontaneous actions which can be implemented at different scales, from individuals to systems, and are not uniform (Ch7). AR4 suggests different and diverse types of adaptation strategies, that may be anticipatory or reactive, self-induced and decentralised or dependent on centrally-initiated policy changes and social collaboration, gradual and evolutionary or rooted in abrupt changes in settlement patterns or economic activity. Others are focused on a sector, such as water, energy, tourism and health. Adaptations can also take a wide variety of forms in costs/prices, applications of technology, and attention to risk financing. AR4 suggests adaptation strategies for human settlements, include assuring effective governance, increasing the resilience of physical and linkage infrastructures, changing settlement locations over a period of time, changing settlement form, reducing heat-island effects, reducing emissions and industry effluents as well as improving waste handling, providing financial mechanisms for increasing resiliency, targeting assistance programmes for especially impacted segments of the population, and adopting sustainable community development practices (Ch7).

In general terms, AR4 suggests that prospects for adaptation depend on the magnitude and rate of climate change; climate-change adaptation strategies are inseparable from increasingly strong and complex global linkages; climate change is one of many challenges to human institutions to manage risks; adaptation actions can be effective in achieving their specific goals, but they may have other effects as well.

Special attention will have to be given to the access to resources in adaptation measures. As climate change and adaptation becomes a widespread need, there is likely to be competition for resources – investment in one place, sector or risk will reduce the funds available for others, and possibly reduce funding for other social needs (Ch7). The same will be true for physical resources, like water or land. A general adaptation trend highlighted for rural communities in developing countries is the diversification of livelihoods strategies, moving livestock, harvesting water, shifting crop mixes and migration. All these require adequate institutional support for longer-term livelihood sustainability.

9.3. 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. Similarly, 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. Such 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.

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.

9.3.1. Impacts of Extreme Events

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. 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). 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. Authors indicate that global warming exacerbates vulnerability to poverty in many regions.

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. The distinction between sudden and gradual climate change and the spatial extension of the natural disaster is of great help to understand which observed impacts can be extrapolated to climate change scenarios. It is expected that a short to medium term increase and intensification of typical labour migration may occur due to degraded and drought/famine areas. 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.

9.3.2. Other Observed Impacts

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). Glacial retreat in Latin America (Orlove 2009) is one of the least ambiguous current impacts on rural areas. There is also a rich specialized literature on the impacts of shrinking sea-ice and changing seasonal patterns of ice formation and melt on Inuit in circumpolar regions (Ford 2009).

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

9.4. Assessing Impacts, Vulnerabilities, and Risks

9.4.1. 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.

9.4.1.1. Trends in Developing Countries

9.4.1.1.1. Demography, dependence on agriculture and poverty

There are important trends in the demography and economy of rural areas that can be generalized to the level of developing countries as a whole: declining rural population growth rates, a declining share of rural population in overall population, and a declining share of agricultural population within rural population. Statistics on these trends are presented by IFAD (2011).

[INSERT TABLE 9-1 HERE
Table 9-1: Key demographic indicators in rural areas of developing countries (adapted from IFAD 2011).]

The rural population has already peaked in absolute numbers in Latin America, the Caribbean, East and South East Asia, as it has in Europe and North America, but it is not projected to do so until around 2025 in the Middle East, North Africa and South and Central Asia and until 2045 in Sub-Saharan Africa. IFAD (2011) mentions the "demographic dividend" associated with a high proportion of prime-age adults within the overall population that will be associated with this peaking.

Across the developing world, around 55% of the population, 3.1 billion people, live in rural areas, and the rural population still accounts for 50% or more of total population across all sub-regions of Asia, and most of Africa, but has become a minority in Southern Africa, Latin America, the Caribbean, the Middle East and North Africa. Equally importantly, within the rural population, the proportion engaged in agriculture (households with at least one member engaged in agriculture) is in significant decline in all regions: it now varies between 14% in South America and 71% in Eastern Africa. The movement away from agriculture has different drivers and takes different forms in different regions: these include growth of both small manufacturing and tourist industries in rural areas, commuting to towns, and dependence on pensions and remittances.

Approximately 60% of Africa's population lives in rural areas, but there are considerable regional differences. In Eastern Africa around 75% of the population is rural. In central and Western Africa this share is significantly lower: around 55% of the people are rural. Northern and Southern Africa denote an even lesser share with around 50 and 40% of its people living in rural areas respectively. If we use Sub-Saharan Africa as a categorisation, we find around 63% of the population to be rural (UN 2010). Estimates suggest that approximately 59% of Africa's poor live in rural areas (Hope 2009).

Despite the continued growth of global rural population between 1998-2008, the absolute size of the rural population in East Asia (China and the Democratic People's Republic of Korea) decreased by 12 percent. The process of rapid rural-to-urban migration has been mainly driven by high rates of sustained growth in the non-agricultural sectors in China. In the same period, incidence of rural poverty (percentage of rural people living on <US$2/day) decreased by more than half from 76 percent to 35 percent, which was substantially below the world average of 61 percent in 2008 (IFAD, 2011). During the 2000s, agricultural value added has grown by 4.2 percent (World Development indicators cited in IFAD, 2011). The share of agricultural population in rural areas has continued to decline from 68 percent in 1998 to 62 percent in 2008. This is a reflection of a worldwide trend of the growing role of non-agricultural activities in rural livelihoods.

Between 1998-2008, rural population of the Middle East (Middle East: Iraq, Jordan, Lebanon, Oman, the Syrian Arab Republic, Turkey, Yemen) has continued to grow faster than the world averages. The Region has experienced rural population growth of 30 percent in this period, mainly due to relatively high birth rates in rural areas and lack of sustained growth in non-agricultural sectors. In the same period, incidence of rural poverty (percentage of rural people living on <US$2/day) decreased by approximately 20 percentage points from 31 percent to 12 percent (including North Africa). During the 2000s, agricultural value added has grown by 1.1 percent in the Middle East

(World Development indicators cited in IFAD, 2011). Partly as a result of slow agricultural growth, the share of agricultural population in rural areas declined rapidly from 39 percent in 1998 to 23 percent in 2008 in the Middle East (IFAD, 2011). Non-agricultural activities have become the predominant sources of livelihoods for rural societies.

[INSERT TABLE 9-2 HERE
Table 9-2: Poverty indicators for rural areas of developing countries (adapted from IFAD 2011).]

From the data in Table 9-2, it is clear that in most developing regions, rates of poverty (defined as percentages of people living on less than $US2.00/day) and rates of extreme poverty (defined as percentages of people living on less than $US1.25) are falling, at national levels and more sharply in rural areas. In the Middle East and North Africa, overall rates of poverty and extreme poverty are roughly stable, but rates of rural poverty and rural extreme poverty are falling. The major exception is Sub-Saharan Africa, where overall rates of poverty and extreme poverty are roughly stable, but rates of rural poverty and rural extreme poverty are *rising*. Rural people in extreme poverty as a percentage of overall people in extreme poverty, a compound of rural-urban demographics as well as poverty trends, has shown a moderate decrease in Asia, a sharp decrease in Latin America and the Middle East, but has risen slightly in Africa.

South Asia and sub-Saharan Africa are the regions where hunger is most concentrated. In South Asia, in particular, malnutrition has been remarkably stubborn: Bangladesh, India, and Nepal occupy three of the top four positions in the global ranking of underweight children (WDR, 2008: 95). In all developing regions children in rural areas are more likely to be hungry than children living in cities and towns. In 2008, the ratio was 1.4 underweight rural children for every 1 underweight urban child in South Asia and sub-Saharan Africa (UN, 2010, *The Millennium Development Goals report,* United Nations, New York as quoted in IFAD, 2011: 50).

In South Asia, home to 1.4 billion people, 72 percent of population resides in rural areas. Rural poverty rates have remained frustratingly high and tenacious in this region and the absolute number of poor in these regions has increased since 1993 (WDR 2008: focus A). In South Asia, like South East Asia and sub-Saharan Africa, the proportion of the poor living in rural areas is barely declining, despite urbanization (IFAD 2011: 47). Within countries with the exception of India in recent years, poverty in rural areas has been higher than urban areas. For instance, in Nepal, the incidence of poverty in rural areas was three and a half times as high as that in urban areas. Following the typology of agricultural development (WDR 2008), in both ‘agriculture-based’ and ‘transforming’ economies a majority of the poor reside in rural areas in countries of South Asia. Children represent a substantial proportion of the poor in rural areas, and the highest proportions of children and youth are found in the poorest regions, above all sub-Saharan Africa and South Asia. Most will go on to become poor adults (IFAD, 2011). Unlike East Asia, where massive reduction took place in rural poverty since the late 1980s, poverty has declined far more slowly in South Asia, where the incidence is still more than 45 per cent for extreme poverty and over 80 per cent for USD 2/day poverty line. South Asia has by far the largest number of poor rural people (over 500 million) (IFAD (2011). For instance, remote regions with a high density of the poor include the Western part of Bangladesh, the Central province of Sri Lanka, the Eastern part of Nepal and a large part of India (e.g. Bihar, Orissa, and part of Uttar Pradesh). Some regions are also home to ethnic minorities and a large share of socially marginalized population. Sparsely populated, high poverty areas include Balochistan in Pakistan, the far Western region in Nepal, Uva province in Sri Lanka, and tribal areas in India (Shilpi, 2010: 5-6).

Ravallion *et al.(*2007) discuss the “urbanization of poverty” as poverty reduction in urban areas proceeds more slowly than in rural areas. Rural-urban migration allows an escape from poverty for some rural people, but it is more important that both urbanization and poverty reduction in rural areas are effects of economic growth. Urbanization has been rapid in the Middle East, China and Central Asia, and relatively moderate by some reckoning in South Asia. Uneven rural – urban transformations has been a characteristic of the developing world. Migration from rural to urban alongside international migration continues to follow the conventional pattern in many places, while the Caribbean has been experiencing the return of international migrants to rural areas.

9.4.1.1.2. Economic, policy, and governance trends

IFAD (2011) also discusses trends in the economic and policy context for agriculture across the developing world: low global food prices coupled with "low levels of investment in agriculture, inappropriate policies, thin and uncompetitive markets, weak rural infrastructure, inadequate production and financial services, and a deteriorating natural resource base". These have all reduced the incentives for investing in agriculture by smallholders and the rural poor. Following the food price shocks of 2007-08, there has been renewed interest by governments and international organizations in improving the policy environment for agriculture, but also increasing the complexity of that environment: expanding and increasingly differentiated domestic food markets, integration of global supply chains, the importance of large emerging countries as both producers and markets. IFAD (2011) also mentions the new opportunities for growth in agriculture and rural economies presented by political democratization and decentralization.

South Asia has also seen over the last two decades a decentralization of governance, through the devolution of power to regional/local entities (Panchayat Raj Institutions in India; Union Parishad, Upazila Parishad and Zila Parishad in Bangladesh; Provincial Councils in Sri Lanka created through the Thirteenth amendment of the constitution in 1987; districts, tehsils and Union Council in Pakistan created from 2000 to 2002). Although all these initiatives could, in theory, improve governance by making decision bodies closer to the people, the devolution processes have not been completed in most countries (Kumar, 2010).

Chronic hunger, malnutrition and vulnerability due to price spikes in food and oil continue to be of grave concern. Lack of access to credit, insufficiency of small holder farming, and land access issues persist in creating concerns for food security in many regions. A high burden of diseases, armed conflicts and inadequate natural resource management exacerbate concerns for rural areas. In general, developing regions tend to be characterized by low resilience arising from poverty, resource degradation, and exposure to risk multipliers for climate change.

While some movement towards land reform, tenancy legislation and decentralization is evident in some parts of Asia in particular, much remains to be achieved in terms of improving governance and implementation. Structural adjustment and market developments have led to an increasing importance of the non-farm sector in rural areas alongside the growth of an informal sector in both rural and urban areas in some regions. Positive developments have occurred with regard to communications, innovation, micro-credit, marketing institutions and the deployment of small scale farm technology.

Policies of structural adjustment and market liberalisation forced many peasants to seek non-agricultural income sources and favoured diversification (Bryceson, 2002). Economic liberalisation also exacerbated vulnerability. For instance, in the 2002-03 drought in savannahs in rural Mozambique, market relations were unfavourable to peasants as the drought progressed, locking in smallholders to informal trade and casual employment activities that barely secured survival (Eriksen and Silva, 2009); similarly in the Limpopo basin structural adjustment has prompted rural people to alter their approach to farming (changing to commercial), but this makes them more vulnerable to environmental change as typical adaptive techniques are based on diversification and flexibility, which is not suited to economies of scale (Silva *et al.*, 2010). Certain region specific factors further exacerbate vulnerability and lower resilience among rural communities. These include the following:

- HIV/AIDS in southern Africa (O'Brien *et al.*, 2009)
- Low employment, high levels of disease, environmental resources under pressure and changing political landscapes in South Africa and Malawi (Casale *et al.*, 2010)
- Health status, lack of information, ineffective institutional structures and processes in Muden area of KwaZulu Natal, South Africa (Reid and Vogel, 2006)
- Wars, economic policies and natural increase have led to natural resource-dependent populations in marginal, previously little inhabited lowland coastal areas, including Mtwara in Tanzania and Maputo in Mozambique. Multiple stresses include climate, food and fuel prices, and related dependence on traders and credit shrunk by negative global market trends (Bunce *et al.*, 2009).

Experiences of economic growth across countries in the South Asian region indicate a pattern of high economic growth over the last couple of decades. High agricultural growth in this period has also been by and large a concomitant feature, accompanied by a growth in rural non-farm sector due to forward and backward linkages with the rest of the economy. This has been triggered by increases in yield, reduced deployment of labour in agriculture and the introduction of modern farming equipment selectively, and the availability of infrastructure (Rao, 2005). By the early 1990s industrial and trade policy reforms had been implemented in most countries in the region although reforms in the area of agriculture lagged far behind. Although macroeconomic policies and human capital investments varied across countries these were relatively uniform within each country. WDRs (2008 & 2009) have identified the roles of policies and institutions on the speed and form of rural-urban transformations: in particular land and labour institutions and the connective institutions which tend to vary both intra- and inter-countries. Dudwick, 2011: 138). Countries in South Asia are characterized by the co-existence of leading and lagging regions based on WDR 2009 typologies (Part one-Chapter 2-Distance, pp. 73-95), with lagging regions including some of the poor, minority and marginalized regions mentioned above.

9.4.1.1.3. Agriculture

Despite recent skepticism, agricultural growth is still important for most low-income developing countries. Empirical studies based on country case studies show that the pro-growth and pro-poor performance of agriculture will continue to depend on the broad participation of smallholder farmers. The agriculture systems face multiple challenges among which the low levels of investment, inappropriate policies, weak markets and rural infrastructure, inadequate production and financial services, and a deteriorating natural resource that prevent smallholders to participate in agricultural markets. For that reason, agricultural policies are important to reduce poverty in developing countries. Evidence from rural Mozambique shows that agricultural initiatives have helped to facilitate effective livelihood renewal, through the reorganisation of social institutions and opportunities for communication, innovation and micro-credit, thereby supporting scope for adaptation (Osbahr *et al*., 2008).

The 2008 World Development Report classifies countries in three categories: (i) agriculture-based countries where agriculture is the major source of growth accounting for 32 percent of GDP growth in average with an average 70 percent of the population living in rural areas; (ii) transforming countries where 7 percent of GDP is from the agricultural sector with an high incidence of rural poverty and (iii) urbanized countries with agriculture contributing to less than 5 percent of GDP and where poverty is mostly urban (WDR, 20O8). In the agriculture-based countries, agriculture and its associated industries are essential to growth and to reducing mass poverty and food insecurity. Agriculture is a source of livelihoods for an estimated 86 % of rural people and provides jobs for 1.3 billion smallholders and landless workers. (Word Bank, 2008).

In rural Africa agriculture plays a dominant role and has therefore attracted a number of economic impact studies (Kotir 2010). Agriculture sustains the livelihoods of the majority of African people and, as the largest single economic activity, accounts for around 60 percent of employment and contributes to more than 50 percent of GDP in some countries (Collier *et al.,* 2008). Agriculture plays a critical role in rural economy in supporting rural livelihood and overall economic growth in many countries since more than 70% of the population lives in rural areas of Africa and the livelihoods of about 85% depend on rain-fed agriculture and agriculture based rural activities. Sub-Saharan Africa belongs to the agriculture-based category since its economy remains strongly based on agriculture which contributes between 20 and 30% of GDP, employs 62% of the population and produces 55% of the total value of African export (World Bank, 2007). In Sub-Saharan Africa, the agricultural growth rose from 2.3% in the 1980s to 3.8% between 2001 and 2005, but was undermined by a steady population growth of 2.3% per annum.

In Sub-Saharan Africa, the agricultural production systems are largely based on smallholder farms. Smallholder farms, when defined as being two ha or less (IFAD, 2010) or producers in rural areas predominantly using labor and for whom the farm provide the principal source of income (AR4, chapter 5) represent 80% of all farms in Sub-Saharan Africa, and contribute up to 90% of the production in some Sub-Saharan Africa countries.
The ability of African farmers to find pathways out of poverty and to contribute actively to the growth process depends on their increased access to assets such as land, water and human capital, and their linkages to the value chains through improved organizations . Female-headed households often have poorer access to land, as is the case in post-war Mozambique (Brueck and Schindler, 2009). Many constraints facing agriculture in SSA – such as poor rural infrastructure and extension services, high market and trade transaction costs, weak producer and market

institutions, and for some countries unstable political environments need to be addressed by sound macroeconomic fundamentals, adequate governance from local to national levels and socio political climate.

In South Asia the contribution of agriculture to economic growth is greatest in Nepal (accounting for 35 percent of GDP), followed by Bangladesh, India and Pakistan (approximately 20 percent), and Sri Lanka (12 percent). The contribution of agricultural to overall GDP growth has varied over time, declining in the case of India, Bangladesh and Sri Lanka, and fluctuating in Nepal and Pakistan. Thus, it becomes evident that in South Asia, growth in the agriculture sector has not kept pace with overall GDP growth, resulting in an increased gap between rural and urban areas, where most of the growth promoting industry and services are concentrated. Agriculture contributes only 22% of GDP despite employing 60% of the labor force in the region. Substantial intra-country disparities are also seen with regard to the stages of agricultural development. For instance, within a large-country country like India, regions with all the three typologies of agriculture based, transforming and urbanized co-exist (WDR, 2008). Countries like Bangladesh, Nepal and Afghanistan are net food importers. A conscious policy of disinvestment in the agriculture sector and a move towards export oriented agriculture with trade liberalization, has caused vulnerability for farmers who face price volatility from global markets (Kumar, 2010). Concerns have arisen over food insecurity and vulnerability of small and marginal farmers. In the South Asia region as a whole, agriculture remained the most important employer of labor force. Even in Sri Lanka, the least poor country in the region, agriculture accounts for 34 percent of total employment. The importance of agriculture is much greater in Nepal, where it employs more than 90 percent of the labor force (Shilpi, 2010: table 2.2). In line with its contribution to creation of employment, agricultural growth is found to have the strongest poverty reducing effect in India during 1960-1990 (Ravallion & Datt, 1996; Rao, 2005; Sen & Jha, 2005).

9.4.1.1.4. Coping strategies and diversification

Rural livelihood diversification, is 'the process by which households construct a diverse portfolio of activities and social support capabilities for survival and in order to improve their standard of living' (Ellis, 1999). While diversification has at times been a distress-driven alternative, at times it has arisen from the realisation of the inability of the agriculture sector to ensure sufficient means of survival. The withdrawal of the state from supportive agricultural programs and activities and, the creation and adoption of new livelihoods made possible by the emergence of new opportunities also lead by the state has favoured diversification (Mukhopadhyay, 2009). As rural households engage in farming, labor, and migration, one of these activities usually dominates as a source of income. Five livelihood strategies can be distinguished, based on these income sources: market oriented smallholders, subsistence-oriented farmers, labor-oriented households; migration oriented households and diversified households. The relative importance of each differs across the three WDR country types: agriculture-based, transforming, and urbanized. It also differs across regions within countries. Farming-led strategies are particularly important in the agriculture-based countries, where farming is the main livelihood for a large share of rural households. In the transforming and urbanized countries, the labour- and migration-oriented strategies are more common, with shares of labour-oriented households varying. Among these households, wages from non-agricultural labour often contribute a large share of average labour income (as in Pakistan, among others), while for others non-agricultural self-employment earnings are more important in labour-oriented households. Even if most households are specialized—that is, they derive the vast majority of their income from only one of the three income sources (farming, labor, or migration)—a substantial remaining share of households in all countries has diversified income strategies (WDR, 2008). Based on groupings into on-farm and off-farm, under 'means of shares', Bangladesh (Household Income-Expenditure Survey, 2000) shows only 17.6% income being generated by the former, while in Pakistan this percentage had reduced from 44 to 35.7% (Davis *et al*., 2007).

9.4.1.1.5. Access to land and land resources

Land ownership and access to land have evidenced different trends affecting rural areas and, for future policies addressing climate change, is an important issue to be addressed, both in developed and developing countries. In general terms, types of land ownership include private property, state land and communal land (Home, 2009).

In Asia, the average farm size is already quite small and across South Asia, rural poverty is exacerbated by highly unequal distribution of land and access to water and other agriculture inputs. In Pakistan, for example, only 37% of rural households own land. The land tenure has also a strong gender dimension, with women owning less than 5% of total land in South Asia (Kumar, 2010). Women are commonly excluded from both land ownership and from land access through tenancy and leasing (Lee *et al*., 2010). WDR (2008) estimates the Gini coefficient of land ownership distribution to be 0.61 in Pakistan, 0.48 in Bangladesh and 0.45 in India.

While all countries in South Asia have initiated some form of land reform, the pace of implementation has been uneven. Government interventions have focused on three main areas: enactment of legislation for ceilings on ownership, tenancy legislation to improve tenure security and limit rents, interventions in land sales markets, restricting the sale and sub-division of land. For instance, in Sri Lanka, large tracts of land came under government ownership following the Crown Lands Encroachment Ordinance, and these were subsequently distributed to landless farmers under the Land Development Ordinance (LDO). In India, the government maintains laws that restrict the sale of land from tribal's to non-tribal's and on the conversion of agricultural land to non agricultural land use.

9.4.1.1.6. Land use and landscapes

From ecosystem functioning and biodiversity to water resources and greenhouse gas emissions, land use is central to the landscapes around us. Changes in agricultural land use and land cover reflect economic causes, policy measures as well as spatial planning objectives and show a wide range of impacts, including biophysical and socio-economic changes and feedbacks between land use and its drivers (Busch, 2006). Globally, rural landscapes are suffering important transformations, from landscapes of production to landscapes of consumption (amenity value), from agricultural to leisure activities. This is reinforced by a decline in informal community space resulting from the privatisation of spatial amenity. Bunce (2008) calls this trend the "leisuring" of rural landscapes, which is an important phenomenon in developed countries and small islands. This involves profound changes to the geography of rural space and generates a conflict between space and place – between the spaces produced by the global leisure economy and the places which have purpose and meaning for local people (Bunce, 2008).

9.4.1.1.7. Environmental degradation

Almost one-third of the rural populations of developing countries, live in less-favoured marginal areas, many of which are either hillside or mountainous regions, or arid and semi-arid drylands. Many of these lands are environmentally fragile, and their soils, vegetation and landscapes are easily eroded. Population growth combined with extreme poverty pushes people into more marginal areas, and compels them to overuse the fragile resource base; the results include deforestation, soil erosion, desertification and reduced recharge of aquifers. As a result, resource degradation represents an increasing risk factor for many poor households. Extreme weather events and climate change can be considered 'risk multipliers' in relation to natural resource degradation, as they exacerbate the fragility of the natural resource base.

There has been a steady decline in resource productivity due to overgrazed pastures, soil erosion, watershed and forest degradation. High incidence of poverty, a high population density and rainfall dependence add to this vulnerability. There is also a question of low resilience to climate change in many rural areas (Kumar, 2010: 22). As much as 5 to 10 million hectares of agricultural land are lost each year to severe degradation through overuse, poor land management or soil nutrient mining (IFAD, 2011). This not only has a direct negative impact on agricultural productivity, making farming a more hazardous activity, it also leaves the land more vulnerable to extreme weather patterns (IFAD 2011). There is broad agreement that agricultural production is likely to decline in most of the developing world as a result of reduced water availability, increased temperatures, uncertain or shorter growing seasons, less arable land and new pest and disease patterns. IFPRI's scenario work to 2050 indicates that agricultural yields and incomes will decline, especially in South Asia. Malnutrition rates will increase as calories per capita decrease to pre-2000 levels. South Asia's agriculture is expected to be most affected by the impacts of temperature change (Nelson, G.C., *et al*. 2009. *Climate change: Impact on agriculture and costs of adaptation*. Appendix 2: Results by World Bank Regional Grouping of countries, IFPRI: Washington, DC as cited in IFAD, 2011).

A recent *Comprehensive Assessment* of global water resources by the International Water Management Institute (International Water Management Institute. 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. Earthscan: London and International Water Management Institute: Colombo) has asserted that one-fifth of the world's population – more than 1.2 million people – live in areas of physical water scarcity including large expanses of South Asia. Specific factors limiting access to water by the poor are many and vary by location and agro-ecozone (IWMI, *ibid* as cited in Lee *et al*., 2010: 17). Energy for rural mechanization is becoming increasingly important in the region. A whole range of alternative sources and uses of energy exists today. At the same time, easier mechanization through these small scale means with a developing and well functioning market may pose newer challenges for groundwater level and soil quality (Biggs *et al*. (2011).

9.4.1.1.8. Rural-urban transformations

While disparities in median incomes between rural and urban areas are an established fact, the process of rural-urban transformation has been geographically uneven (WDR, 2008, 2009). Amongst the five major countries of South Asia - Bangladesh, India, Nepal, Pakistan and Sri Lanka - only Nepal is still a predominantly agricultural country where urbanization is at an incipient stage. The other four countries are 'transforming' or 'urbanizing' even while as per the agglomeration index of the WDR (2009: Table A2, 335-37), urbanization levels are much higher in India and Pakistan than in Sri Lanka and Bangladesh. The pattern of urbanization in South Asian countries indicates that rural areas continue to account for a large share of population and employment, even in the non-farm sector. For instance, nearly half of all manufacturing activities are located in rural areas in Bangladesh, Pakistan and Nepal. The evidence on the patterns of rural-urban transformation shows that South Asian countries are at different stages of structural transformation besides following different paths of transition. Notwithstanding their common colonial history, implementation of policy and institutional reforms had been uneven, and they now face different constraints in rural-urban transformation (Dudwick, 2011: 197).

Due to the small size of many Caribbean nations, the distinctions between 'rural' and 'urban' are not always clear, and the region also has an extremely high rate of urbanization. However, the main forces driving rural change in the Caribbean are related to the region's close integration into the global society and economy (Potter *et al.,* 2004). Migration has been a significant force shaping rural demography in the region. From the early twentieth century, rural-urban migration was common, but increasingly there has been direct international migration from rural areas. This has affected the size and composition of the rural workforce, as migrants have tended to be from the cohort of working age populations (Thomas-Hope 2010). In recent years, many return migrants have settled in small towns or rural areas, often in areas that were previously agricultural land (Potter *et al.,* 2005).

Rural areas in the Caribbean have, at various times, received foreign direct investment, often in the garment manufacturing or offshore services industries (Potter *et al.* 2004). However, these have often been 'footloose' in nature, and many have subsequently closed. The opening of these factories encouraged engagement in non-farm activities, while their closure has resulted in unemployment among low-skilled workers in areas with few other economic activities.

9.4.1.2. Industrialized Countries

An important account of changes in the rural economy in the industrialized countries is given by OECD (2006), for the OECD member states which include the European Union, other Western European countries, Turkey, Israel, North America, Japan, South Korea, Australia, New Zealand and Chile. Within these countries, predominantly rural regions account for approximately 75% of the area and 25% of the population. The per capita GDP of these regions is only 83% of the national average, and declining in more than half of OECD countries. Drivers of this decline include out-migration, aging, lower educational attainment, lower productivity of labour, and low levels of public services. However not all rural regions are in such decline, and some are currently demonstrating high levels of employment creation (OECD, 2006).

Agriculture continues to shape rural landscapes and has a strong indirect influence on rural economies, but accounts for less than 10% of overall rural employment and low proportions of gross value added. In the EU25 (the European Union excluding Bulgaria and Romania), agriculture accounted for only 13% of rural employment in 2006 and 6% of rural gross value added. Subsidy-based policies towards agriculture proved ineffective in stimulating broader rural development, but in any case are under pressure both from the WTO and international trade negotiations, and from domestic budgetary constraints. An additional trend is an increased policy focus on the broader amenity value of rural landscapes for recreation, tourism, and ecosystem services (OECD, 2006).

Several OECD countries are developing policies that can be aggregated as “the new rural paradigm”. These policies give a role to a variety of key actors, including decentralized local governments, the private sector and NGOs. They use investment rather than subsidy as a key tool, target a range of rural economic sectors rather than just agriculture, and focus on competiveness of rural areas, and use of unused resources, rather than redistribution between regions (OECD, 2006).

The remainder of this section focuses on the European Union (EU): material on North America and other industrialized regions will be added in subsequent drafts. In the EU, rural areas comprise about 80% of the total area, with 45% under agriculture and 36% as forestry. Both land use types have changed considerably during the last few decades. While agricultural land areas have declined by about 13% between 1961 and 2000, the area used for forestry has increased steadily and has almost compensated for the contraction in agricultural land use (Rounsevell *et al*., 2007). Changes in rural areas in Europe cannot be easily summarized since different trends, both ecological and socioeconomic, can be found in different rural areas. Depopulation and land abandonment in some regions coexist with counter-urbanization (the movement of urban people to the countryside) and agricultural intensification in others. Yet certain trends can be seen as generally significant, such as depopulation, land abandonment, intensification and loss of biodiversity. As some authors have shown, these trends are in most occasions more affected by policies and socioeconomic scenarios than by climate change itself. For instance, Audsley *et al*. (2006) found that land-use in Europe is relatively little affected by different climates, whereas there are large variations when economic scenarios are included, thereby the effect of policies being more important than climate change. Reidsma *et al*. (2006) also found that different socioeconomic scenarios can have different impacts on land-use changes affecting agricultural biodiversity, with the global economy scenario (A1) having the most negative effects and the regional community scenario (B2) providing the best opportunities to improve ecosystem quality of agricultural landscapes.

Changes in agricultural land use and land cover reflect economic causes, policy measures and spatial planning objectives and in turn show a wide range of impacts, including biophysical and socio-economic changes and feedbacks between land use and its drivers (Busch, 2006). Rural landscapes are suffering important transformations, from landscapes of production to landscapes of consumption (amenity value), from agricultural to leisure activities. The “leisuring” of rural landscapes (Bunce, 2008) already mentioned for small islands, is also important in the industrialised countries.

Land-use and land-cover patterns at the urban–rural fringe are affected by actors including households that purchase residential properties, developers that make these properties available, farmers who use the land for agriculture, and the local governments (including their planning commissions and township boards) that regulate these transactions and provide infrastructure for the new developments (Brown *et al*., 2008), as well as by credit institutions, infrastructure and environmental regulations.

According to Brown *et al*. (2008), the primary set of actors affecting land-use and land-cover patterns at the urban–rural fringe include: the households that purchase residential properties, the developers that make these properties available to consumers, the farmers who use the land for agriculture, and the local governments (including their planning commissions and township boards) that regulate these transactions and provide infrastructure for the new developments. Secondary actors also contribute to this process by affecting the availability of credit (lending institutions), broader sets of infrastructure like the interstate highway system (federal government), and environmental regulations like those governing wetlands (state and federal governments).

9.4.1.2.1. Agriculture

Agricultural land use (change) requires special attention since it is the major land use in rural areas. It is increasingly perceived as a multi-level, multi-actor and multi domain process. Thus, modelling of agricultural change needs to consider different levels, actors and domains (Busch, 2006). In Europe there exist divergent agricultural models with different impacts on rural landscape, land-use, livelihoods, employment and social configuration. According to Marsden and Sonnino (2005) these divergences convert the rural space within Europe into a “battlefield” of knowledge, authority and regulation. They theorise a competition among three paradigms. As the dominant one, the agri-industrial paradigm promotes globalised production of standardized food commodities for international markets. In the post-productivist paradigm, rural spaces become consumption spaces for urban and ex-urban populations. In the sustainable rural development model, agri-production is relocalised, by embedding food chains in highly contested notions of place, nature and quality. Each model has different implications for rural livelihoods or land-use. Yet, Mijl *et al*. (2006) found that in none of the SRES scenarios, drastic decrease in land for agricultural purposes is expected for the EU25 in the coming 30 years.

Exposure to increased competition brought about by economic globalization has resulted in agriculture no longer being the main pillar of the rural economy in Europe. Agriculture has remained the main land-use, but employment rates have experienced a sharp decline (Lopez-Gelats, 2009). Rural areas are gradually becoming less self-sufficient, less self-contained and sectorally controlled, and more open to the wider forces of the world economy (Marsden, 1999). These trends of social recomposition and economic restructuring entail, to the detriment of farmers and long-term residents, an increasing influence of urban and non-farming interests on rural places and their lifestyles. Although in most of Europe the question of land ownership is not as relevant as it is in developing countries, land ownership in rural areas is undergoing different changes, and this may be an important issue to be addressed in future policies addressing climate change.

Change in agricultural land-use requirement is increasingly perceived as a multi-level, multi-actor and multi domain process, and modeling of future agricultural change needs to consider this (Busch, 2006). In Europe there exist divergent agricultural models with different impacts on rural landscape, land-use, livelihoods, employment and social configuration. According to Marsden and Sunning (2005) these divergences convert the rural space within Europe into a “battlefield” of knowledge, authority and regulation. They theorize a competition among three paradigms. As the dominant one, the agri-industrial paradigm promotes globalised production of standardized food commodities for international markets. In the post-productivist paradigm, rural spaces become consumption spaces for urban and ex-urban populations. In the sustainable rural development model, agricultural production is relocalised, by embedding food chains in highly contested notions of place, nature and quality. Each model has different implications for rural livelihoods or land-use.

9.4.2. Future Impacts and Vulnerabilities

This section will examine the major impacts of climate change identified or projected for rural areas, under the headings of: economic base and livelihoods; housing and settlements; infrastructure; social capital and resilience; rural governance; landscape and regional interconnections; second-order impacts of climate policy. The biophysical impacts of climate change on crops, particularly food crops, are dealt with primarily in Chapter 7; but given the importance of agriculture in rural economies, many agricultural impacts will also be covered here.

This section makes reference to concepts of vulnerability and resilience, important socio-economic concepts that provide a context for discussion of impact. Vulnerability in particular is a problematic concept, as it can refer either to pre-existing socio-economic factors that make populations vulnerable to extreme events (or climate change more broadly), or as a combination of exposure to hazards, sensitivity and adaptive capacity (AR4 Glossary). Ribot (2009) reviews some of the literature around this. References to vulnerability and resilience in the literature on rural areas are reported here, without further theoretical discussion.

9.4.2.1. Economic Base and Livelihoods

Climate change will affect the rural economic base. These impacts can be conceptualized in economic terms or in terms of livelihoods, "the capabilities, assets (stores, resources, claims and access) and activities required for a means of living" (Chambers and Conway, 1992) considered holistically in the broader context of vulnerability to shocks and trends, institutions and policies, and the differing livelihood objectives people may have. Livelihoods are embedded in peoples' histories, cultures, relationships and the environment, all of which change over time (Kepe, 2008). Especially for agriculture and other traditional livelihoods in developing countries, the concept of the "centrality of the social" (Fairhead and Leach, 2006) is important: social relations within households (particularly gender relations) and between households, profoundly affecting production decisions, management of knowledge, and marketing (Morton, 2007).

Morton (2007), adapting findings from AR4, suggests that the impacts of climate change on smallholder and subsistence farmers can be conceptualized as a combination of: biological processes affecting crops and animals at organism or field level; environmental and physical processes affecting production at a landscape, watershed or community level; and other impacts, including those on human health and on non-agricultural livelihoods. This schema is developed by Anderson *et al.* (2009), with a cross-cutting dimension of extreme events, increased variability and shifts in average temperature and rainfall, as well as introducing indirect impacts, for example through trade and food prices, and through climate mitigation policies.

Impacts of climate change on agriculture will vary between regions and at smaller scales, with some experiencing increases in productivity and others decreases. In general analysis since 1960 shows that climate plays a bigger role in influencing agricultural production in Sub-Saharan Africa than in other regions (Barrios *et al.*, 2008); and more specifically southern Africa (Gregory *et al.*, 2005):

- In Southern Africa, simulated future outputs show a decline of 36% for maize and 31% for sorghum production in the sandveld region, and 10% for each maize and sorghum in the hard veld region of Botswana. Changes are attributed to a shorter growing season (5 days and 8 days less in the sandveld for maize and sorghum respectively, and 3 and 4 days in the hard veld) (Chipanshi *et al.*, 2003)
- Areas of Africa already marginal for food production will become increasingly marginal (with a higher frequency of failed seasons), and livestock may become an alternative (Jones and Thornton, 2009)
- Water withdrawal for irrigation in Southern Europe will increase due to climate change (IEEP, 2007).

There will be corresponding impacts on food security and resultant increases in malnutrition (Ringler, 2010). Projects hotspots in Africa include areas located in Ethiopia, Uganda, Rwanda and Burundi, southwestern Niger, and Madagascar, while regions located in Tanzania, Mozambique and the Democratic Republic of Congo might face more serious undernutrition (this based on investigating anthropometric data on weight and length of individuals as a measure of nutritional status, compared with the impact of climate change on production of cassava, maize, wheat, sorghum, rice and millet - Liu *et al.*, 2008). Poverty exacerbates vulnerability, with the poorest likely to be most affected (Jones and Thornton, 2009).

There will also be negative impacts on fisheries: impacts of climate change on aquatic ecosystems will have adverse consequences for the world's 36 million fisherfolk as well as the nearly 1.5 billion consumers who rely on fish for more than 20% of their dietary animal protein (Badjeck *et al.*, forthcoming)

There will also be corresponding impacts on incomes of rural peoples. A study of 9,000 farmers across 11 countries shows that revenues fall with warming for dryland crops (temperature elasticity of 1.9) and livestock (5.4), whereas revenues rise for irrigated crops (elasticity of 0.5) which are located in relatively cool parts of Africa (Kurukulasuriya *et al.*, 2006). But as Sen's (1992) entitlement theory showed, famines and food insecurity are not solely production-related, and in the case of the three countries in African which suffered mass mortality food crises since 2000 – Ethiopia, Malawi and Niger, these crises were triggered by a moderate decline in crop and/or livestock production, exacerbated by "exchange entitlement failures" – food price spikes and asset price collapses (Devereux, 2009). This has also expressed as vulnerability of the food system not only to ecological, but also to social factors (Ericksen, 2008a, b). These considerations need to be taken into account in discussions of future climate change impacts and food security.

How climate change affects land use, and how land use change affects climate, require examination of societal and environmental systems across space at multiple scales, from the global climate to regional vegetative dynamics to local decision making by farmers and herders (Olson *et al.*, 2008). Local land use changes can have regional impacts. Olson *et al.* (2008) suggested that the seemingly subtle land use change from savannas to cropping in East Africa may have a significant regional climate impact. Spatial pattern is also important, for instance, different socioeconomic scenarios can have the same urbanisation trend, but the spatial pattern may differs, reflecting alternative development processes, e.g. periurbanisation versus counter urbanisation (Rounsevell *et al.*, 2007). Yet, traditional rural landscapes can be a source of inspiration for making better future landscapes and offer a base for restoration. Also, they contain many forgotten lessons and landscape structure is crucial for the maintenance of diversity, both biodiversity and cultural diversity. According to Antrop (2005), these landscapes are a source of essential (barely studied) knowledge about sustainable management techniques. Also, we must consider the linkeages between rural spaces and how they are shaped by their associated food and agriculture.

It is accepted that climate change will favour desertification. Around one-sixth of the world's population is living in arid and semi-arid regions, which are mostly formed by rural areas. More than 250 million people are directly affected by desertification, while another one billion are at risk. The world's major arid regions are in the developing world, where the population growth rate is high, and socio-development levels are low (Jiang and Hardee, 2011).

Climate change may in different regions accelerate or retard processes of livelihood diversification away from agriculture, but diversification will also be affected by other factors such as trends in the availability of, and policies on agricultural land. Access to diversification as adaptations to climate extremes depends on gender, age, governance institutions based on studies in South Africa, Tanzania and Uganda (Goulden *et al.*, 2009)

9.4.2.2. Landscape and Regional Interconnections

In both developing and developed countries, rural areas have been increasingly integrated with the rest of world. The main channels through which this rapid integration process takes place are migration (permanent and cyclical), commuting, transfer of public and private remittances, regional and international trade, inflow of investment and diffusion of knowledge through new information and communication technologies. In this context, one of the important ways with which climate change will affect rural societies will be through its future impacts on regional interconnections. Climate change induced extreme events, increased variability, and changing mean climate parameters are likely to have significant implications for regional and global integration trends in rural areas.

Desakota systems represent a change in the type of relationships between human society and ecosystems, and therefore create shifts in the geographical and social distribution of risk and vulnerability (Pelling and Mustafa 2010, p3). Because of this, the characteristics of desakota regions can both increase and decrease disaster and climate risk, and can pose both opportunities and challenges for disaster response and reconstruction (Pelling and Mustafa 2010). For example, increased transport connectivity in desakota regions can reduce disaster risk by providing a greater diversity of livelihood options and improving access to education, but can also encourage land expropriation to enable commercial development (hence increasing vulnerability of those who are made landless). Similarly, the expansion of local labour market and wage labour in these areas can reduce disaster risk and improve disaster response through providing new livelihood opportunities and more effective risk management through the management and financial capacity of the formal sector but can simultaneously increase disaster risk as reliance on wage labour can increase dependence on the external economy and exposure to systemic shocks (Pelling and Mustafa 2010, p7, Figure 2).

In the Caribbean, the two most important rural activities are agriculture and tourism: although whereas agriculture's economic importance to the region has decreased in economic importance, the importance of tourism has grown.

Few regions of the world are more dependent on tourism than the Caribbean (Duval 2004), with several regional states (including the Bahamas, the Cayman Islands and St Lucia) receiving more than 60 percent of their GDP from this industry (Meyer 2006). Tourism has led to considerable coastal development in the region (Potter 2000), which may exacerbate vulnerability to sea-level rise. The economic benefits of this increased reliance on tourism have not been distributed evenly throughout Caribbean societies (Dodman 2009), and some tourism developments have caused localized environmental problems that may increase vulnerability to shocks and stresses associated with climate change.

9.4.2.2.1. Migration

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. Recent literature discusses this with reference to both the Sahel region of West Africa and South Asia. The Sahel region has a tradition of migration for which characteristics, parameters, motivations and implications vary in time and scale. During prosperous periods, Senegal and Ivory Coast were host countries to migrants from land-locked countries (Burkina Faso and Mali) while international migration to other sub regions (central, eastern and Southern Africa) or to Europe were triggered by socio-economic as well as environmental factors due to desertification and repeated droughts. The internal migration from rural to urban areas which produces social and economic ties between rural and urban spaces is motivated by differing livelihoods and income diversification. However, the urban centers are no longer the only destination; there is a better distribution towards small and medium size towns (Sall and al, 2010). Internal migration is less and less seasonal because of the downturn in the agricultural sector, which was a low priority of many governments in the region until the recent food crisis of 2007-2008 refocused attention on the needs of this sector

The Sahel experienced severe droughts between the 70s and the 90s which triggered population movements but it is hazardous to link environmental degradation to mobility and migration. This is even more complex considering the likely impact on population movements of climate change resulting from environmental degradation. Estimates and forecasts (very few of which exist in the Sahel) of the potential number of displaced people because of climate change are being challenged due to the lack of evidence from research, studies and empirical observations. Few studies carried out in the Sahel argued that the climatic variable is certainly the most significant catalyst for migration toward urban centres. However, other possible responses might reduce the influence of this factor in the minds of potential migrants (Gueye, 2007). This conclusion needs to be nuanced because the Sahel is characterized by climate variability and uncertainty whose origins, impacts and responses are not yet fully understood (A. Toure, 2009).

In South Asia, low-skilled migrants dominate seasonal labour flows, mostly from agriculturally backward and poor areas to increasingly urban centres, industrial zones and coastal areas. High-productivity agricultural areas continue to be important destinations, but more migrants have opted for non-farm employment due to greater returns. Unlike in East and South East Asia, people with limited education dominate seasonal labour flows in South Asia, and they mostly find employment in the informal sector (IFAD, 2011). Difficulties in obtaining data on internal migration, poses a challenge to reliable estimates of migration flows across regions. The estimates based on recent population census indicate, however, substantial differences in migration rates across countries. With migrants defined as 'those who are living in areas different from their place of birth', about 30 percent population of India, 20 percent of Sri Lanka, 15 percent of Nepal, and 9 percent of Pakistan, fall under such classification (Dudwick *et al.*, 2011). Evidence from censuses also indicates an speeding up of migration rates during recent years. While more than 60 percent of migration in Sri Lanka, Nepal and Pakistan is from rural to urban areas, in India, more than half of all migration is rural to *rural*. Even gender differences exist on migration within these countries: pace as well as reason differ. Women constitute more than 70 percent of all migrants in India; and in Nepal just over half of all migrants. For nearly three-fourths of South Asian women marriage is the cause of migration: for miniscule 2 percent it is work in India while it is 22 per cent in Nepal. In contrast, work is the principal reason why men migrate. Among all male migrants, its share is one third in India, more than half in Nepal and a little less than half in Sri Lanka. Among *adult* males, nearly 70 percent migrated for work in Nepal. The pace of work migration has accelerated in recent years in most South Asian countries. The evidence points that these migrants are often better educated than those who do not migrate. For instance, in Sri Lanka, of households moving within the country, the proportion of people with O level education or above is much higher among the heads of migrant households than among those who remained in the district of origin (World Bank, 2010: 22). A similar pattern is also true for Nepal where for households in the mountain and rural hills regions, temporary and permanent migration has been an important livelihood strategy. Remittances and transfers account for a large share of rural income, particularly in transforming and urbanized economies. Urban-to-rural migration highlights agriculture's role as a safety net, showing that many urban residents are still part of a broader rural kinship network (WDR, 2008). Countless numbers of the rural poor in South Asia have turned to wage labour for various reasons. Unfortunately this labour force is often poorly paid and forced to work in unhealthy or unsafe environments, reflecting a process of increasing vulnerability to climatic change and environmental degradation. There are limited job opportunities and a lack of appropriate skills for employment in higher productivity sectors such as formal manufacturing and service sectors, leading to the majority of rural migrants working irregularly and insecurely in the poorly-paid informal economy (Akram-Lodhi, 2009). Climate change is likely to exacerbate the seasonal migration.

Until recently migration was central in the climate change adaptation discourse but now there is shift because it is accepted that complex interactions mediate migratory decision-making. This is backed by the acceptance that physical vulnerability to climate change constitutes only one vulnerability to environmental hazards (Raleigh, 2008). Hence current alarmist predictions of massive flows of refugees are not supported by past experiences of responses to droughts and extreme weather events, predictions for future migration flows are tentative at best (C Tacoli, 2009).

9.4.2.2.2. Trade

The volumes of trade in agricultural commodities have been growing rapidly over the last decade. In addition to trade in basic staples such as cereals, trade in processed agricultural commodities and food products has been expanding too, which is largely due to changing diets as a result of rising incomes in developing countries. A growing number of producers and consumers of agricultural goods are connected to global markets. Hence future climate impacts on trade are likely to have significant implications for rural societies. Climate change is expected to affect the pattern and volume of international trade flows. At the sectoral and product level, it will shift the comparative advantage of countries by affecting their supply and demand capacities. The extent to which the future impacts of increased variability and mean of climate parameters and the higher frequency of extreme events on agriculture will vary substantially across countries. As early modelling studies indicated, changing mean climate parameters are likely to have positive impact on crop yields in mid- to high-latitude regions while reducing yields in low-latitude regions. Countries which are likely to benefit from increased yields are largely developed countries, whereas countries that are likely to lose from yield drops are developing countries located in low-latitude regions (e.g. Fischer *et al*., 2005). This would mean that the comparative advantage for producing cereals is likely to shift towards developed countries and agricultural trade volumes between developed to developing countries will increase as a result of climate change. On the other hand, there will also be a global shift in trade in timber products on the opposite direction - from the Northern to Southern Hemisphere (Hagler, 1998).

Future climate impacts on agriculture will be reflected on agricultural prices – which are the signals of economic scarcity or abundance. Given population growth and rising incomes, prices of agricultural commodities are expected to increase between 2000-2050. Climate change is likely to inflate these prices even further. Under the no climate change scenario, some recent modelling studies estimated that the price of rice will increase by 62 percent, maize by 63 percent, and wheat by 40 percent. Climate change will result in additional price increases –30 to 37 percent for rice, 52 to 55 percent for maize, 94 to 111 percent for wheat (Nelson *et al*., 2009). As a result of production and price changes across regions, trade flows are expected to change. Without climate change, net developed-country exports (of rice, wheat, maize, millet, sorghum, and other grains) to developing countries are expected to increase by 22.4 million mt. It has been estimated that climate change will lead to an additional export volume of 0.9 million mt to 39.9 million mt.. Regions such as South Asia, East Asia and Pacific are expected to increase their imports substantially over this period. For example, South Asia which exported around 15 million mt in 2000 is expected to import 54 million mt (based on a dry climate scenario). Similarly Middle East and North Africa and Sub-Saharan Africa which are already net importers of agricultural commodities are likely increase the volumes of agricultural imports significantly. In addition, due to climate impacts on prices, trade flow values will increase even at higher rates than trade volumes.

In this context, climate change will also lead to trade implications through its impact on food security. Recent statistical modelling studies report that a temperature increase of 1° C would lead reductions up to 21.4 percent in the yields of major food crops produced in developing countries. Rice yields are estimated to decline by 1.4 percent in South-east Asia and 4 percent in South Asia. Wheat yields are likely to decline by 5.1 percent in Central America, while maize yields in Southern Africa could fall by more than 20 percent (Deryng *et al.,* 2011). This would lead to significant food security implications given that these crops account for a substantial share of the total calories consumed by food insecure populations. For example, rice accounts for 30 percent of the total calories consumed by food insecure people in South Asia, maize contributes to 17 percent of the total calories consumed by the poor in Africa. It is important to note that impact projections for some crops are more uncertain than those for other crops (Lobell *et al*., 2008). Nevertheless, it is likely that additional food deficits caused by climate change will be supplied through trade from surplus regions.

The likely increases in variability of climate parameters and increasing frequency and intensity of extreme events will create short term volatilities. The impacts of the recent examples of extreme climate events in major exporters of agricultural commodities have created additional market volatility and prices hikes, which led to substantial increases in the number of people suffering from hunger and poverty. For example, the droughts that occurred in Australia and Ukraine in 2006–2007 created local shortages of wheat which were strong enough to put pressure on the global markets. This was considered to be one of the cyclical factors that contributed to the price hikes of 2008 which led to the ‘food crisis’. Areas which will be exposed to higher degree of climate variability and extreme events may face unexpected crop failures which may leave rural people vulnerable. Due to climate change, the number of people who will need emergency food relief is likely to grow.

The impacts of climate change through extreme events on trade infrastructure are likely to be significant too. The reliability of supply chains, including communication, transport, storage and energy is vital for the maintenance and growth of trade. Sea level rise in coastal areas which trade activities concentrate, and increased frequency and intensity of hurricanes and flooding are likely to affect storage and port facilities, roads, railways and airports, and energy supplies. These impacts are likely to be stronger in countries where infrastructure capacity is already weak and fragile. On the other hand, climate change induced sea ice decline in the Arctic might lead to the availability of new shipping routes which would enhance global trade.

Global agricultural markets are relatively ‘thin’ because only a small share of global farm production is traded internationally (Anderson, 2010). This increases price instability. Hence one of the best insurance policies against market volatility and supply shortages caused by climate change is to deepen the markets through trade reform and improved market access as well as by improving supply capacity in rural areas in developing countries (Headey, 2011).

9.4.2.2.3. Investment

Climate change may also affect investment patterns in rural areas. On the one hand, countries, regions and sectors that are likely to be affected adversely by climate change may have difficulty attracting investment. On the other hand, ecological zones that will become favourable due to climate change are likely to see increasing inflow of investment. For example the recent price hikes in agricultural commodities have led to new initiatives of foreign direct investment (FDI) in the form of large-scale crop production in poor countries. This type of FDI seems to follow a new pattern whereby capital-endowed countries with high imports of food or feed crops are preparing to invest in large production projects in low-income countries endowed with low-cost labour force and natural resources. Climate change may lead to similar investment patterns. However, there is a risk that these new investments might not be integrated into local structures and the new investors might follow an export processing zone track solely for the purpose of promoting food security in the investor country at the expense of food security in the host country. On the other hand, If FDI comes with a basket of new technology, business connections, infrastructure and human capital, and if such investments lead to local spin-offs, they could bring enormous benefits to the host country.

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

9.4.2.2.4. Knowledge

Rural areas, as never before, are exposed to diffusion of knowledge through migration, trade and investment flows, technology transfers, and improved communication and transport facilities. Future impacts of climate change on these channels of integration will affect the pace and intensity of knowledge transfers. If trade, migration and investment flows will be intensified as a result of climate change, this will inevitably have a positive impact on knowledge transfer to rural areas.

9.4.2.3. Second-Order Impacts of Climate Policy

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

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

The promotion of biofuel crops as a source of energy in substitution of fossil fuels will also have impacts on rural areas (land-use change) and agriculture. Calls for future policies to support a switch to biofuel production indicate how current concern about climate change will manifest as future landscape change (Dockerty *et al.*, 2006). Concerns already expressed about the impact of biofuel production on food security due to increase in food prices, increasing land concentration (and land grabs), and competition for water (Eide, 2008, also Müller *et al.*, 2008). Model potential production and implications of a global biofuels industry: estimate production at the end of the century will reach 220-270 exajoules in a reference scenario, and 320-370 exajoules under a global effort to mitigate greenhouse gas emissions. They recognise the need for a high land conversion rate to achieve this (Gurgel *et al.*, 2007). The need to work towards increasing energy supply from renewable resources as responses to climate change, will in time manifest themselves in landscape changes, whether it be through the granting of planning consents for wind farms, the creation of a market for energy crops, structural changes in coastal defences, etc. (Dockerty *et al.*, 2006)

9.4.3. Valuation of Climate Impacts

The impacts of climate change are expected to be unequally distributed across the globe, with developing countries at a disadvantage, given their geographical position, low adaptive capacities (Stern, 2007; World Bank, 2010a) and the significance of agriculture and natural resources to the economies and people (World Bank 2010b; Collier *et al.*, 2008). Both direct and indirect impacts are likely to be felt, with lower agricultural productivity, increase in prices for major crops and rise in poverty (Hertel *et al.,*2010).

Though climate change would impact a range of sectors, water and agriculture are expected to be the two most sensitive to climatic changes in Asia (Cruz *et al.*, 2007). Despite the ongoing debates around the uncertainty and limitations of valuation studies, scholars generally seem to agree that African countries could experience relatively high losses compared to countries in other regions (World Bank 2010b; Watkiss *et al.*, 2010; Collier *et al.,* 2008). Overall negative consequences are seen for Africa and Asia, due to changes in rainfall patterns and increases in temperature (Müller *et al.*, 2011). In South American countries, higher temperatures and changes in precipitation patterns associated with climate change affect the process of land degradation, compromising extensive agricultural areas in LAC countries. Research on climate change impacts in rural North America has largely focused on the effects on agricultural production and on indigenous population, many of whom rely directly on natural resources. Developed countries in Europe will be less affected than the developing world (Tol *et al.,* 2004), although most of their climate sensitive sectors are located in rural areas.

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

Regional and sub-regional estimates for the value of impacts of climate change are presented here. Estimates for agriculture in most cases relate directly to rural lives. A range of other impacts on which available information exists is also considered, since these values and costs concern significant proportions of livelihoods and assets in rural areas. It is also to be noted that available literature also concentrates on certain sectors and a few countries. Research on specific rural populations is less developed than for particular sectors that are largely located in rural spaces in North America. Limited information is available on West Asia and Pacific islands, on health impacts for both Africa and Asia, small and poor communities of the Arctic (Furgal and Seguin 2006, Lemmen et al 2007, Ford and Pearce 2010).

9.4.3.1. Agriculture

Various studies conclude a decline in crop yield and water availability of agriculture due to climate change over the next three to four decades in different parts of the Asia-Pacific region (ADB & IFPRI, 2009, ADB 2009a, Srivastava *et al*., 2010, De Silva *et al*., 2007, Xiong *et al*., 2009, 2010). Some of these also report values for associated economic losses. A study by Vaghefi *et al*. (2011) estimates impact of climate change on rice yield in the South-East Asian nation of Malaysia. In a hypothetical scenario with a 2ºC increase in temperature and CO2 levels stabilising at 383 ppm, the study suggests a decline in rice production with an estimated economic loss of $ 54.17million per year. Zhai and Zhuang (2009) in a study of south East Asian countries suggest that by 2080 GDP of countries like Thailand, Vietnam and Philippines would contract between 1.7 to 2.4% because of the loss of agricultural productivity due to climate change. Similarly, Guiteras (2007) argues that agricultural losses due to climate change in India would result in a loss of 1 to 1.8% of GDP per year for the country and could reduce consumption by India's poor by 18% (ibid). ADB and IFPRI, (2009), argue that climate change would reduce the calorie availability of all the sub regions by 13-15%, which would in turn adversely impact child nutrition in the region. It is estimated that climate change could increase the number of malnourished children in the region by 9-11 million (ibid). Barring a few studies (Wassmann 2010, Reily *et al*., 2007) the evidence overwhelmingly suggests that climate change would negatively impact crop yield across the region.

ADB and IFPRI (2009) estimate that that an additional spending of $4.2- $5 billion per year or a total of $168-$201 billion over a period of 2010-2050 is required to mitigate the impact of climate change on agriculture in the region. Further, it is estimated that at a carbon price of $20/ton of Co2equivalent, the region could earn $5.5 billion annually through mitigation in the agriculture sector (ibid).

The heat wave of 2003 illustrates the North South effects of climate change for Europe. The European Farmers Unions, COPA COGECA (2003) report crop yields in Southern Europe fell 25% in 2003 but increased in Northern Europe; by 25% in Ireland and 5% in Scandinavia. Using temperature and rainfall data from the Hadley Centre Climate Model Warren *et al*. (2006) run strong carbon fertilisation and weak carbon fertilisation models for temperature increases of up to 4º C. Assumptions of strong fertilisation show yield across North America, Europe and Australasia peaking at +15% at +3º C and assumptions of weak fertilisation show declines occur above +1ºC.

Much larger declines in yield occur as critical growth thresholds are reached. This tendency for production to move North would be reinforced by the impact of climate change on water supply.

There would be impact on crop productivity in the Pacific region, specifically in the developed nation of Australia. Anwar *et al*. (2007) in a study of climate change impact on rain fed wheat in south eastern Australia find that under the IPCC's low, medium and high global warming scenarios, median wheat yield may decrease by 29% between the period of 2000-2070. They also suggest that in an increased CO2 concentration scenario, yield might decline by 25%.

The most recent work on Mexico's farm sector includes Mendelsohn *et al*. (2010), who find that farmland values will decline by 4-6,000 pesos per acre for each degree of (average) warming, and that by 2010 farms will lose 42-54% of their value, with larger income loses for farms without irrigation in place. Studying extreme events rather than average impacts, Boyd and Ibarrarán (2009) use a CGE model to simulate the effects of a long drought on the Mexican economy. They found declines in production of 10-20% across a variety of agricultural sectors as well as impacts in other areas, and their modeled mitigation strategies were of limited usefulness in avoiding the associated declines in GDP.

Studying the US, Schlenker and Roberts (2009) and Roberts and Schlenker (2010) estimate small initial increases followed by large yield declines for corn and soybeans by in their current spatial arrangement by 2100 when non-linear plant responses to temperature changes are considered. They also find that these crops have not become more heat tolerant during the 20th centuries' long period of rising yields. These results contrast with the findings of Deschênes and Greenstone (2007), whose results suggest small, positive effects on farm profitability and no significant effects on yields. Fisher *et al*. (forthcoming) suggest that these results are not robust to including the impact of storage decisions, accounting for spatially correlated error terms, and correcting errors in some of the data used. Mendelsohn *et al*. (2007) also find that rural US communities will fare poorly under a modeled 10% average increase in temperature, especially in the southeast and the prairies, with cropland values falling by 13%. Hatfield *et al*. (2008) provide detailed data on estimated yield impacts across a broad array of economically significant crops and animal products in the US but do not extrapolate to changes in values. Niemi *et al*. (2009) examine Washington State and find that losses associated with 'business as usual' choices are significant for forestry, fire fighting, and agriculture, with estimates for several crops for 2020, 2040, and 2080 outcomes. Wolfe *et al*. (2008) focus on impacts on the relatively small farms of the Northeastern US and find a mixture of estimated outcomes across crops, animal products and possible climate scenarios. Mendelsoh and Reinsborough (2007) reach more optimistic conclusions for Canadian farming, finding mixed effects but the possibility for improved profits with increasing precipitation, while US farming is again likely to be harmed by rising temperatures. Wittrock *et al*. (2011) examined the responses of several recent communities to the 2001-2 drought to draw inferences about vulnerabilities to future climate change, noting crop losses valued at from CAN$7-171 per hectare during the drought and identifying necessary changes to support future adaptation.

The impacts of climate change on the smallholder and rain-fed dominated (96% of all agricultural land is rain-fed) agricultural sector are considered to be very significant to the economies and livelihoods in Africa (Müller *et al*., 2011; Kotir, 2010; Collier *et al*., 2008; Hassan, 2010). By 2050, average yields of rice, wheat and maize could decline by 14, 22, and 5% respectively in Sub-Saharan Africa, without taking into account the CO2 fertilization effect, according to a study by the International Food Policy Research Institute. As a result food security could be negatively impacted resulting in an average of 500 calories less per person, representing a 21% decline (Nelson *et al*., 2009). Another study estimates the aggregate production changes for main cereals in Sub-Saharan Africa to be -22, -17, -17, -18, and -8% for maize, sorghum, millet, groundnut, and cassava, respectively. They also suggest that in all cases, except cassava, there is a likelihood of 95% that losses exceed 7%, and a 5% probability that they will exceed 27% (Schlenker & Lobell, 2010). Roudier *et al*. (forthcoming) suggest a median value of a negative yield loss of around -11% for West African crop yields with increased warming contributing to more severe impacts. Individual country studies demonstrate declines in yields, net revenues from crops the associated links with food security and poverty (Molua, 2009, Thurlow *et al*., 2009), Reid *et al*., 2008, World Bank, 2010a, Thurlow and Wobst, 2003 in Ahmed *et al*., 2011)

Yield patterns are expected to present spatial differences in South America. According to PRECIS regional climate projections for scenarios A2 and B2, the Southern and western Pampas region in Argentina may benefit from increased productivity in wheat, maize and soybean, while in North-Central Pampas yields are expected to decrease. Atmospheric warming, water shortages and increased evapotranspiration will reduce productivity in North and Central Chile, shifting agricultural activities towards the south (ECLAC, 2009, 2010a). In Brazil, the Southern region may gain more areas suited for tropical crops, given the reduction in the risk of frosts. Sugarcane presents a high adaptation capacity to warmer temperatures and it may double its area of occurrence in Brazil (Assad and Pinto, 2008).

Recent agronomic studies based on climate models from IPCC 4th Assessment Report show that, in Bolivia, the effects of less rainfall and higher evaporation would lead to a substantial reduction in agricultural yields in the Altiplano, the valleys and El Chaco region (World Bank, 2010). In Central America, large temperature rises or greater variability in rainfall are likely to affect bean production quite seriously. Yields could fall drastically in Guatemala and El Salvador. Given that many bean growers in Central America are small, low-income farmers, climate change may have large repercussion throughout the region, endangering the food security of large segments of the population (ECLAC, 2010b). The worsening of land degradation in Central American countries is particularly critical. Staple crop yields may fall heavily as a result of degradation processes. It is estimated that the gross value of production in Guatemala may fall approximately by 25%. In terms of magnitude of losses, Guatemala is followed by Belize, Costa Rica and Honduras (ECLAC, 2010b).

9.4.3.2. Fisheries, Livestock

Besides the impact on agricultural crops, there have been some studies which suggest impact on fisheries and livestock. Fisheries are significant ecosystems that are vulnerable to climate change impacts. According to a study by Allison *et al*. (2009) fisheries in Western and Central Africa are particularly vulnerable. In fact, half of the 16 highly vulnerable countries are categorised as Africa's Least Developed Countries and two thirds of the most vulnerable countries are to be found in tropical Africa. Seo (2010) considers adaptation behavior explicitly by analyzing farming system choices. In a study of 132 countries, Allison *et al*. (2009) find that four Asian countries of Bangladesh, Cambodia, Pakistan and Yemen are among the most vulnerable countries in terms of impacts of climate change on fisheries. This vulnerability is due to combined impact of warming, relative importance of fisheries to national economies and diets, and limited adaptive capacities. In another study of changes in climate and social systems in north eastern Asia on fisheries development, Kim (2010) argues that in countries like China, Japan and South Korea these changes could have a negative impact on fisheries adversely affecting livelihoods and food security of the region.

Climate change can also have significant impacts on livestock keeping in rural Africa. One study by Hein *et al*. (2008) of the Ferlo Region in Northern Senegal, where livestock keeping is the main economic activity of a total rural population of 100,000 people, illustrates how a modest reduction in rainfall of 15% in combination with a 20% increase in rainfall variability could have considerable effects on livestock stocking density and profits, reducing the optimal stocking density by 30%. Livestock is also important to the livelihoods of many citizens of Kenya (Kabubo-Mariara 2009), a country where more than 77% of its people live in rural areas (UN 2010). A recent study shows that livestock production is highly sensitive to climate change, whereby increased mean precipitation of 1% could reduce revenues by 6% (Kabubo-Mariara 2009).

A mixed crop-livestock farming system is chosen most often for Latin America when the given climate is hot. In temperate climate zones, farmers more often choose to specialize in crops or livestock. When rainfall increases, farmers switch from livestock to crops. Mixed farming systems are favored when temperature varies little but rainfall fluctuates significantly. The author finds that the impacts will be negative for the agricultural systems, although the magnitude of the impacts will vary substantially by farming system. Under the CCC scenario, the reduction in land values amounts to 20% in the case of specialized crop farms, but is limited to 10% for mixed farms. Therefore, mixed crop-livestock farming is found to be more resilient to severe climate change due to its diversification benefits.

9.4.3.3. Water Resources

Climate change is expected to impact water resources in the region in a major way. A study by the World Bank (2010a) argues that diminishing Himalayan glaciers would impact water requirement and food security of more than one billion people in Asia. There are some regional and country studies, which support this view. Immerzeel *et al.* (2010) in a study of major river basins of the region viz. Indus, Ganges, Brahmaputra, Yangtze and Yellow rivers conclude that different river basins would have different impacts on water availability and food security due to climate change. They further argue that the Brahmaputra and Indus basins would be more susceptible to water availability affecting food security of 60 million people (ibid). ADB, (2009a) argues that climate change would increase water stress in four south East Asian countries of Indonesia, Philippines, Thailand and Vietnam. This study further emphasises that Thailand and Vietnam are especially vulnerable to such impacts (ibid). Similarly, Yu and Shen (2010) in a study of four lake basins from northern China suggest that in the next few decades water could decrease between 20-40% due to climate change.

In assessing the impacts of climate change on water resources in rural areas of Europe, it is predicted that Mediterranean climates will experience more pressure on water resources from reduced rainfall and melt water from glacial ice and snow. Schroter at al (2006) predict that in the Mediterranean region summer water supply could fall by 20 to 30% following global warming of 2ºC and 40 -50% for 4ºC . These declines would increase the costs of production and living in the South. As a result agricultural production would tend to shift from Southern to Northern Europe with currently irrigated production systems at greatest risk. Drought could threaten biodiversity and traditional ecosystems particularly in Southern Europe with problems exacerbated by declining water quality. According to MacDonald *et al.* (2009) climate change will not lead to a widespread failure of improved rural groundwater supply in Africa, but it could affect a population of up to 90 million people, as they live in rural areas where annual rainfall is between 200 and 500mm per year, and where decreases in annual rainfall, changes in intensity or seasonal variations may cause problems for groundwater supply.

9.4.3.4. GDP and Economy-Wide Impacts

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

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

In Arctic Canada and Alaska, infrastructure built for very cold weather will deteriorate as the air and ground warm. Larsen *et al*. (2008) estimate increases in public infrastructure costs of 10-20 percent through 2030 and 10% through 2080 for Alaska, amounting to several billion dollars, much of it to be spent outside of urban centers. Lemmen *et al.*

(2007) reports that foundation fixes alone in the largely rural Northwest Territories could cost up to CAN$420 million, and that nearly all of Northern Canada's extensive winter road network, which supplies rural communities and supports extractive industries which bring billions of dollars to the Canadian economy annually, is at risk. Replacing it with all-weather roadways is estimated to cost CAN$85,000/km.

IPCC (2007) suggests that agricultural losses could amount to between 2 and 7% of GDP in parts of the Sahara, 2 to 4% in Western and central Africa, and between 0.4 and 1.3% in Northern and southern Africa. Integrating socio-economic and climatic data to estimate total economic costs of climate change impacts, recent application of two IAMs indicate that the central net economic costs of climate change in Africa could be equivalent to 1.5 to 3 percent of GDP annually by 2030 (Watkiss 2011). At the country level, analysis showed strong distributional patterns of economic costs by country and region as well as considerably rising economic costs in all regions over future years. Another recent study (World Bank 2010a) estimated country specific impacts for developing countries. Mozambique could face losses, mainly from damages to agriculture, hydropower generation, infrastructure and coastal areas, of up to $7.6 billion by 2050; Ghana could experience a reduction in annual real GDP by between 1.9 to 7.2 percent and real household consumption by 5-10 percent by 2050; Ethiopia could face a decline in GDP by 2 to 8 percent mainly as a result of the impacts of extreme weather on agriculture and infrastructure. As per Mideksa's study (2010) adverse impacts of climate change on Ethiopia's agricultural output and the sectors linked to it could reduce Ethiopia's GDP by about 10% from its benchmark level. Furthermore, the study suggests that this would likely lead to an increase in income inequality of up to 20%, with peasant farmers being particularly hit relative to others.

Research based on a Ricardian analysis of climate change impacts on agricultural systems across 11 African countries suggested that various climate scenarios impacts could generate total net revenue changes ranging from losses of $48.2 billion to gains of $90 billion by 2100 (Dinar *et al.,* 2008). Net farm revenues could be decreased by up to 25% from current levels across Africa in a 2020 climate scenario that is 1.6 percent warmer and 3.7 percent dryer. In a less pessimistic climate scenario with very moderate warming and increase in rainfall, estimates suggest that African agriculture would benefit (Hassan 2010). The literature based on agroeconomic models applied to the LAC is relatively recent and it is mostly focused on South American countries.

Seo and Mendelsohn (2008) present a continental scale Ricardian analysis of climate change impact on agriculture in South America. Under the Canadian Climate Center (CCC) scenario, South American farmers are estimated to loose on average 14% of their income by the year 2020, 20% by 2060, and 53% by 2100 under the A1 emission scenario. Estimates based on the less severe CCSR and PCM models suggest lower income decreases. Irrigated farms were found to be twice more vulnerable to temperature increases by 1 ºC than rainfed farms were. Small household farms were slightly more vulnerable to higher temperatures than large commercial farms, while large commercial farms were more vulnerable to higher precipitation. Sanghi and Mendelsohn (2008) applies the Ricardian analysis to Brazil and find that global warming could cause annual damages in Brazil between 1% and 39%. Notwithstanding the ability of Ricardian models to incorporate adaptation strategies by farmers, the analysis does not incorporate features like technological progress, relative price changes, agricultural policy and other characteristics that evolve over time.

9.4.3.5. Extreme Weather Events, Sea-Level Rise

The main climate change related events outlined in Stern (2009) are Heat waves and Droughts, storms, and innundation and Flooding. In rural areas major impacts hit farming and forestry with an estimated $15 billion production lost through drought, heat stress and fire (Munich Re 2004). Longer term adaptation could mitigate the severity of losses but could include displacement of agricultural and forestry production from Southern Europe to the North. The UK Government's Foresight Programme (2004) estimates that global warming of 3 to 4 ºC could increase flood damage from 0.1% up to 0.4% of GDP. In Europe costs could rise from $10 billion today to $120-150 billion by 2100. With strengthened flood defences these costs may only double. Much of the investment in flood defences and coastal protection would be in rural coastal areas.

Stern (2007) points specifically to the effect of more frequent extreme weather events on the global capital base of the insurance industry. More frequent inundations and heat waves in rural areas lead to a higher proportion of extreme losses by comparison with average annual losses thus greatly increasing risk based capital needs (Association of British Insurers 2005a).

Ahmed *et al*. (2009) simulate the effect of climate extremes on poverty in Mexico and find that rural poverty increases by 43-52% following a single climate shock. Kronik and Verner (2010) note that some 12% of Mexico's population is indigenous and that these rural subsistence communities are more vulnerable to extreme weather events and often depend on climate-sensitive crops like coffee.

The occurrence of extreme weather events such as droughts and floods in Africa causes losses, which however vary widely across regions and studies when evaluated in terms of GDP (Pauw *et al*., 2011, Grey & Sadoff, 2007, FAO, 2008 in Hope, 2009; DFID 2010, Oxfam, 2008 in Hope, 2009). Kenya, for instance, incurred losses of about $4 billion, as a result of flooding that was associated with El Nino in 1997-98 and the La Nina drought in 1998-2000. In the long-term, economic growth could be reduced by more than 2 percent of GDP annually due to the continuous occurrence of such events (SEI, 2009). Sea level rise also leads to wetland loss and coastal erosion. Loss of agricultural land and changes in the saline-freshwater interface is estimated to impact the economies of Africa adversely (SEI, 2009, S. Dasgupta *et al.,* 2007). Ahmed *et al*., (2009) suggest that for households, characterized as agricultural self-employed (95% or more income from farm income), climate volatility increases poverty rate in some African countries.

9.4.3.6. Recreation and Tourism

Lal *et al*. (2011) discuss impacts on various rural sectors in the US, noting that most recreational workers and Native Americans live in rural communities. They note that the dairy sector in California is predicted to lose $287-902 million annually to climate impacts by the end of the century, up to a fifth of total revenues, and that other states will be comparably affected; that niche crops like cranberries may no longer be viable at all; and that models predict declines of 50-90% of trout populations in recreational fisheries.

Economically significant sectors of tourism and recreation are mostly located in rural and coastal areas with the greatest concentration in Southern Europe. Tourism may shift northward where warmer summers will occur while Southern Europe will increasingly suffer from heat waves and water shortages. Hamilton *et al*. (2005) have projected that Russia and Canada would both see a 30% increase in tourism for 1ºC of warming. Mountain regions such as the Alps which rely on snow for high value winter sports such as skiing may see declines in earnings and activity.

9.4.3.7. Forestry, Biodiversity

It has been argued that climate change would have a devastating impact on various ecosystems. There are various studies, which support the argument that 15-40% of the species face extinction with an increase of 2ºC in temperature (Stern, 2007). Impacts on forest ecosystems (Eliasch 2008, Ogawa-Onishi *et al.,* 2010, ADB 2009a), mangroves, river basins and coral reefs have also been studied (Tran *et al.,* 2010, Preston *et al*., 2006) for Asia-Pacific and the linkages are likely to be significant for rural areas. In Europe, Scandinavian and Siberian forests should benefit from a longer warmer growing season and the carbon fertilisation effect. Mediterranean forestry will suffer from prolonged drought and forest fires.

Canadian forestry is very important to the economics of rural communities and is affected by invasive species, increased fire risks and changing growth patterns driven by climate change; valuation is complex and partly dependent on the potential for carbon sequestration credits, and detailed estimates are not available (Safranyik and Wilson, 2006, Kurz *et al*.,2008). The current, unprecedented pine beetle outbreak is expected to kill about 2/3 of merchantable pine in British Columbia by 2020 (Walton, 2010). Waring *et al.,* (2009) consider the effects of range changes on forestry in Mexico and the Southwestern US and find substantial increases in beetle infestation with predicted climate change. An economic analysis limited to New Mexico and Arizona found that losses could be partially but not fully offset by treating forests to limit infestation.

Canadian waterfowl and wetlands are also impacted by climate change. Withey and van Kooten find that optimal numbers of Western Canada ducks decrease under all modeled scenarios and that wetland acreage decreases by 5-38% from base case levels. Existence values of the duck population decline between CAN$2.4-13.5 million and estimated value of hunted ducks declines by CAN$60-334 million.

9.4.3.8. Health

Some studies have looked at the health impacts in various regions of the world, however for the most part these do not by and large distinguish the rural from the urban sector . Studies have examined the linkages between health and climate change terms of the implications for vector-borne and waterborne diseases. For Asia, studies include Tseng *et al*. (2009), Potter 2008, World Bank 2010b. For Europe, reductions in energy production and transmission may have a direct negative effect on Europe's rural economies because of the rural location of many major energy supply installations. No comprehensive assessment of climate change effects on health in Africa or Asia has been conducted so far, and there remain considerable gaps in knowledge (Costello *et al*., 2009; Byass, 2009). In general it appears that the region of Africa could be seriously affected if counter measures are not put in place (Byass, 2009; Costello *et al*., 2009; Ebi, 2008, SEI, 2009). Malaria is already a significant problem in Africa, where around 90% of all annually reported deaths caused by this disease can be found, climate change could contribute to an increase in its distribution and prevalence, with previously unsuitable regions becoming affected (Egbendewe-Mondzozo *et al*., 2011; Tonnang *et al*., 2010). Examining this relationship in 25 different African countries, Egbendewe-Mondzozo et al. (2011) suggest that in almost all of the countries studied climate change has increased the number of malaria cases.

Often economy wide estimates valuing climate impacts are based on models that do not capture the full complexity and specificity of impacts to rural areas, as these necessitate simplification and build in assumptions that aggregate across multiple contexts. Valuation of non marketed ecosystem services poses further methodological and empirical concerns (Dasgupta 2008, Watkiss 2011, Stage 2010). In certain instances, available literature also concentrates on certain sectors and a few countries. Research on specific populations with significant rural populations is less developed than for particular sectors that are largely located in rural spaces in North America. Limited information is available for instance on West Asia and Pacific islands, on health impacts for both Africa and Asia, small and poor communities of the Arctic (Furgal and Seguin 2006, Lemmen et al 2007, Ford and Pearce 2010).

9.4.4. Key Vulnerabilities

Rural areas and rural livelihoods are vulnerable to combinations of climate change impacts, across economic sectors or other categorizations of impacts, in the context of non-climate trends. These combinations vary by region: this section summarises some of the most important vulnerabilities for three regions of the developing world. It then discusses a cross-cutting set of key vulnerabilities in rural areas: those associated with gender.

9.4.4.1. South Asia

The Asia pacific region is especially vulnerable to climate change because of its large population and prevalent poverty. The region is home to 4.1 billion people, which constitute around 60% of the global population (UNESCAP, 2009) of which 58% live in rural areas (ibid). Around 903 million people in the region live in poverty surviving on $1.25 per day or less (ADB, 2009c). Many countries of the region are already struggling with climate variability and some of the most climate vulnerable countries of the world like Bangladesh, India, Philippines and Vietnam and several low lying island states are from the region (ADB, 2009b).

This region is characterized by its diverse range of ecosystems and landscapes, and socioeconomic conditions, with the Pacific countries constituting small island states, which are vulnerable to sea level rise and cyclones. 50% of the population in these countries live within 1.5 km of the shoreline which makes them extremely vulnerable (ADB, 2009d). Climate change is expected to impact coral reefs, fisheries and tourism in these island states, thus disrupting their main sources of livelihoods (ibid). In central and west Asia, a sub region characterised by droughts, water scarcity would increase, affecting livelihood and energy needs of millions of people (ADB, 2009b). South Asia, which represents half of the world's poor, has millions of farmers and coastal communities which are extremely vulnerable to rainfall variability and sea level rise. East Asia, which is characterised by varying socioeconomic levels between countries like China and Mongolia faces issue related to land degradation and water resource management. Similarly, dense populations living along the coastal areas face major challenges in South East Asia (ibid).

60% of the economically active population and their dependants, accounting for 2.2 billion people in Asia Pacific, depend on agriculture for their livelihoods (ADB and IFPRI, 2009). This dependence continues despite the decline in the share of agriculture in GDP in the region over the years. For example, in the Peoples Republic of China (PRC) with a population of 1.34 billion, though agriculture only accounts for 12% of the GDP, 64% of the economically active population is dependant on it (ibid). However, there is variation within this overall situation of the declining share of agriculture in GDP, with some notable exceptions. For example, agriculture still constitutes 30% of GDP in Cambodia and 40% in Lao PDR. In Papua New Guinea (PNG), share of agriculture in GDP has increased from 32% in 1995 to 42% in 2005 (ADB and IFPRI, 2009). Rural population is relatively larger in these countries. Cambodia, Lao PDR and PNG have 78%, 68% and 84% of their respective population living in rural areas.

With heavy dependence on agriculture, there is a tough competition for land and water resources in many countries of the region especially in the central and south Asian sub region. Climate change is an added stress to this precarious situation. It would impact livelihoods and food security of a large population in the region. The South Asian region would be particularly affected due to a decline in crop yields (World Bank, 2010b, Lobell *et al.*, 2008).

It has been argued that impacts of climate change in Asia Pacific would have an impact on global food security as the region influences global food demand and supply (ADB and IFPRI, 2009). Asia Pacific accounted for 43% of total crop production in the year 2000 and is expected to account for 33% of total cereal demand over the next several decades (ibid).

9.4.4.2. Africa

Sub Saharan African in general and West Africa in particular are vulnerable to Climate Change and climate variability because some of its physical and socio-economic characteristics predispose them in such a way as to be disproportionally affected by the adverse effects of climate variability (IUCN, 2004). Climate change will add to the burdens of those who are already poor and vulnerable and there is high confidence in the AR4 that small holders and subsistence farmers, pastoralists and artisanal fisher folk will suffer complex localised impacts of climate change.

As stated in the chapter 9 on Africa in the AR4, Africa is one of the most vulnerable continents to climate change and climate variability, a situation aggravated by the interaction of 'multiple stresses', occurring at various levels, and low adaptive capacity (high confidence). Sub-Saharan Africa is considered highly vulnerable to climate change threat because of its dependence on agriculture, natural resources and others highly exposed development sectors to climate change impacts (Kotir, 2010). This situation is attributed and exacerbated by the low capacity of Sub-Saharan Africa countries to adapt (Thornton *et al.*, 2008).

Indeed, the vulnerability of countries and societies to the effects of climate change depends not only on the magnitude of climatic stress, but also on the sensitivity and capacity of affected societies to adapt to or cope with such stress (OECD, 2009). Socio-economic systems play a role in amplifying or moderating the impacts of climate change and it is largely agreed that the ability to adapt and cope depend upon many factors, such as wealth, technology, education, institutions, information, skills and access to resources, which are generally scarce in poor countries and communities. In sub Saharan Africa, climate sensitive sectors such as agriculture, tourism and coastal resources are critical for the livelihoods of the poor especially those practicing smallholding and subsistence agriculture.

Short-term natural extremes such as storms and floods, interannual and decadal climate variations as well as large scale circulation change such as the El Niño Southern Oscillation (ENSO) all have important effects on crops, pasture and forest production(AR4) .

There are various and differentiated impacts of climate change in Africa, while Sub-Saharan Africa suffers from natural fragility with two-thirds of its surface area being arid and semi arid, North Africa will suffer additional water scarcity (WDR, 2010). Sub-Saharan Africa is exposure to droughts and floods, which are forecast to increase with further climate change. In the chapter on food, fibre and food products, the AR4 noted that current vulnerability to climate variability including, including extreme events, is both hazard and context-dependent. For agriculture, forest and fishery systems vulnerability depends on exposure and sensitivity to climate conditions and on the capacity to cope with changing conditions. The region's economies are highly dependent on natural resources and rainfed agriculture contributes some 23 percent of GDP (excluding South Africa) and employs about 70 percent of the population.

In North Africa per capita water availability is predicted to halve by 2050 even without the effects of climate change. The region has few attractive options for increasing water storage, since close to 90 percent of its freshwater resources are already stored in reservoirs. The increased water scarcity combined with greater variability will threaten agriculture, which accounts for some 85 percent of the region's water use. (WDR, 2010)

9.4.4.3. Latin America

In Latin America, there are evident synergies between climate impacts and land use change trends that can increase the vulnerabilities in rural areas. An example of this feature is the study of flood impacts on Haiti and a specific region of the Dominican Republic, where deforestation was the main component that explained the difference in impacts and loss of lives in comparison to similar hydroclimatic conditions in Puerto Rico and most of the Dominican Republic (Aide and Grau, 2004).

Even though its share of the GDP is relatively low, the agricultural sector plays an important role in food and livelihood provision, serving of other economic sectors such (Trotman *et al.,* 2009). The food and nutrition problems of the Latin American and Caribbean region are far from being resolved. Enormous segments of the population are affected by hunger and undernutrition, while at the same time malnutrition, in the form of overeating, is increasing daily (Martínez *et al*., 2009). Extreme climate events could influence poverty by affecting agricultural productivity and raising prices of staple foods that are important to poor households in developing countries. (Ahmed *et al.,* 2009).

People living under critical conditions in Latin America will be more exposed to disease and pest transmission processes as a consequence of global warming. Climate extreme increases associated with climate change would cause physical damage, population displacement, and adverse effects on food production, freshwater availability and quality. It would also increase the risks of infectious and vector-borne diseases (Moreno, 2006).

9.4.4.4. Vulnerability and Gender

Gender issues were a "latecomer" to the climate debate (Denton, 2004), but vulnerability reflects gender-related inequalities that pervade in the developing world (Denton, 2002; Vincent *et al*., 2010). Gender differences in roles, responsibilities and capabilities mean that climate change may actually reinforce disparities between men and women (Vincent *et al*., 2010). These points are demonstrated by cases from rural Africa. In the context of climate change-induced conflicts among the Turkana pastoralists of Kenya, women are likely to be more adversely affected than men (Omolo, 2011). Female-headed households in drought-prone rural Zimbabwe are disadvantaged in terms of access to land, access to markets, and access to productive labour (given women's time sharing with reproductive labour), hence more vulnerable than their male-headed counterparts (Huisman, 2005). African women farmers have typically not benefited from government interventions to increase production, such as support for cash cropping and non-farm enterprises – since cash income is seen as a male activity – hence reinforcing their vulnerability (Gladwin *et al.*, 2001).

9.5. Adaptation and Managing Risks

9.5.1. Framing Adaptation

Adaptation needs and gaps are often high in societies with low socio-economic development, and in rural areas, vulnerabilities to climate change often go in hand in hand with poverty and food insecurity. For example, rural areas in Sub-Saharan Africa, South Asia and parts of East Asia where incidence of poverty and malnutrition are high are deemed to be more vulnerable to the impacts of climate change. Moreover, other prevailing development constraints, such as high incidence of HIV/AIDS, low levels of educational attainment, environmental degradation and armed conflict create additional vulnerabilities which undermine rural societies' ability to cope with climate risks. In this context, it is important to note that building capacity to adapt is a dynamic process. Economic and institutional development, improvements in health, education and infrastructure, growing interconnectedness and technology transfers help rural societies develop their human and social capital which allows them to deal with a range of risks including climate change. Rural societies always adapt to the impacts of change in exogenous factors including weather and climate. They undertake a range of adjustment measures relating to their farming practices (e.g. planting, harvesting and watering), crop and livestock varieties that they use, investment decisions in relation to infrastructure and technologies. Although risk management is not new in rural areas, since these areas have typically been characterised by change (of climate and other variables), developing capacity to cope with current variability is an important prerequisite to adapting to the predicted future increase in variability (Cooper *et al.*, 2008). Rural societies also diversify their income sources, which allows them to reduce their risk exposure. For example, an environmental history over the last century in northeastern Botswana reveals changes in the abundance and distribution of natural resources such as grazing, browse, firewood and edible fruits and berries (Dahlberg, 2000) which have led rural societies to develop coping strategies. However, with climate change rural societies are exposed to a range of new and potentially higher risks which require them to develop additional adaptation capacities. It is often the case that adaptation measures are implemented to address climate conditions as part of risk management strategies of individuals, societies or governments. Government-provided safety nets lead to adaptive social protection and can be e used to scale up to meet unanticipated circumstances, such as those caused by climate hazards (Alderman and Haque, 2006). There are possibilities of using social protection (cash transfers, asset transfers and conditional cash transfers) to manage and reduce the risks of forced displacement resulting from climate change by increasing the threshold for distress migration (as opposed to economic migration that is voluntary)(Johnson and Krishnamurthy, forthcoming). According to data from Suriname and French Guiana, when shocks are extreme, irreversible, cumulative and co-variate, as in climate change, public welfare systems complement informal risk-sharing arrangements. Government-provided safety nets reduce climate risks by alleviating poverty, enabling new risk management strategies, and promoting human capital development (Heemskerk *et al.*, 2004).

Integration across various types of schemes, such as for drought insurance, microfinance and social protection programmes can prove effective as risk management strategies (Osgood and Warren, 2007; Conway and Schipper, 2011). Index based insurances are largely characterized by pilot schemes of limited areal extent, yet spatial pooling of micro-insurance schemes reduce capital requirements and encourage micro-insurers to cover drought-related losses (Meze-Hausken *et al.*, 2009). Microfinance can improve delivery of adaptation financing to the grassroots, as in the case of Bangladesh and Nepal (Agrawala and Carraro, 2010).

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

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

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

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

There are important gender dimensions to adaptation. Social institutions — laws, norms, traditions and codes of conduct - have not only a direct impact on the economic role of women but also an indirect one through women's access to resources like education and health care (Morrison and Juetting, 2004), and are thus essential in promoting adaptation. Computable general equilibrium (CGE) model evidence from Mozambique shows that agricultural technology improvements benefit both men and women within rural households, and technological change in cassava appears to be a particularly strong lever for increasing female and overall household welfare, especially when risk is considered (Arndt and Tarp, 2000).

9.5.2. Decisionmaking for Adaptation

Public institutions play an important role in undertaking proactive and planned adaptation measures in rural areas. As such adaptation is a policy area where rural governance comes into play. Transparency of decision making through which adaptation measures are undertaken and the participation of various stakeholders in these processes are key in facilitating adaptation. For example, in Canada's North, communities use resources from "land and sea" for their nutrition, livelihoods, and cultures (Van Oostdam *et al*., 2005). Climate change has had a negative impact on health and safety by warming ice in the winter and making it less stable for hunting, fishing, and traveling. Inuit Tapiriit Kantami, Canada's national Inuit organization, has initiated a program with regional Inuit groups and research groups in Canada to document changes in communities and means of adaptation. The approach demonstrates the value of engaging small communities to target specific problems since climate impacts and response abilities can vary substantially, calling for independent assessment at the community level.

Recognising that stakeholder perceptions of risks associated with climate change vary considerably across and within countries is essential for ensuring the sustainability of adaptation options. A case study of a resettlement programme in Mozambique showed that farmers and policymakers disagreed about the seriousness of the climate risks, and the potential negative consequences of proposed adaptive measures (Patt and Schroeter, 2008). In Bangladesh, the ambitious national Flood Action Plan (FAP) did not receive support from NGOs, who embarked upon an anti-FAP movement and attained what they perceived to be a more people-oriented national water policy, (Mallick *et al*., 2005).

The participatory approach has been advocated as crucial for effective implementation of adaptation measures has been such as for building trust in index based insurance schemes. In Africa where understanding of insurance is low, participation rates can be improved by using simulation games, as trialed in Ethiopia and Malawi, or by more conventional training methods (Patt *et al*., 2010). Data from India, Africa and South America shows that the trust that people have in the insurance product and the organisations involved in selling and managing it may be more important than economic factors, such as the size and timing of the premium and potential payouts (Patt *et al*., 2009).

Since adaptation strategies involve dealing with uncertainty, whether stakeholders have access to information for decision making and how they perceive and utilize this information affects their adaptation choices (Sheate *et al*., 2008; Dockerty *et al*., 2006). There have been attempts to assess factors influencing uptake and utility of climate forecasts. Agent-based social simulation models show that to be effective in reducing climate risk, trust in forecasts has to be high, and they have be right 60-70% of the time to benefit smallholder farmers (Ziervogel *et al*., 2005). As well as trust, the effects of user wealth, risk aversion, and presentational parameters, such as the position of forecast parameter categories, and the size of probability categories, on perceived value of seasonal forecasts have been investigated (Millner and Washington, 2011). An assessment of the extent to which climate change scenarios are currently used in developing adaptation strategies within the agricultural development sector in Africa shows that annual climate information (such as seasonal climate forecasts) is used to a certain extent to inform and support some decisions, yet climate change scenarios are rarely used at present in agricultural development (Ziervogel and Zermoglio, 2009). Although, there is a large and growing literature on the role of seasonal forecasts, in particular on the needs of rural end-user groups, e.g. smallholder farmers in a mountainous village in southern Lesotho (Ziervogel, 2004), the optimal use of seasonal forecasts in risk management by smallholder farmers is largely limited by constraints related to legitimacy, salience, access, understanding, capacity to respond and data scarcity (Hansen *et al*., 2011).

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

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

9.5.3. Practical Experiences of Adaptation in Rural Areas

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

In Northern China, the negative effects of climate change such as "drought and ecological degradation," are very serious. As an adaptive measure, China moved "winter wheat northwards" and expanded rice crops to increase yields and the quality of wheat-flower. In order to sustain 'Northeast Rice' with limited water availability, policy efforts have been focused on better irrigation systems, water-management, multiple-cropping systems, and water-saving techniques. This case has shown that the combined efforts of "individual farmers, extension staff, technology institutes and governments," in conjunction with financial support, may help farmers in efficiently adapting to climate change (Lin *et al.*, 2005).

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

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

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

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

An environmental factor that has often been neglected is wind, which erodes soils and thus leads to a decline in agricultural productivity. In Sebikotane, Senegal, "brutal sea winds" hinder vegetation and erode soil. Hence a new, "third-generation agricultural system," intended to "produce" an environment rather than merely protect or conserve it, was adopted to help adapt to climate change, increase yields, maintain biodiversity, and "improve the lives of women and girls". The system included natural intensification techniques such as diversification, contour cropping, sprinklers, ploughed furrows, and drop irrigation, "'producing' the right environment" for optimal production and ecosystem health, targeting local markets and export markets with agricultural production, and training the farmers in future generations. The Sebikotane farms have received substantial international funding and have promoted similar farms throughout Senegal (Seck, *et al*., 2005).

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

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

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

_____ START BOX 9-1 HERE _____

Box 9-1. Title?

Rajasthan in India is located in an arid ecological zone and experiences severe droughts, a condition that communities have learned to cope with through conservative use of natural resources. Ways in which communities have adapted to drought include ending production of crops such as wheat and cotton that require a large amount of water, storing fodder for times of drought and scarcity, using savings or borrowing “from cooperatives and banks” for drinking water well construction, bunding fields, digging and deepening ponds and wells to retain water, growing medicinal plants to contribute to revenue, making compost using earthworms for environmentally friendly fertilizer. With the help of a local NGO, women have also formed a self-help group (SHG) to collect money to lend to the needy during emergencies. Additionally, a government Food-for-Work Programme helps provide communities with wheat, cash, and subsidized fodder (Chatterjee *et al*., 2005).

_____ END BOX 9-1 HERE _____

_____ START BOX 9-2 HERE _____

Box 9-2. Title?

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

_____ END BOX 9-2 HERE _____

9.5.4. Limits and Constraints to Rural Adaptation

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

Rural households' lack of access to technologies and markets is also a major barrier to adaptation. According to a study of adoption of improved, high yield maize in Zambia, production and price risks that could render input use unprofitable and prevent rural households from benefiting from technological change which is crucial for adaptation (Langyintuo and Mungoma, 2008). The severe 1997 drought in the Central Plateau of Burkina Faso highlighted that household with a larger resources base took the advantage of distress sales and high prices of agricultural commodities (Roncoli *et al*., 2001). A nationally representative rural household survey in Mozambique from 2005 shows that, overall, using an improved technology (improved maize seeds, improved granaries, tractor mechanization, and animal traction) did not have a statistically significant impact on household income. However when distinguishing between households using improved technologies, especially improved maize seeds and tractors, and those who do not, households who had better market access had significantly higher income (Cunguara and Darnhofer, forthcoming).

There are also limits to the role of social capital in resilience: the scale of the 2000 Mozambique floods surpassed response capacity in Limpopo basin communities not helped by external aid – although supporting local support mechanisms was identified as appropriate to assist recovery (Brouwer and Nhassengo, 2006).

9.6. Key Conclusions and Research Gaps

9.6.1. Key Conclusions

There is a lack of clear definition of what constitutes rural areas, and definitions that do exist depend on definitions of the urban. Across the world, the importance of peri-urban areas and new forms of rural-urban interactions are increasing.

Cases in the literature on rural areas of observed impacts on rural areas often suffer from methodological problems of attribution, but evidence for observed impacts, both of extreme events and other categories, is increasing.

Climate change in rural areas in developing countries will take place in the context of many important economic, social and land-use trends. In different regions, rural populations have peaked or will peak in the next few decades, and will be overtaken by urban populations. The proportion of the rural population depending on agriculture is extremely varied across regions, but declining everywhere. Poverty rates in rural areas are falling more sharply than overall poverty rates, and proportions of the total poor accounted for by rural people are also falling: in both cases with the exception of sub-Saharan Africa, where these rates are rising. Rural people are subject to multiple non-climate stressors, including under-investment in agriculture (though there are signs this is improving), problems with land policy, and processes of environmental degradation.

In industrialized countries, there are important shifts towards multiple uses of rural areas, especially leisure uses, and new rural policies based on the collaboration of multiple stakeholders, the targeting of multiple sectors and a change from subsidy-based to investment-based policy.

Major impacts of climate change in rural areas will be felt through impacts on food security and agricultural incomes. Migration patterns will be driven by multiple factors of which climate change is only one, and projections of migration can only be tentative. There will be secondary impacts of climate policy, such as policies to encourage cultivation of biofuels.

Most studies on valuation highlight that climate change impacts will be significant especially for the developing regions, due to their economic dependence on agriculture and natural resources, low adaptive capacities, and geographical locations. The valuation of non marketed ecosystem services and the limitations of economic valuation models which aggregate across multiple contexts pose challenges for valuing impacts in rural areas.

There is a growing body of literature on successful adaptation in rural areas. Prevailing development constraints, such as low levels of educational attainment, environmental degradation and armed conflict create additional vulnerabilities which undermine rural societies' ability to cope with climate risks. The supply of information for decision-making, and the role of social capital in building resilience, are key issues.

9.6.2. 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.

This will include research on practical adaptation options, not only for agriculture, and not only technical but institutional, addressing lack of access to credit, markets, information, risk-sharing tools and property rights.

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.

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

	Total population growth (%) 1988-2088	Rural population growth 1988-2008	Rural as % of total population 1988	Rural as % of total population 2008	Agricultural as % of rural population 1988	Agricultural as % of rural population 2007
Asia & the Pacific	33	14	75	62	63	54
Sub-Saharan Africa	66	54	71	64	70	57
Latin America & the Caribbean	34	5	29	22	28	17
Middle East And North Africa	63	47	54	44	40	29

Source: adapted from IFAD 2011

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
Asia & the Pacific	80.1	55.0	90.5	60.5	52.5	26.8	59.1	31.4	82.6	72.5
Sub-Saharan Africa	74.8	75.6	75.2	87.2	52.3	52.5	51.7	61.6	71.8	75.0
Latin America & the Caribbean	23.1	14.3	42.4	19.9	13.6	7.2	25.7	8.8	57.6	26.5
Middle East And North Africa	16.1	17.2	32.7	11.7	4.6	4.0	9.5	3.6	99.0	40.1
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 2011