IFAD

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Conference on New Directions for Smallholder Agriculture
24-25 January 2011, Rome, IFAD HQ

Prospering Despite Climate Change

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Session 5
Breakout Session 11

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(DRAFT)

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Paper presented at the IFAD Conference on New Directions for Smallholder Agriculture
24-25 January, 2011

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Prospering despite climate change

Introduction and summary of paper.

This paper explores the prospects for smallholders prospering despite climate change. It examines the major threats by region, and different forms that adaptation might take before investigating new market opportunities emerging from climate change policy and markets. It assesses the best mix of measures to help smallholders adapt before concluding with a call for combining a range of supports alongside market options. It counsels against assuming that the market can substitute for questions of deep social change and transformation[1].

"Smallholder agriculture" covers an enormous range of producers in terms of size, crop and land use mix, income diversification, and market engagement. There has been a long-running debate about the merits of small and large farms but, increasingly, the case for support to smallholders has been holding ground. Such a case relies on the relative neglect to date of smallholder agriculture and the consequent unmet potential from increased investment in their livelihood systems. Smallholders usually exhibit more intensive use of labour and higher yields per area than extensive agricultural holdings. Evidence shows that growth originating in agriculture is much more effective at benefitting the lowest income groups than growth generated from industrial or service sectors, so investment in smallholders should ensure increased output and reduced rural poverty.

Adapting to climate change has until recently been seen as requiring concrete investment in flood protection measures or irrigation systems. And, while this hardware has a role to play, it needs to be complemented by investment in the software of development, governance and accountability systems. Institutional structures are invisible to the naked eye, but no less vital to building more resilient social and economic systems.

Smallholders throughout the world face a fundamental hurdle thrown up by their lack of political and economic weight. This means that they face an asymmetry of power vis-a-vis government and corporations in relation to their access to land, water and natural resources. Equally, the large and diverse nature of smallholder production means that engagement with high value markets can be very risky as well as costly. The global economy is undergoing major shifts, with a rapid increase in demand for key commodities and the resources on which they grow. Global markets are also changing in the face of consumer and other pressures. This presents smallholders with an increasingly complex world, both of opportunities but also rising uncertainties. The impacts of climate change and greater variability are likely to exacerbate such difficulties[2].

Main climate threats by region and type of farm.

Direct impacts

Agricultural development faces an array of challenges in Africa and south Asia, due to pressures on resources, falling farm size, and changes in market structure. The impacts of climate change and more variable rainfall and greater volatility will exacerbate such difficulties. Recent extreme events in Africa and Asia illustrate how climate change is already having an impact on agriculture and rural systems. The floods in Pakistan in August 2010 brought widespread loss of human life and devastation to the irrigated rice fields of the Indus valley, roads, canals, towns and villages. It is reckoned that the Indian Monsoon has already weakened somewhat, due to the atmospheric brown cloud that sits in a haze over the continent and Indian Ocean[3]. The floods in 2007 in sub-Saharan Africa also led to agricultural losses, infrastructural damage and homelessness. In both cases, climate change impacts were associated with unexpectedly heavy rainfall, as predicted by Stern[4]. They note that while temperature rise will affect growing conditions, its main impact comes through changes to the water cycle, which will involve more heavily moisture-laden air. But climate change has also brought drought to the pastoral lands of northern Kenya, farmlands of south-west China and much of Australia and this drying is expected to worsen. Rising temperatures will speed up evaporation from plants and soils, and could lead to a fall in yields from rain-fed agriculture in North Africa of up to 50% by 2020, due to a reduction in the growing season and increased heat stress on plants[5].

Looking forward, the impacts of climate change on different agricultural systems depend on the assumptions made as regards the rise in levels of greenhouse gases in the atmosphere, and how this affects global, regional and more local weather patterns. Projections from different climate models used by the IPCC present a range of pathways to 2100, depending on how sharply emissions growth is controlled over the next few decades. Most observers agree that there is little that can be done to avoid a 2C degree rise in global average temperatures, by 2050. However, further increases depend on the speed at which we can start bringing down global emissions. The window for keeping global warming to only 2C degrees seems to be closing fast, and evidence from recent models suggests it is now highly unlikely that global temperatures will be kept to 2 degrees C. Analysis of commitments made at Copenhagen and Cancun shows that a 4 degree world is far more probable[6]. As can be seen from Figure 1 below, a global average of 4 degrees C is projected to bring terrestrial temperatures of more than 4 degrees in most places, with a sharp temperature gradient from the tropics towards the poles. Predicted temperatures for parts of northern Europe and the Americas of more than 10 degrees C would bring catastrophic levels of sea-level rise from melting of the ice sheets, plus highly likely de-frosting of methane stocks in Siberia[7]. Thus, climate change will get worse in terms of rising temperatures and increasingly volatile rainfall patterns.

The higher the level of greenhouse gases in the atmosphere and associated shifts in temperature and rainfall, the greater the impacts. In the event of exceeding 2C significantly, there will be evermore marked consequences for survival in different regions, especially those reliant on rainfall and natural resources. A major increase in environmental migration has been flagged as a likely outcome by Thornton et al in a 4+ degree world[8].

A large number of assessments exist for how climate change will impact on agricultural systems around the world. Smallholder farmers are expected to be particularly at risk because of their high dependence on agriculture, limited reserves, poor access to credit, insurance and other financial services, the fact they operate in areas with already high levels of risk and uncertainty, and in countries with weak governance. Crops are also often growing at the margins of their range and,

hence, have little room for adaptation. In global terms, an IFPRI study shows the greatest impacts are in irrigated wheat, and rice systems, where yields could fall by 30 and 15 % respectively, by 2050, with farmers in South Asia faring worst[9]. However, the smallholders of sub-Saharan Africa are seen as being most vulnerable, due to their more limited resources and lack of access to government systems of support. Particular difficulties are faced in areas where sea-level rise threatens high potential farming zone, such as the Nile delta south of Alexandria, and the urban belt along the coast of West Africa.

Figure 2 illustrates expected changes in the length of growing season for sub-Saharan Africa, between 2000 and 2050. This shows the particular vulnerability of farming systems in southern Africa and the northern coastal fringe, with the former region likely to see a shortening by 20% of its growing season. Most models show that the East African region will receive more rain, but it is likely to come in more intense bursts. There is much less certainty about West Africa, where the models show a wide range of possible outcomes, from 20% drier to 20% wetter[10].

Modelling of rainfall and temperature in India shows high levels of vulnerability in a broad swathe, across the centre of the country from Gujarat and Rajasthan in the west to the bay of Bengal in the east (Figure 3). Pakistan and Nepal face a combination of heightened risks of flooding from rapid snow melt, and increased aridity in dry areas. Bangladesh is particularly vulnerable from sea-level rise and storm surges, alongside increased flooding from the Brahmaputra river system. Many dry areas have already become drier, and major rivers and associated irrigation systems are vulnerable to excessive flooding, as was seen in August 2010. These areas are most vulnerable because of high reliance on the monsoon, and on irrigation from snowfall in the Himalayas. Water stress is likely to grow significantly, with less available from groundwater sources, given continued depletion of supplies. This highlights the enormous importance of water storage mechanisms to capture and store rainfall, for use later in the season. However, as was seen with the floods in August 2010, the volume of rain falling in a very short period may be impossible to accommodate.

Given the uncertainty and complexities around modelling and the results, several authors have identified “hot spots” of vulnerability, as a means to focus attention on adaptation challenges, and implications for action in particular areas. These are shown in Figure 4 for sub-Saharan Africa, and include central Sudan, Rwanda-Burundi, the Ethiopian highlands. Taking a global view flags up the extreme vulnerability of Bangladesh and Nepal, Vietnam and south east coast of China (Figure 5).

Impacts from climate change affecting the agricultural sector also stem from increased water scarcity and associated stress, plus increased risks of flooding. The EACC study for Ethiopia assesses the costs of climate change for a range of scenarios, both wet and dry[11]. In both cases, there is an adverse impact on levels of GDP, ranging from 2 to 12%, in the first case because of flood damage to infrastructure and in the second from failed harvests and grazing resources due to drought.

Indirect climate change impacts:

Climate change brings not only direct impacts on farm and livestock production from changes to temperatures and the length of the growing season, and the amount and distribution of rainfall, but will also affect people’s welfare and livelihoods through a number of other processes, such as rising sea-level, shifts in pests and diseases[12], and changes to resource availability. For example, as water becomes scarcer, this will place heavier burdens on women and girls who traditionally have the task of fetching domestic water supplies.

There are also a number of indirect policy related impacts which, combined with other powerful global forces, are already unleashing a big rise in demand for land and natural resources. Well-known examples include the rapid increase in demand for biofuels, following the agreement of legal directives on their use in EU, US, Brazil and China, and the search for extra-territorial land to purchase or lease for growing food crops by countries with a high dependence on food imports[13]. In most cases, these new forces have generated adverse impacts for smallholders, since it has put further pressure on land availability in contexts where their own rights are poorly respected by government. Overall, this will be damaging for smallholder farmers, due to their weak negotiating position.

Overall costs of climate change impacts

Discussion of adaptation of agriculture to climate change is often couched in the language of "win-win-win", with investment in "sustainable intensification" bringing improvements in productivity and livelihoods, reduced greenhouse gas emissions, and greater resilience. There may indeed be examples where there are clear positive gains to be made of this nature. However, such optimism needs to be tempered by the real, tangible costs identified from studies of current and future impacts, and the unequal damage caused by climate change. It also needs to be tempered by remembering the formal responsibility held by the major emitters of GHG under the UNFCCC, of compensating those countries and communities damaged by global warming. At a global level, the UNFCCC and World Bank have produced estimates of the costs of adaptation which range from $41-171b/year by 2030. Stern states that "adaptation is so broad and cross-cutting – affecting economic, social and environmental conditions and vice versa – that it is difficult to attribute costs clearly"[14]. Parry et al suggest that these figures may underestimate the costs to a significant extent, and that actual costs are likely to be bigger by a factor of 2 to 3[15]. The higher the rise in average global temperatures, the greater the cost will be and risk of a breakdown in life support systems.

Adapting to climate change

Dealing with risk and uncertainty, building resilience.

People face a range of different risks relating to production, prices, and personal circumstances. Dealing with risk involves assessing a set of outcomes, with known probabilities attached, based on the past being a good guide to the future. This is the basis on which coverage can be sought from insurance companies. Uncertainty is harder, as it involves an unknown distribution of different outcomes, such that the past is not an accurate guide to the future, and insurance is not so readily available. One current example is the rapid change in pension provisions for people in Europe given the recognition that people are living longer than anticipated and consequently the sums set aside are no longer enough t[16]o provide cover. Climate change is another example of uncertain outcomes, given the recognition that the past no longer provides a good guide to today and tomorrow. Small island states have had difficulty in getting insurance for infrastructure, and hotels for more than a decade because of fears of sea-level rise and more intense storms. A further area of risk and uncertainty relates to state fragility and poor governance. IFAD notes "unaccountable public authorities and institutions introduce an element of unpredictability into public life that can significantly increase transaction costs associated with market investments and contracts, acces to services and utilities, and practices of citizenship. These affect particularly poor rural people due to their lack of power." [17]

There are various responses to uncertainty, which include diversification into less weather-prone activities, seeking out information to update likely risks and returns to different activities, and

building a more resilient system. Resilience refers to the ability of a region, country, city, village or household to protect itself from adverse impacts and recover from damage. Debate surrounds the best ways of ensuring resilience with some arguing for more intense market links, while others see market engagement adding further risks. Thus, for example, increased income and economic development are often presented as the best means to adapt to climate change. Others argue that agriculture and rural development should seek greater self-reliance, reduced use of external inputs, re-use and recycling and resources, and stronger local organisations[18]. As will be seen, some combination of the two strategies seems the best answer, depending on context.

Diversification: Strategies to address risk and uncertainty surrounding production include diversification of assets and activities, mixing crop and livestock production, pursuit of off-farm incomes, and so on[19]. Analysis of household survival in risk-prone areas has often taken an approach based on portfolio analysis, farm households protecting themselves by investing in a range of different assets[20]. Such protection works best when each asset or activity is subject to risks which are not correlated. For example, growing crops of different cycle length provides greater assurance of a harvest when distribution of rainfall within the growing season is highly variable. Planting a combination of different crops, and raising a mix of cattle, sheep and goats achieve the same purpose. Combining crops and livestock not only generates co-benefits from provision of traction, dung, and fodder but there are also different risks associated with each. Livelihood diversification has for long been a strategy pursued by many smallholders in all parts of the world. In Mali, farming households combine cultivation of two millet varieties, with groundnuts and sesame, cattle, sheep and goats, a shop-keeping business, craft-work, migration of young men and women, and individual ways of earning cash (hunting, fortune-telling, cloth dyeing). In the north-west highlands of Scotland, crofters mix off-farm work and running a Bed & Breakfast with fishing, a few head of sheep on the hill, and reliance on a plot of vegetables. Rural dwellers also try to improve their options in the longer term by, for example, getting some of their children into school, marrying their children into better-off families and establishing part of the household in town[21].

Farm and crop contracts: People also face other risks, such as those linked to market price, and may seek to reduce their exposure to this risk by contract farming, storage for later sale, or use of forward contracts. A range of farm contracts exist, such as sharecropping, which enable land owners and land users to share the risks associated with growing a particular crop, and associated investments. Well-documented examples are those of *abuna* and *abusa* sharecropping contracts amongst the Akan of Ghana and Cote d'Ivoire, which have been at the heart of the expansion in cocoa plantations through the 20th century[22]. Individuals also face risks linked to health and welfare; strengthening ties with family, friends, social networks and relationships being one means by which to ensure some help in case of need.

Insurance. In developed countries farmers can access a range of insurance packages. A Google search for the UK found 95 different companies offering a range of products. In the event of a claim being made, this often requires costly time-consuming loss assessments through farm visits to see the damage being claimed, a cost which is bearable if the farm is large. As a consequence, many insurance schemes have some level of government subsidy; for example, in the US, it is estimated that the Federal Government covers 59% of the main crop insurance programmes.

To date, there are few examples of crop-related insurance products in lower income countries. Over the last decade, a number of pilots have been developed. For example, in India the Hyderabad based micro-finance company ICICI launched the first index-based weather insurance for 200 groundnut and castor farmers, which has now spread to some 11,000 farmers. Equally, an Indian seed company

has attached free weather insurance to its cotton-seed packages in Maharashtra. Syngenta Foundation has experimented with weather insurance in Kenya, aimed at covering maize crops from adverse weather in western Kenya. Starting with 200 farmers in 2009, and 11,500 in 2010, the aim is to scale up rapidly. Payments are made based on weather data recorded at a particular set of weather stations, there are no farm visits, and payment is made through M-PESA mobile telephone banking. Farmers can buy the insurance at a 5% premium when purchasing farm inputs[23].

Alternative models are needed for insurance to be of value to poor farmers. New weather related insurance considers the rainfall data rather than actual yield which is much easier and less costly to monitor. It also eliminates the need for farm visits. As a reliable and independently verified index, it can be re-insured into the international market, but does require a dense, high quality network of weather stations. However, there are concerns that the historic rainfall record may provide insufficient guidance to future conditions. Such insurance policies are often bundled into input packages, and farm credit deals. Drawbacks include that policies only cover some of the risks farmers face regarding production. They will also experience risk surrounding price fluctuations and impacts of pests. In many cases, the relationship between farmer and institution offering the insurance is vital, for farmers to feel confidence that their losses will be covered fairly[24].

Collective insurance mechanisms: Social groups have various means by which to protect themselves against risk. Individuals and households invest in relationships which assure some level of mutual support. In "normal" times, these may be pretty effective, as when one family or one village is badly hit by crop losses. In such cases, people will know they can go for help to others in the same or neighbouring communities. They may be much less able to cope where losses are extensive and heavy, such as when drought affects a whole region.

There is much that can be learnt for adaptation strategies from the last 30 years' analysis of drought and famine, in terms of household resilience, why some are more vulnerable than others, and the form taken by successful interventions. These lessons demonstrate the importance of protecting the assets of poorer households in times of drought and famine to avoid loss of essential assets such as cattle, land, ploughs and work-oxen. Evidence from disaster-preparedness shows it is far better to invest in effective preparation, than to restore damage ex post[25].

Adapting rural systems to climate change risks

Climate change adaptation encompasses according to the IPCC "not just adjustments in ecological, social or economic systems in response to actual or expected climate stimuli and their effects" but also adjustments to moderate harm from, or to benefit from, current climate variability as well as anticipated climate change[26]. It can be a specific action, a systemic change in livelihoods or an institutional reform which provides better management and protection of natural resources. People have always sought ways of adapting, sometimes successfully and sometimes not.

Adaptation is thus likely to involve a range of strategies, pursued by actors at different scales, some market-based and others relying more on social and institutional networks. Governments have an important role to play to facilitate adaptation at community level. Work by local governments, rural councils and municipal authorities is of great importance in building an effective response that can make the most of local knowledge and priorities. IIED's engagement with national and local governments in Nepal and Kenya is aimed at exploring the best way for government to support the diverse means by which different households and communities are adapting their livelihoods.

The debate on what makes for effective adaptation has evolved considerably over the last five years, from an initial focus on large scale infrastructure, such as building flood defences, to recognition that adaptation needs to promote bottom-up processes of change based on support for community-based action. This demands that the "software" of development and change is addressed, especially issues around power, accountability and governance. Investment in physical infrastructure may be essential , but choices made here need to consider how this infrastructure will protect and benefit different groups. For example, there is currently renewed enthusiasm for investment in major dam projects in many parts of Africa, to fulfil multiple purposes, such as hydro-power, irrigated agriculture and domestic water supply. Yet those local people most affected by construction and changes to river flows are usually last to be consulted, and rarely compensated for their losses[27]. Smaller scale systems of water capture and use may generate far broader benefits to local people than the building of a large dam, yet the latter is usually preferred by governments and donors as it is seen as "modern" as well as generating contracts and revenue for those in government and the private sector.

IIED has championed the concept of Community Based Adaptation as the best means to enhance capacity amongst NGOs and other civil society groups working with the most vulnerable groups. It starts from the basis of recognising the knowledge and skills of local people and seeks to facilitate their own analysis and identification of forms of adaptation that make sense in their context. Over the last four years, an annual international workshop has brought together practitioners from across the world to learn and share from each other on how best to support CBA. There is a growing body of evidence from the field of many diverse adaptation activities in practice[28]. Work has also been carried out to support local innovation systems, through PID, PLA, CFS and other approaches, drawing on the legacy of earlier approaches to support for sustainable rural development.

Box 1. Pastoralist responses to climate change in Ethiopia and Niger[29].
Developing cut and carry fodder systems, to conserve fodder.
Development of water points to ensure secure access for people and herds
Closer relationships with people in town, often former pastoralists
Shift in herd composition to more hardy species, especially donkeys for transport
Diversification of livelihood sources
Strengthening of traditional institutions to re-establish control over key resources, enable negotiations with neighbouring groups.
Reliance on mobile phones for access to information and social contact
Many of them are collective responses, given strong traditional structures in pastoral groups.

This celebration of indigenous knowledge and innovation capacity needs also to recognise the limits to adaptation, the costs, and the value of complementary investments in infrastructure, knowledge, markets and policy which can further strengthen people's ability to cope with change. A combination of measures, operating at different levels, is the ideal response with local and national governments seeking to support community-based processes. This is the ideal scenario, but there are no guarantees of this approach being followed. Instead, governments faced by what they perceive as a "crisis" may adopt a much more top-down approach. Equally, some people may seize their chance to exploit new opportunities, such as by grabbing land or tapping into REDD mechanisms.

Much of the debate around adaptation to climate change presents an optimistic picture in which there are potential win-wins between what constitutes effective mitigation and adaptation options. However, it must be recognised that adaptation has its limits. There are some shifts in rainfall and temperature to which it is very hard to adapt. Equally, the higher level of volatility as regards weather patterns brings its own challenges. Such difficulties will increase the higher the level of warming.

There are likely to be thresholds and disruptions to production systems particularly in a 4+ world and beyond. We do not know where these thresholds might be.

New opportunities from climate change policy and markets

There are three main market opportunities generated by climate change policy. The first involves agreement of a global cap on carbon emissions and associated market for permits to emit carbon, which have generated a set of new activities and potential market opportunities. The ETS and CDM are examples of this. Given that the agricultural and land use sectors are reckoned to contribute up to 30% of global emissions, agriculture is expected over the next few years to be brought into arrangements to curb greenhouse gas emissions by setting targets for their reduction. The principal sources of GHG from agriculture are carbon dioxide associated with ploughing and land clearance, methane from livestock emissions and irrigated rice growing, and nitrous oxide from use of chemical fertiliser.

While agriculture and land use is a major source of GHG, it is also a significant potential sink for absorption of greenhouse gases, through sequestration of carbon in soils and vegetation. Estimates vary for the quantities of carbon that could be sunk into agricultural landscapes, but these may be as high as 5Gt of carbon per year, equivalent to one sixth of the global emissions[30]. In theory, if land users could gain revenue from sequestering carbon, and reducing emissions from methane and NOx, this could provide a significant source of additional income. This could be achieved through changes to land use practices, such as conservation agriculture, biochar, managing manure, grazing management, re-greening through natural regeneration and tree-planting.

Table 1 shows the potential for carbon sequestration in different soil management and cultivation systems. A recent review of 22 carbon sequestration projects in agriculture around the world shows huge diversity in scale and returns, with levels of sequestration spanning from 1.37 to 140t/ha per year and prices of C varying from $10-180/ha per year[31]. The average was 20t of C/ha/yr. Almost all projects were being financed through the voluntary carbon market.

Thus, in theory, there are a range of options for smallholders to pursue. In practice, however, access to the formal carbon market may be harder to establish, and for smallholders to access. For markets to work well requires a clear specification of the product being transacted. In the case of sequestered carbon in farming landscapes, there are several hurdles to jump, not dissimilar to those encountered for a range of other goods and services, such as organic or fair trade produce, and for REDD. The current science of understanding, monitoring and measuring changes in the status of soil carbon is limited, especially in tropical soils. As with REDD, there are questions around persistence of soil carbon pools and their vulnerability to shocks (such as heavy rain bringing soil erosion), leakage due to intensified pressure in neighbouring areas, and issues around who can claim rights over the resources able to provide this service, e.g. soils or forests. There are also significant costs for producers of these services in engaging in markets, because of the transaction costs associated with certification and quality assurance. Hence, if carbon markets are to bring significant benefits for smallholders they need design in ways which minimise their costs. This would require use of a simple proxy for C sequestration, and bundling of C services to reduce transaction costs.

A second area where smallholders could potentially gain from climate change-related markets concerns production of feedstocks for biofuels. The market in biofuels is driven very largely by policy measures by governments around the world. The EU for example has proposed a mandatory target by

2020 for ten per cent of all member states' transport fuels to come from biofuels, and similar targets have been set by the US, Brazil, India and China. As a result global demand has increased by around 20 per cent per year up to 2011, reaching more than 90 million metric tons, and will expand further. The expected mismatch between global demand and supply within these regions means that international trade in biofuels is expected to grow very rapidly in the coming years. African countries have a very limited market share in biofuel production and trade at present, but there has been great interest from governments and investors seeking to establish an industry in a number of countries. One reason is the prospect of attracting investment, for example through accessing some funds from carbon trading systems (e.g. the Clean Development Mechanism). Another is that many developing countries located in tropical and subtropical areas have, or may develop, a comparative advantage for feedstock production, such as sugar cane and oil palm.[32] This creates an opportunity for African nations to develop a new export market for their agricultural produce and to increase export revenues. Biofuel production has been presented as potentially able to improve agricultural employment, incomes and livelihoods. Such potential may be attained when cultivation involves small-scale farmers, particularly for meeting their own energy needs. However, in the case of large scale farms, there are serious concerns about where these crops will be grown, the risks of eviction for thousands of smallholders, and urgent need for consultation, arbitration and compensation in the event of land deals being struck which displace smallholders.

A third field for potential income for smallholders involves access to REDD+ funding, in exchange for reducing emissions from deforestation and forest degradation. There is significant potential for benefit, but concerns for how it might work out in practice. The focus to date has been on tropical moist forests, in countries such as Brazil, Indonesia, Guyana and the DRC. The basic assumption driving a REDD scheme is that forests need to be more valuable standing than felled. But it needs to be asked – "more valuable to whom?" Standing forest may well be more valuable to forest dwellers than seeing their land cleared, but they are rarely in a position to decide. Conversely, standing forest may be worth much less to a forestry official than when it is felled, since he can gain money from the issue of timber-felling permits.

REDD+ could also offer revenue for savanna and dryland regions. Recent work in the Sahel shows that ehese dry lands can act as significant carbon sinks, because of the very extensive areas involved. A conservative estimate for carbon sequestration in the woodlands of the Sahel gives a figure of 20 tons of carbon per hectare, based on the tree mass. Including the below-ground carbon and grassland elements would increase the volume associated with the restoration of woodlands in the Sahel. If carbon is priced at $10/ton of carbon, this would generate the equivalent of $200/hectare. Reij reckons an area of 5 million ha. in Niger has already undergone this improvement, equal to $1 billion worth of carbon (Chris Reij pers.comm.)[33].

There are many challenges to building a strong and equitable market-based REDD policy,[34] given the weak institutions responsible for managing forests and woodlands, and associated systems of governance. Serious concerns have been raised about the distribution of funding from such a scheme, and the share to be gained by national and local government coffers, as opposed to local people. Equally, there are risks that forest land will become more valuable as a result of the REDD scheme, and more powerful groups will seek to displace forest-dwellers in order to reap the REDD rewards. In a global context where commodity prices are highly volatile, it is unclear at what level the REDD payment should be pitched. If it is too low, relative to the gains to be made from soya bean and oil palm, then it will not act as an incentive to stop further forest clearance.

While many governments are keen to acquire REDD money, they are much less keen to share this with local people who actions ensure the maintenance of forest cover. There is a mismatch between REDD as a mechanism for reducing emissions and the best ways of ensuring sustainable management of forests for local people's benefit. REDD strategies need to base themselves on building rights, capacity and incentives for good forest management. Reliance on a market mechanism alone will not deliver either the carbon or the local livelihoods[35].

What mix of measures to help smallholders adapt and prosper?

An array of measures is available to help support adaptation to climate change amongst smallholder farmers. These include technology, securing property rights, investment in infrastructure, and support for local organisations and knowledge systems. Each of these elements has something to offer, but no single one can provide all that is needed. Rather, a combination of measures is required, the particular mix depending on context and opportunity. A focus on market opportunities should not diminish Annex 1 nations' commitment to support adaptation as a legally binding component from the UNFCCC treaties.

Research and technology. Much agricultural research and development has focused to date on breeding new varieties for drought or flood tolerance as the best means to address climate change. There are considerable opportunities here from selective breeding of livestock and crop varieties for changes to the amount and distribution of rainfall, length of growing season, and frost conditions. However, it is important to also think about the broader cultivation system, such as ways of making best use of water, managing soil and water in the wider landscapes, and building more effective nutrient recycling systems. In the case of sub-Saharan Africa, a key constraint on sustainable farming is the low availability and use of nutrients across the continent. The use of chemical inputs averages 6-7 kg/ha in comparison with 100kg/ha globally and close to 200kg/ha in China. In a context of global agriculture needing to cut emissions of GHGs, by improving nutrient use efficiency, and curbing methane and CO2 emissions, farmers in Africa will need to increase their inputs of key soil nutrients if they are to increase their crop yields[36].

One of the drawbacks of the agricultural research system has been the privatisation of most research capacity in many developed countries, which had formerly been a major source of innovation for adaptation and take-up in many lower income nations. Since the 1980s, state support for this research has fallen such that research by large agri-food corporations now dominates the landscape. While this corporate concentration provides strong incentives for development of products which can be commercialised, there is no incentive for research into the generation of public goods, nor changes in agronomic practice which might lead to using fewer, rather than more inputs. In many developing countries, agricultural research and extension was cut back in the structural adjustment programmes of the 1980s and 90s. Some more positive changes are now underway, with substantial public investment in agricultural research in major middle income countries, such as Brazil, China, India and Turkey, and also in Ethiopia. There has been renewed commitment by donors to the global network of CGIAR research centres, and some pilots are underway to test out private-public partnerships that could generate crop varieties of value to poor countries and communities.

Information and communication technologies. The revolution in information and communication technologies (ICT) and in information management systems is opening up access to external knowledge among even the poorest. The growth in the number and spread of mobile phones is particularly striking, and they are helping producers to link to one another, gain information about extension, and tap into market information. Mobile phone networks have witnessed rapid growth in

the last decade, with little government support. Investment in transmission masts, "pay as you go" contracts and sharing of handset costs have brought mobile phones within reach of many relatively remote communities in low income countries. This has facilitated greater connectivity, access to extension services, and reduced market transaction costs. There is evidence, for example, that the introduction of mobile phones in Niger reduced the volatility of prices in local markets and the differences in prices between markets[37]. Mobile phone technology may also facilitate greater transparency and better governance, through local people being better informed about their rights and expectations of government[38]. In sub-Saharan Africa, subscriptions have risen from 16 million in 2000, to over 500 million in 2009, an astonishing 30 fold increase, which demonstrates the receptiveness of many poor people to new technology when it fits their priorities and the price is affordable.

Recognising local resource rights. Investment in land, soils, trees requires an incentive, and confidence that the benefits reaped tomorrow and next year will repay effort laid out today. Effective adaptation to climate change demands that local people have rights recognised to encourage them to improve the resilience of their systems, and gain some benefit from sale of land assets should they decide to leave. In the case of land, and other natural resources, such as water and forests, there may be poorly defined rights at both individual and collective levels, with overlapping and inconsistent claims to these resources. Many countries exhibit pluralistic legal systems, where customary rights continue alongside more formal statute law. Uncertainty surrounding land rights may discourage agricultural investment, through fear of contest and eviction. Land rights are particularly insecure for groups with little political weight at local or national levels, such as women, pastoral herders and migrants. Equally, tenancy and sharecropping arrangements can lead to sub-optimal levels of investment, if the land-user feels a risk of land being taken away. Attributing firmer rights to land-users and clarity regarding the terms of tenancy can bring substantial yield gains through increasing the incentive to invest in longer term improvements. This is of growing importance given rising pressures on land in many developing countries[39]. As IFAD notes, "land dispossession has been a continuous process over centuries. Yet the new attractiveness of agriculture resulting from higher commodity pricess and subsidies from biofuel production are leading to increases in domestic and transnational demand for agricultural land, bringing new risks for poor rural people"[40].

Weak property rights also generate difficulties in the management of collective resources, such as common land, forests and fisheries. Without well-defined and recognised institutions for management, the pursuit of short-term interests by individuals may result in a race for harvesting what can be taken, with adverse consequences for the long term viability of the resource in question. This problem also applies to ecosystem services, such as those associated with air, soil and water quality, and the lack of private incentives to invest in maintaining and enhancing their value. The assertion by many African governments of rights over all trees and forests in rural areas, including those on farmland, and an inability to exercise management responsibility in practice, due to inadequate staff and other resources, opens up a vacuum in which local people feel no ownership of these resources and the state can exert no effective authority.

Bridging local knowledge and modern science. The understanding and application of modern science offer large benefits for food production, when linked to local knowledge of soils and ecosystems. Blending insights from different knowledge systems can help improve productivity and efficiency as well as produce more resilient food production systems by engaging local farmers in defining research priorities, and assessing new methods and practices[41]. It is particularly vital to integrate a better understanding of gender and inequality into research and extension design by recognising women's expertise and the diverse roles they play in the farm and food economy. Women often have greater

responsibility for family food production and processing, whereas men have greater engagement in market-oriented production. Women also have responsibility for preparing food for their families which means they have preferences for certain crop varieties. Women are often more involved in vegetable and fruit production around the homestead, which rarely receive as much attention as the main grain crops. Research shows that a better understanding of the different roles played by women and men in the agricultural system and related businesses leads to better interventions for boosting productivity. It is reckoned that reducing inequalities in inputs between men and women farmers could bring about an increase in agricultural productivity of 10-20%[42].

Investment in social infrastructure and social learning lies at the heart of building more resilient social systems, by strengthening the collective capabilities of people to work together.[43]. Traditional extension has been centred on the linear transfer of knowledge from an expert to the farmer[44]. The best of modern extension embodies a more sophisticated approach to building social capital, including group approaches to extension drawing on ideas from social psychology and other disciplines. Social learning, group development, collective action and general empowerment have been shown to be more effective in spreading knowledge and uptake of new practices.

An alternative more "bottom-up" method of facilitating knowledge transfer in the absence of major public or private financing is provided by "farmer field schools" and related initiatives[45] (ref). Originating as a movement in Indonesia to reduce reliance on agrochemicals, farmer field schools have become an international movement incorporating many of the ideas of group membership, collective action and local research aided by trained facilitators that have now become part of modern extension practice.

Thus, strengthening farmer associations is a vital means to address the range of challenges faced by farmers, whether for issues of the environment, market access or innovation. In Uganda, women have organised into groups to process and sell cassava. In Nigeria, aquaculture entrepreneurs have emerged to focus on raising and selling fish, while others concentrate on producing and selling feed. In Kenya, the extension system encourages farmers to form common interest groups for business activities[46].

As markets become ever more connected and complex, food producers must learn how to link to markets, identify market niches and consumer requirements, and navigate the complexities of national and international regulations involving food safety, food quality and environmental sustainability. Individuals need the basic training to cope with business challenges and the skills to make use of information sources – both economic (market prices for example) and agronomic (such as up-to-date weather forecasts). The notion of "farming as a business" has become a theme in the national agriculture strategies of several low-income countries including Uganda and Ethiopia and has been shown to increase rural incomes when communities have sufficient training to be able to capitalise on commercial opportunities[47]. In India and Vietnam, evidence shows the important role to be played by market intermediaries, in helping farmers gain information and guidance in new market conditions[48].

Infrastructure. In many poorer countries, agricultural production and market access may be severely limited by lack of transport infrastructure, energy or irrigation facilities. In sub-Saharan Africa, public investment in infrastructure fell from 6.3% of government budgets in 1980 to 3.7% in 2005[49], bringing in its wake low levels of irrigated agriculture, poor road density and inadequate maintenance, and minimal electrification in rural areas. Levels of irrigation development are particularly low in sub-Saharan Africa, at only 4% of cultivable land, in contrast to the world average of 18% and 34% in Asia. Yet yields from irrigated crops tend to be up to 3 times higher than those on rainfed lands[50]. Cheaper, quicker transport between farm and market is also likely to increase levels of investment and

production, since the gap between farm gate and market price is reduced, and perishable crops can reach the buyer in a better condition. Amongst road infrastructure investments, it is estimated that rural and feeder roads have a larger impact than higher quality roads[51].

Market engagement. There has been considerable effort to think through how markets might "work for the poor", through fair trade and other mechanisms. Some major companies have sought to show they are drawing some part of their produce from smallholders (smallholder fair-trade roses from Kenya). Yet evidence also shows that the bottom third of the farm population will find it much harder to access new market opportunities and require specific attention if they are to reap the benefit. IIED's analysis of markets for ecosystem services shows that the rules for participation in many of these markets tend to favour the better-off. A review of eleven years of Costa Rica's payments for ecosystem services, a role model for initiatives worldwide, illustrates the difficulties in making such payment systems accessible to the poorest farmers. A very clear filtering process is needed if more payments are to reach the hands of smallholders[52]. Reasons why poorer groups find it difficult to access include information, transaction costs, and costs of compliance.

A broader question concerns whether market engagement is a good form of adaptation and protection from risk, or does it generate greater vulnerability? IIED's analysis shows that it rather depends on the "markets" in which people engage, how they are structured and governed. Smallholders face dualistic markets; on the one hand high value export crops require a high level of traceability, quality control, and certification. Transaction costs for market engagement are high and there are high risks associated with the high returns, as was seen from the impact of the volcanic ash cloud on air freight in April 2010. There are also consumer concerns around buying air-freighted produce because of its higher transport carbon footprint. On the other hand, many local and regional markets may have few if any barriers to entry, but returns may be much lower, especially in markets for coarse grains. Over time, this dualism is blurring, with the transformation of food markets in many middle and low income nations, and the arrival of large scale wholesale and retailers. This will put a tighter squeeze on local farmers, unless they can demonstrate that they can meet the rising standards required[53].

The 2007-09 food and commodity crisis also showed the limits to reliance on global markets to assure food supplies at times of shortage. While there were various causes for the escalation in food and commodity prices, the globalisation of commodity and financial markets means hot money can flow into a set of assets which include foodstuffs. Even those food importing countries with plenty of money found in practice it was much harder to secure stocks than assumed, generating a strong interest in securing farmland elsewhere for their own production. The financial crisis showed there are dangers from a system in which aggregation leads to a few large banks and financial conglomerates. Financial markets need a larger number of more diverse operators if resilience is to be built, as with biological diversity[54].

Overall. The root of smallholder vulnerability lies in the marginalisation of farmers, pastoralists and other rural groups in power and decision-making. This is a fundamental problem for smallholders everywhere, and a consequence of their large numbers, weak and costly organisation and consequent very limited political power. In any negotiation, smallholders are faced with asymmetric information and power, whether its government or corporations. It is possible that new forms of communication offer a means to demand greater accountability from local and national government. Several projects aim to open up government decisions and administration to greater transparency, such as the computerisation of land registers in several Indian states, participatory budget design in West Africa and the Twaweza initiative in East Africa. Equally, programmes to empower smallholders by support to their organisations, and training in basic legal rights could make a difference[55].

6 Conclusions

Climate change will generate increased difficulties for many smallholders, particularly those in low income tropical nations. Increased uncertainty and volatility as regards rainfall and length of growing season will add to existing challenges they face over competition for land, and changing market access. The higher the level of GHG emissions, the more extreme will be the impacts on farming systems. There are very serious concerns about the slow speed with which GHG emissions are being reined back.

Addressing the impacts of climate change demands a combination of measures, which include building social institutions for learning and accountability, investment in securing property rights, and in infrastructure, agricultural research, and developing new markets. Support for adaptation is fundamental to balance within the UNFCCC agreements on addressing climate change. Reliance on market opportunities alone would be unwise. Its not a question of either market-focused interventions and measures, or collective, social infrastructure and investment. It's a question of doing both in varying mixtures, plus recognising the advantages brought by the informal economy. This mix is essential in generating greater resilience within broader livelihood systems. This also means a focus on the farming sector alone misses out many of the most important means by which smallholders currently make ends meet and which will become ever more important.

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Annex I

Figure 1: Met Office 4 Degree World

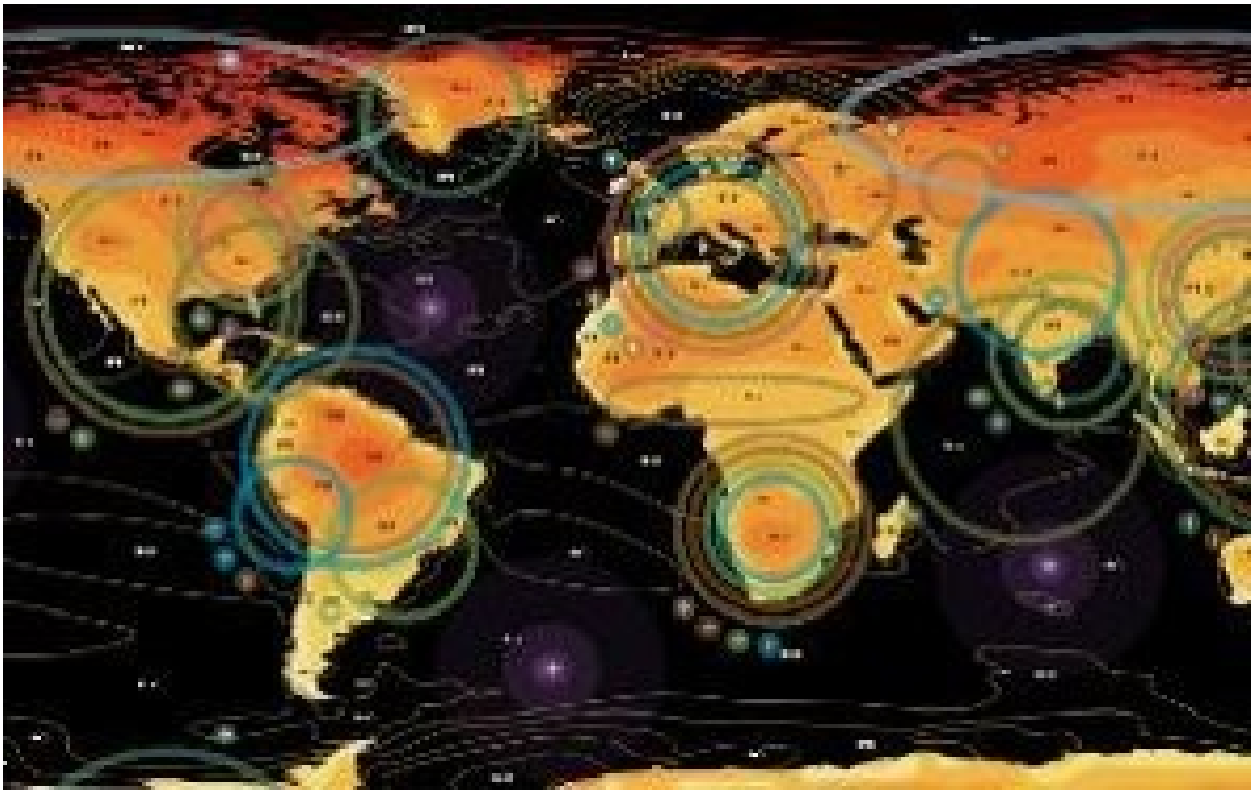

Figure 2: Changes in the Growing Season to 2050

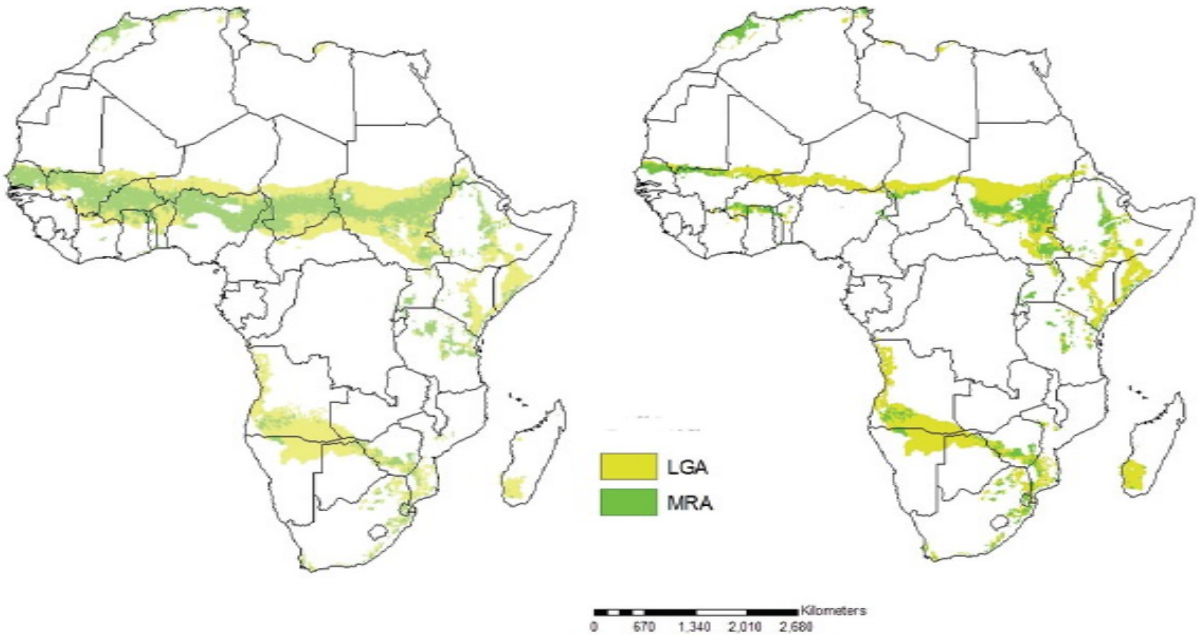

Figure 3: Districts in India vulnerable to Climate Change and Globalisation

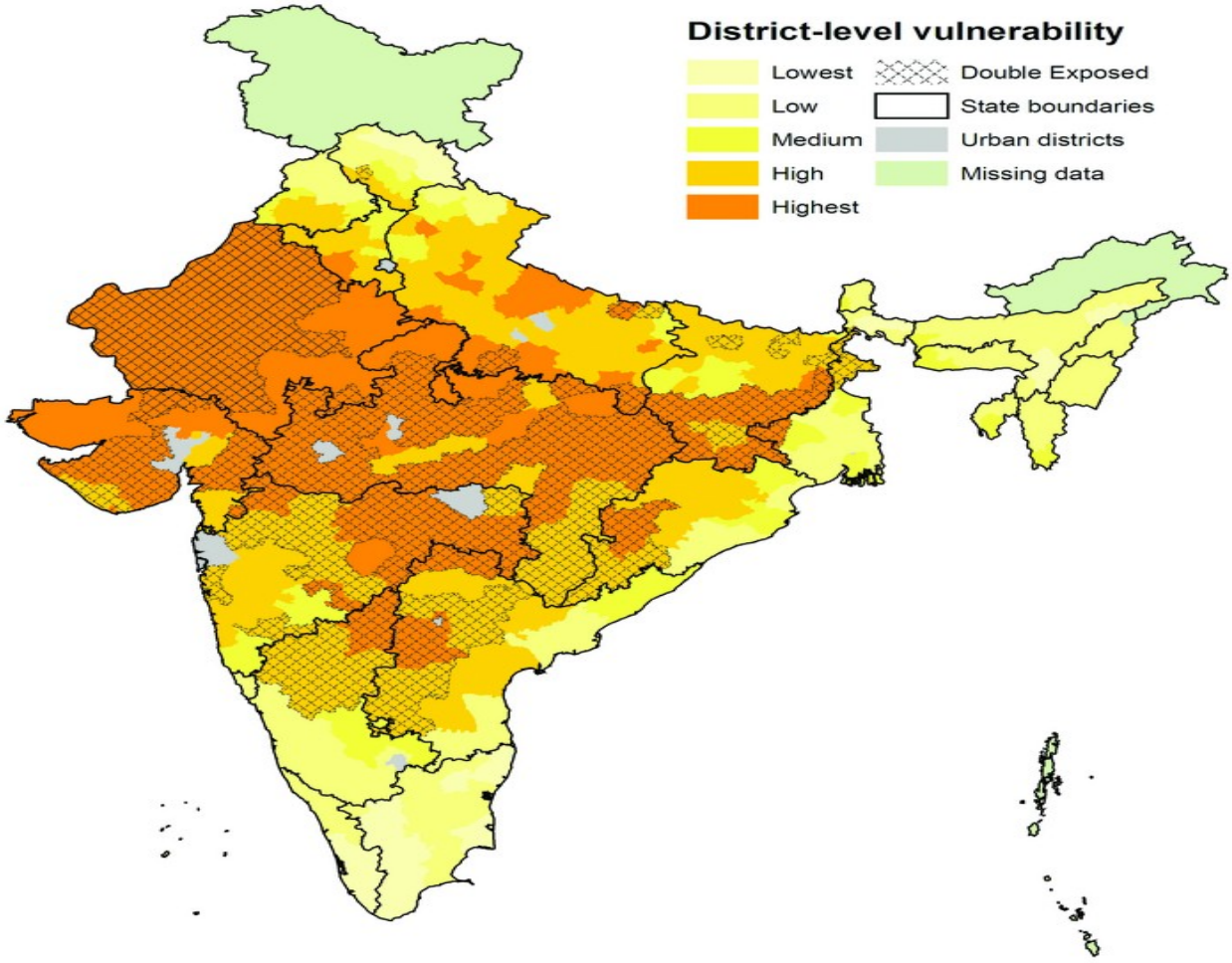

Figure 4: Hotspots of Greater Vulnerability

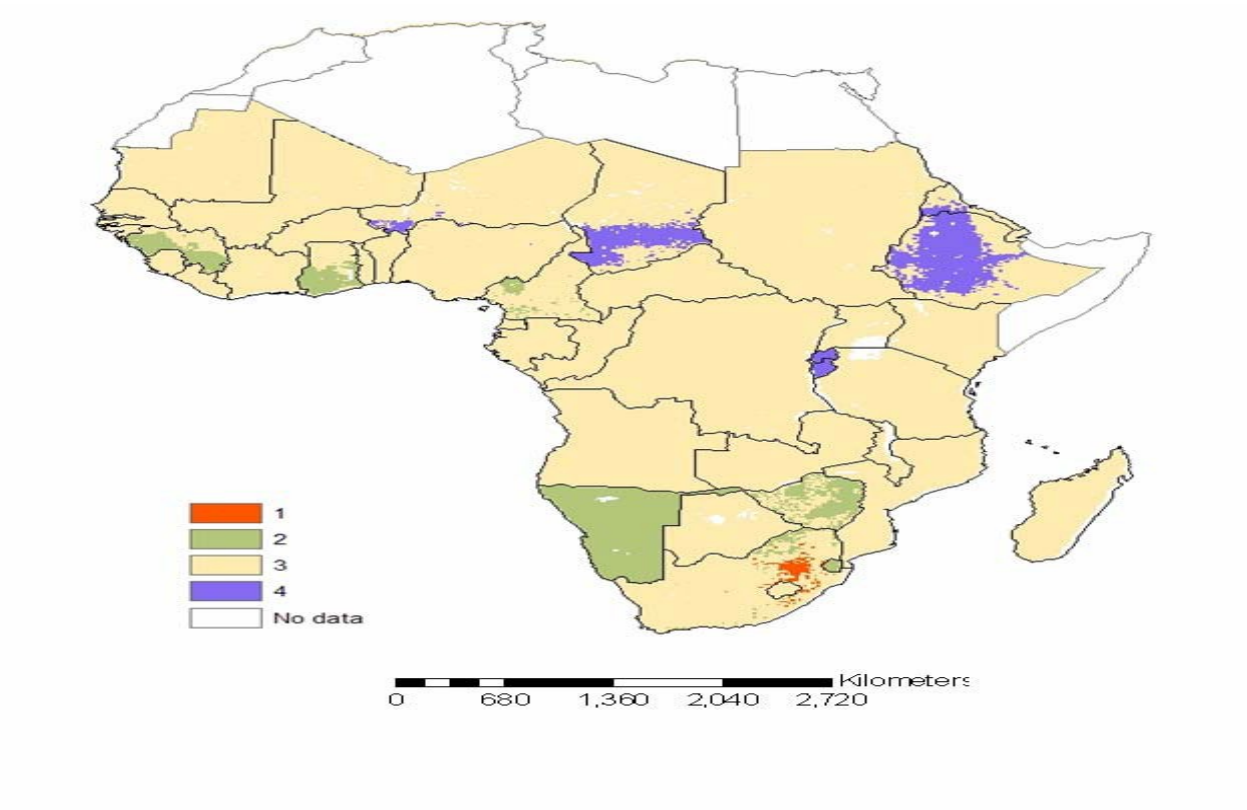

Figure 5: Climate Change Vulnerability Index

Rank	Country	Category
1	Bangladesh	Extreme
2	India	Extreme
3	Madagascar	Extreme
4	Nepal	Extreme
5	Mozambique	Extreme
6	Philippines	Extreme
7	Haiti	Extreme
8	Afghanistan	Extreme
9	Zimbabwe	Extreme
10	Myanmar	Extreme
11	Ethiopia	Extreme
12	Cambodia	Extreme
13	Viet Nam	Extreme
14	Thailand	Extreme
14	Malawi	Extreme
16	Pakistan	Extreme

Rank	Country	Category
160	Netherlands	Low
161	Latvia	Low
162	Lithuania	Low
163	Qatar	Low
164	Estonia	Low
165	Denmark	Low
166	Sweden	Low
167	Ireland	Low
168	Iceland	Low
169	Finland	Low
170	Norway	Low

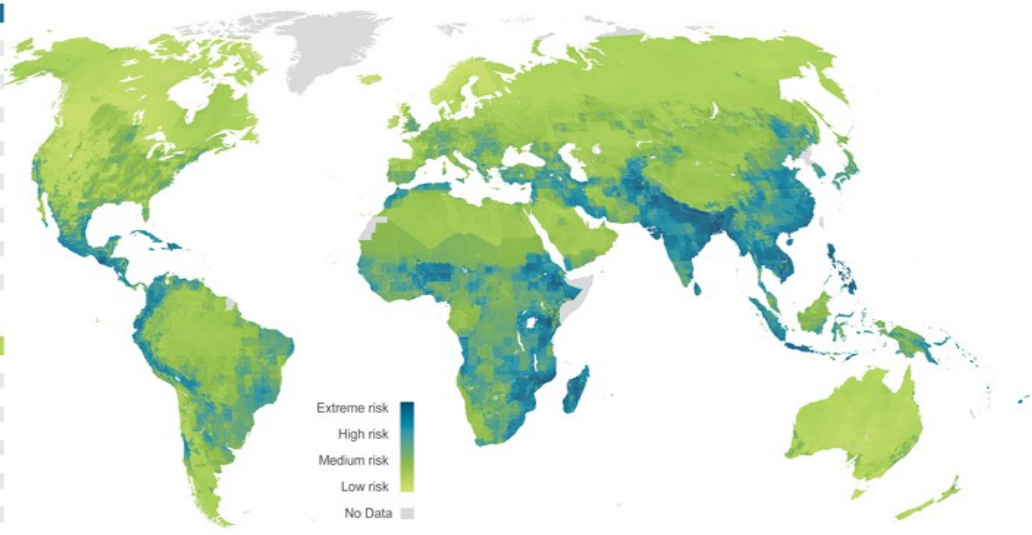

Table 1: Carbon sequestration potential of rangeland management practices

Management practice	Mean change in tCO_2e/ha/yr
Vegetation cultivation	9.39 tCO_2e/ha
Avoided land cover/land use change	0.40 tCO_2e/ha
Grazing management	2.16 tCO_2e/ha
Fertilization	1.76 tCO_2e/ha
Fire control	2.68 tCO_2e/ha

Source: Tennigkeit and Wilkes, 2008.