IFAD
Enabling poor rural people to overcome poverty

# Livestock and Climate Change

## Background and purpose of the paper

Evidence from the Intergovernmental Panel on Climate Change (IPCC, 2007) is now overwhelmingly convincing that climate change is real, that it will become worse, and that the poorest and most vulnerable people will be the worst affected.

The International Fund for Agricultural Development (IFAD) acknowledges climate change as one of the factors affecting rural poverty and as one of the challenges it needs to address[1].
While climate change is a global phenomenon, its negative impacts are more severely felt by poor people in developing countries who rely heavily on the natural resource base for their livelihoods. Agriculture and livestock keeping are amongst the most climate-sensitive economic sectors and rural poor communities are more exposed to the effects of climate change.

The IPCC predicts that by 2100 the increase in global average surface temperature may be between 1.8 and 4.0 ℃. With global average tempera ture increases of only 1.5 – 2.5°C degrees, approximately 20-30 percent of plant and animal species are expected to be at risk of extinction (FAO, 2007).

Responses to climate change include: (i) Adaptation[2] to reduce sensitivity to climatic changes and (ii) Mitigation[3] to reduce the magnitude of climate change impact in the long run. However, neither adaptation nor mitigation alone can avoid all climate change impacts. To respond to this threat it will be necessary to focus on both mitigation, to reduce the level of emission of gases contributing to global warming, and adaptation, to support local communities deal with the impacts.
At present, very few development strategies promoting sustainable agriculture and livestock-related practices have explicitly included measures to support local communities to adapt to or mitigate the effects of climate change. Activities aimed at increasing rural communities resilience will be necessary to support their capacity to adapt and to respond to new hazards.

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[1] IFAD's Strategic Framework 2007-2010 is available on line at www.ifad.org/sf/. For further details also consult: "IFAD/GEF partnership on climate change: Fighting a global challenge at the local level" available on www.ifad.org/climate/

[2] Adaptation includes all activities that help people and ecosystems reduce their vulnerability to the adverse impacts of climate change and that minimize the costs of natural disasters. There are no unique solutions for adaptation. Ad hoc measures need to be tailored to specific contexts, such as ecological and socio-economic patterns, and to geographical location and traditional practices. (IFAD: a key player in adaptation to climate change, available at www.ifad.org/operations/gef/climate/ifad_adaption.pdf)

[3] Mitigation activities involve taking actions to reduce and to enhance sinks aimed at reducing the negative effects of climate change. (IPCC Glossary Working Group III).

At the same time, while small scale agricultural producers and livestock keepers, especially poor farmers, are relatively small contributors to greenhouse gas (GHG)[4] emissions, they have a key role to play in promoting and sustaining a low-carbon rural path via proper agricultural technology and management systems.

This thematic paper analyses key issues concerning climate change, livestock and farming system development practices[5].To this end, some of the experiences and lessons learned regarding livestock and climate change have been documented, drawing on knowledge gained from IFAD's supported projects and programmes. The paper will also briefly describe and analyze the following:

1. Climate change effects on livestock and fisheries;
2. Adaptation and mitigation livestock strategies;
3. Livestock and soil carbon sequestration;
4. Gender issues in relation to livestock and climate change.

Building on these, the paper will provide recommendations for project design as well as possible responses to promote both adaptation and mitigation activities in development projects.

## 1. Climate change effects on livestock and fisheries

The possible effects of global change on food production are not limited to crops and agricultural production. Climate change will have far-reaching consequences for dairy, meat and wool production mainly via impacts on grass and range productivity. Heat distress on animals will reduce the rate of animal feed intake and causes poor performance growth (Rowlinson, 2008). Lack of water and increased frequency of drought in certain countries will cause a loss of resources. Consequently, as in the case of many African countries, it will exacerbate existing food insecurity and conflict over scarce resources[6]. The following sections aim at providing an overview of the effects of climate change both on livestock and fisheries.

### 1.1. Climate change effects on livestock

In pastoral and agro-pastoral systems, livestock are key assets for poor people, providing multiple economic, social, and risk management functions. The impacts that climate change will bring about are expected to exacerbate the vulnerability of livestock systems and to reinforce existing factors that are simultaneously affecting livestock production systems such as rapid population and economic growth, increased demand for food (including livestock) and products[7], increased conflict over scarce resources (i.e. land tenure, water, biofuels, etc). For rural communities losing livestock assets might lead to the collapse into chronic poverty with long-term effects on their livelihoods.

Among the direct effects of climate change for example, there will be higher temperatures and changes in rainfall patterns, translating in an increased spread of existing vector-borne diseases and macro parasites of animals as well as the emergence and spread of new diseases. In some areas, climate change may also cause new transmission models; these effects will be felt by both developed and developing countries, but developing countries will be most impacted because of

[4] The major greenhouse gases are: carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_20$). Less prevalent but very powerful greenhouse gases are hydro fluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6). Further details available online at www.ifad.org/climate/

[5] Changes in agriculture worldwide output potential due to climate change are briefly described in Annex I**.**

[6] See Annex II for the impact of climate change on livestock management in Africa.

[7] Globally, livestock products contribute approximately 30 percent of the protein in human diets (Gill and Smith, 2008), and this contribution is only expected to increase (FAO Stats).

their lack of resources, knowledge, veterinarian and extension services and research technology development[8] (FAO, 2008).

Some of the indirect effects for example will be brought about by changes in feed resources linked to the carrying capacity of rangelands, the buffering abilities of ecosystems, increased desertification processes, increased scarcity of water resources, lower production of grain, etc. Other indirect effects will be linked to the expected potential shortage of feed due to a rapid increase in production competition between food, feed, fuel and land use systems.

In a recent paper, Thornton *et al*. 2008 have provided an overview of some direct and indirect impacts of climate change on livestock and livestock systems. This is exemplified in Table 1 below.

| FACTOR | IMPACTS |
|---|---|
| **Water:** | Increasing water scarcity is an accelerating condition affecting 1-2 billion people. Climate change impacts will have a substantial effect on global water availability in the future. This will not only influence livestock drinking water sources, but it also affect livestock feed production systems and pasture yield. |
| **Feeds:** | • **Land use and systems change**<br>As climate changes and becomes more variable, species niches change (i.e. plant and crop substitution). This may modify animal diets and compromise the ability of smallholders to manage feed deficits[9].<br><br>• **Changes in the primary productivity of crops, forages and rangeland**<br>Effects will depend significantly on location, system, and species. But in C4[10] species, temperature increases up to 30-35 °C may increase productivity of crops, fodders and pastures. In C3[11] plants, temperature has a similar effect but increases in $CO_2$ levels will have a positive impact on the productivity of these crops. For food-feed crops, harvest indexes will change and so will the availability of metabolisable energy for dry season feeding.<br>In the semi-arid rangelands where contractions in the growing season are likely, rangeland productivity will decrease.<br><br>• *Changes in species composition*<br>As temperature and $CO_2$ levels change, optimal growth ranges for different species also change; species alter their competition dynamics, and the composition of mixed grasslands changes. For example, the proportion of browse in rangelands will increase in the future as a result of increased growth and competition of browse species due to increased $CO_2$ levels (Morgan *et al*., 2007). Legume species will also benefit from increases in $CO_2$ and in tropical |

[8] Increasing temperature can have varying effects, depending on when and where they occur. Increase in temperature during the winter months can reduce the cold stress experienced by livestock remaining outside. Furthermore, warmer weather reduces the energy requirements of feeding and keeping the animals in heated facilities (FAO, 2007).

[9] For example: in parts of East Africa, maize being substituted by crops more suited to drier environments (sorghum, millet); in marginal arid southern Africa, systems converting from a mixed crop-livestock to rangeland-based.

[10] C4 plants possess biochemical and anatomical mechanisms to raise the intercellular carbon dioxide concentration at the site of fixation, and this reduces, and sometimes eliminates, carbon losses by photorespiration. C4 plants, inhabit hot, dry environments, have very high water-use efficiency, so that there can be up to twice as much photosynthesis per gram of water as in C3 plants, but C4 metabolism is inefficient in shady or cool environments. Less than 1% of earth's plant species can be classified as C4.

[11] C3 plants, account for more than 95% of earth's plant species, use rubisco to make a three-carbon compound as the first stable product of carbon fixation. C3 plants flourish in cool, wet, and cloudy climates, where light levels may be low, because the metabolic pathway is more energy efficient, and if water is plentiful, the stomata can stay open and let in more carbon dioxide. Carbon losses through photorespiration are high.

| FACTOR | IMPACTS |
|---|---|
| | grasslands, the mix between legumes and grasses could be altered.<br><br>• *Quality of plant material*<br>Increased temperatures increase signification of plant tissues and thus reduces the digestibility and the rates of degradation of plant species. Resultant reduction in livestock production may have impacts on food security and incomes of smallholders. Interactions between primary productivity and quality of grasslands will demand modifications in grazing systems management to attain production objectives. |
| Biodiversity: (genetics and breeding) | In places, will accelerate the loss of genetic and cultural diversity in agriculture already occurring as a result of globalisation, (Ehrenfeld, 2005), in crops as well as domestic animals. A 2.5 ℃ increase in global temperature wi ll see major losses: 20-30% of all plant and animal species assessed could be at high risk of extinction (IPCC, 2007). Ecosystems and species show a wide range of vulnerabilities to climate change, depending on the imminence of exposure to ecosystem-specific, critical thresholds, but assessments are fraught with uncertainty related to $CO_2$ fertilisation effects etc.<br>Local and rare breeds are at risk of being lost through the impact of climate change and disease epidemics. There are global health implications related to biodiversity loss and many of the anticipated health risks brought about by climate change will be caused by loss of genetic diversity. |
| Livestock (and human) health: | Major impacts on vector-borne diseases:<br><br>Expansion of vector populations into cooler areas (in higher altitude areas: malaria and livestock tick-borne diseases) or into more temperate zones (such as bluetongue disease in northern Europe).<br>Changes in rainfall pattern may also influence expansion of vectors during wetter years, leading to large outbreaks of disease (Rift Valley Fever virus in East Africa). Also climate change.<br>Helminth infections are greatly influenced by changes in temperature and humidity.<br>Climate change may affect trypano tolerance in sub-humid zones of West Africa: could lead to loss of this adaptive trait that has developed over millennia and greater disease risk in the future.<br>Effects (via changes in crop, livestock practices) on distribution and impact of malaria in many systems and schistosomiasis and lymphatic filariasis in irrigated systems (Patz *et al*., 2005).<br>Increases in heat-related mortality and morbidity (Patz *et al*., 2005) |

**Table 1: Thornton et al, 2008 (pg.22-23)**

## 1.2 Climate change effects on fisheries

Climate change represents a threat to the sustainability of capture fisheries and aquaculture development. Impacts will occur as a result of gradual warming at the global scale and associated physical changes, as well as consequences of the increased frequency of extreme weather events.

Until a few years ago, the production trends in aquaculture and capture fisheries were continuing without any drastic modification to those already in place at the start of this decade. The capture fisheries sector was regularly producing between 90 and 95 million tonnes per year, and aquaculture production was growing, albeit at a gradual rate. However, the substantial increases in energy and food prices, which started in 2007 and have continued into 2008, as well as the threat of climate change, mean that the conditions for capture fisheries and aquaculture are changing[12].

The effects of increased pressure on fisheries (environmental pollution, environmental degradation due to unsustainable aquaculture practices, intensive exploitation of marine resources, etc) together with future climate change will affect a very large number of fisheries in different socio-economic and geographical contexts.
Kibuka-Musoke (2007)[13] identifies both positive and negative impacts of climate changes on fisheries:

- *Positive impacts:* The projected climate change will generally be positive for aquaculture, often limited by cold weather. Since many of the changes will involve warmer nights and winters, there should be longer periods of growth, and growth should be enhanced. Also, costs involved in making structures ice-resistant and to heating water to optimum temperatures should be lowered. Indeed, by developing appropriate technologies, farmers can use flooded and saline areas no longer suitable for crops to cultivate fish. Farmers can also use the water used for fish culture to moderate the swings between drought and flood.

- *Negative impacts:* Climate change will negatively impact fisheries through direct and indirect ways. Fisheries will be impacted by changing water levels and flooding events; temperature changes will cause a shift in the range of fish species (in different geographical areas) and a disruption to fish reproductive patterns. Also, rising sea-levels could affect important fishery nursery areas. Warming, can increase disease transmission and have an influence on marine pathogens (Harvell, 2002). Indeed, there is a large number of countries heavily depending on fish that have low capacity to adapt to change due to their comparatively small or weak economies (WorldFish Center, 2007). These countries are Angola, Congo, Mauritania, Mali, Niger, Senegal and Sierra Leone. Other vulnerable countries in Africa are Malawi, Mozambique and Uganda. Beyond Africa, it is the Asia river depend fishery nations including Bangladesh, Cambodia and Pakistan that are most at risk.

A number of IFAD projects currently have activities that promote a more sustainable utilisation of fisheries resources and value-adding through diversification activities, as in the example of Mauritius summarised in Box 1.

In particular, fishing communities in Africa will be most vulnerable to climate change because of their risk exposure, and low adaptive potential. Africa's inland fisheries play a crucial role in supporting the livelihoods and food security of millions of people across since approximately 30 to 45 million people depend on fish for their livelihoods (the World Fish Centre, 2007). Fisheries also provide a safety-net against the effects of agricultural product price unpredictability. In this sense, fisheries could, depending on local circumstances, support adaptation of some coastal communities.

Region specific ecosystem based approaches are needed to address climate change impact on fisheries and fishing communities. While it will be important to have an understanding of both regional and global impacts that climate change will have on fishing communities in developing countries, it is essential that context specific vulnerability assessments are carried out to inform the development of locally tailored strategies to support fishing communities to adapt to a changed environment.

[12] FAO (2008). The state of world fisheries and aquaculture.
[13] Doreen Kibuka-Musoke, 2007. Issue paper II. African Partnership Forum, OECD.

**Box 1: Promoting a sustainable utilisation of fisheries resources**
**The Mauritius Rural Diversification Programme**

Over-fishing in the lagoons has a destructive effect on the coral reef and the marine life it harbours. To increase the incomes of small-scale fishers and relieve pressure on depleting marine resources, the Mauritius Rural Diversification Programme helps provide incentives for fishermen to give up lagoon fishing. It encourages fishing beyond the lagoon, using fish aggregating devices (FADs), which are used by small-scale fishers to attract fish in deeper seas.
To back up the introduction of FADs, the programme included training in fishing techniques, boat handling and other safety measures, to help fishermen make the transition from net fishing in the lagoon to fishing in the open sea, under very different conditions. The programme trained women involved in octopus fishing on Rodrigues to fish without damaging the reef, and it also helps them find alternative activities. Moreover, the programme supported the government in sustainable management of marine resources and builds the capacity of the Fisheries Protection Services to monitor FAD fisheries and other fishing activities. It also helped build institutional capacity to support poor people's rural enterprises through training and improving access to financial services and by strengthening grass-roots organizations.

A follow-up programme, the Marine and Agricultural Resources Programme (MARS), will further promote non-fishing activities to reduce unsustainable (for the national fiscus) payment of bad weather allowances received by fishermen when they are unable to go out to fish due to weather conditions. This is expected to have the effect of reducing pressure on fisheries resources, as well as a positive effect on agricultural productivity and food security.

## 2. Meeting the challenge: adaptation and mitigation livestock strategies

Livestock can play an important role in both mitigation and adaptation. Mitigation measures could include technical and management options in order to reduce GHG emissions from livestock, as well as the integration of livestock into broader environmental services. As described in the section below, livestock has the potential to support adaptation efforts of the poor. In general, livestock is more resistant to climate change than crops because of its mobility and access to feed. However it is important to remember that local communities' capacity to adapt and mitigate the impacts of climate change will also depend on their socio-economic and environmental conditions and on the resources that they have available.

The sections below provide a brief overview of possible adaptation and mitigation activities of the livestock sector.

### 2.1. Livestock adaptation strategies

Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. However increased human population, urbanization, environmental degradation and increased consumption of animal source foods have made some of those coping mechanisms ineffective (Sidahmed, 2008). In addition, changes brought by global warming will happen at such a speed as to exceed the capacity of spontaneous adaptation by both communities and animal species.

The following have been identified by several experts (FAO, 2008; Thornton, et al., 2008; Sidahmed et al, 2008) as ways to increase adaptation in the livestock sector:

- *Production adjustments*: diversification, intensification, integration, of pasture management, livestock and crop production, changing land use and irrigation, altering the timing of operations, conservation of nature and ecosystems.
    - Modifying stock routings and distances;
    - Introducing mixed livestock farming systems – i.e. stall-fed and pasture grazing.

- *Breeding strategies:* many local breeds are already adapted to their harsh conditions. However, developing countries are usually characterised by a lack of technology in livestock breeding and other agriculture programmes which might help to speed adaptation. Adaptation strategies include not only their tolerance to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases (Hoffmann, 2008). Those adaptation mechanisms include:
    - Identifying and strengthening local breeds which are adapted to local climatic stress and feed sources;
    - Improving local genetics through cross breeding with heat and disease tolerant breeds. If climate change is faster than natural selection the risk of survival and adaptation of the new breed becomes greater (Hoffmann, 2008).

- *Market responses*: improvement of agriculture market, promotion of inter-regional trade, credit schemes.

- *Institutional and policy changes*: removal or putting in place of subsidies, insurance systems, income diversification practices as well as the introduction of Livestock Early Warning Systems, as in the case of IFAD-supported interventions in Ethiopia (see box no 2) and other forecasting and crisis preparedness systems.

- *Science and technology development*: better understanding of the causes and impacts of climate change on livestock, development of new breeds and genetic types, improved animal health, and improved water and soil management.

- *Capacity building livestock keepers* – increased awareness of global changes, and improved capacity of herders/livestock producers to understand and deal with climatic changes. Training in agroecological technologies and practices for the production and conservation of fodder is improving the supply of animal feed, reducing malnutrition and mortality in herds.

- *Livestock management system*s – efficient and affordable adaptation practices have to be developed for rural poor not able to buy expensive adaptation technologies.
    - Provision of shade and water to reduce heat stress from increased temperature. Current high cost of energy, providing natural (low cost) shade instead of high cost air conditioning is more applicable to rural poor producers;
    - Reduction of livestock numbers – lower number of more productive animals will cause more efficient production and lesser emission of GHG from livestock production (Batima, B., 2006);
    - Change in livestock/herd composition (large animal versus small animal, etc.);
    - Improved management of water resources through the introduction of simple techniques for localized irrigation (e.g. drip and sprinkler irrigation), accompanied with infrastructure to harvest and store rainwater, such as small superficial and underground dams, tanks connected to the roofs of houses, etc[14].

[14] IFAD, 2009.

**Box no 2: Early Warning Systems**
**The Pastoral community development project in Ethiopia**

The project's goal is to improve prospects for sustainable livelihoods among herders living in arid and semi-arid lowlands. It aims to harmonize development between Ethiopia's lowlands and the more fertile highlands, reduce vulnerability to drought as well as risks of local conflict.

In its first phase (2004-2009), the project responded to drought and the need to create sustainable livelihoods for herders in arid and semi-arid lowlands. In partnership with the World Bank, the project established early warning systems and disaster preparedness plans, through a participatory approach to programming, implementation and monitoring. The aim was to improve the resilience and ability of participants to cope with external shocks and to reduce rural poor people's vulnerability to drought and other natural disasters, thus indirectly contributing to enhanced adaptation to climate change. Initial activities included strengthening the institutional capacity of indigenous social organizations.

In phase II the disaster preparedness and contingency fund (DPCF) will be created with separate 'windows' for early response and disaster preparedness investment financing. Through the disaster preparedness strategy and investment programme (DPSIP) subcomponent, the project will identify local needs for long-term regional disaster preparedness and mitigation. Finally, under the DPCF, each region will receive DPSIP grants to finance disaster preparedness investments.

## 2.2. Mitigation of livestock GHG emissions

Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural and human systems to adapt. The magnitude of the challenge to reduce the GHG concentrations in the atmosphere makes imperative the contributions of all sectors with significant mitigation potentials. Agriculture is recognized as a sector with such potential and farmers, herders, ranchers and other land users could and should be part of the solution. Therefore, it is important to identify easy to implement and cost effective mitigation activities strengthening the adaptive capacities to climate change of local actors[15]. The livestock production system contributes to global climate change directly through the production of GHGs emissions[16], and indirectly, through the destruction of biodiversity, the degradation and desertification of land and the pollution of water and air. In the livestock production system, there are three main sources of the GHG emissions: the enteric fermentation of the animals, manure (waste products) and production of feed and forage (field use) (Dourmad, et al., 2008). While, indirect sources of GHGs from livestock systems are mainly changes in land use and deforestation to create pasture land.
For example, in the Amazon rainforest, 70% of deforestation occurred in order to create grazing lands for livestock. Smallholder livestock systems have, in general, a smaller ecological footprint[17] compared to large scale industrialized livestock operations.

[15] See case study No 1 on IFAD activities in Mongolia.
[16] According to the Livestock's Long Shadow report (FAO 2006) livestock is responsible for 18% of the global warming effect. Indeed, livestock contributes 9% of total greenhouse gas emission has measured in $CO_2$ equivalents, 65% of human-induced nitrous oxide (which has 296 times the global warming potential of $CO_2$), and 20% of methane (which has 23 times the global warming potential of $CO_2$).
[17] These are a means to assess the human demand on the overall Earth's ecosystem. Environmental footprints compared the human demand (in terms of energy, air etc) with the planet's capacity to regenerate resources and provide services. The measure is based on the amount of biologically productive land and sea area needed to regenerate the resources the human population consumes and to absorb and render harmless the corresponding waste.

Mitigation of GHG emissions in the livestock sector can be achieved through various activities including:

- Different animal feeding management,
- Manure management (collection, storage, spreading, etc),
- Management of feed crop production.

Livestock contribution in emissions reduction varies; mitigation options include (FAO, 2008):

- *Selection of faster growing breeds* - improved livestock efficiency to convert energy from feed into production, and reducing losses through waste products. Increasing feed efficiency and improving digestibility of feed intake are potential ways to reduce GHG emissions and maximize production, gross efficiency, and by reducing the number of heads (Wall, et al., 2008). This includes all the livestock practices - such as genetics, nutrition, reproduction, health and dietary supplements and proper feeding (incl. grazing) management – that result in the improved feed efficiency.

- *Improved feeding management* – the composition of feed has some effect on the enteric fermentation and emission of $CH_4$ from the rumen or the hindgut (Dourmad, et al., 2008). Also the amount of feed intake is related to the amount of waste product. The higher proportion of concentrate in the diet results in a reduction of $CH_4$ emission (Yan, et al., 2000).

- *Improved waste management* – improving management of animal waste products through different mechanisms such as covered storage facilities is also important. The amount of GHG emission from manure ($CH_4$, $N_2O$, and $CH_4$ from liquid manure) will depend on the temperature and duration of the storage. Therefore long term storage in high temperature will result higher GHG emissions. In the case of ruminants, pasture grazing is an efficient way to reduce $CH_4$ emission from manure, because no storage is necessary. Indeed, there is not only the possibility of mitigating the GHG emissions, but also of create an opportunity for renewable energy as in the case of the IFAD-supported activities in China and Eritrea (see Box no. 3)[18].

- *Grazing management* – one of the major GHG emission contributions from livestock production is from forage or feed crop production and land use of feed production. Thus pasture grazing and proper pasture management through rotational grazing is the most cost effective way to mitigate GHG emissions from feed crop production. Animal grazing on the pasture also helps reduce emission due to animal manure storage. Introduction of grass species and legumes into grazing lands can enhance carbon storage in soils.

- *Lowering livestock production consumption* - lowering consumption of meat and milk in areas having high standards of living will support short term response to the GHG mitigation.

[18]Concerning the generation of carbon credits through soil conservation initiatives, there is no approved methodology yet by the UNFCCC to calculate the amount of Carbon sequestration when sustainably improving the different livestock husbandry systems.

**Box 3: Biogas: an environmentally-friendly alternative energy source**
**The West Guangxi Poverty-Alleviation Project in China and**
**The Gash Barka Agricultural & Livestock Programme in Eritrea**

(i) The IFAD-supported West Guangxi Poverty-Alleviation Project (2000-2007) aimed at improving and sustaining the livelihoods of poor rural people while rebuilding and conserving natural resources.

The use of biogas as a source of household energy has been promoted within the remote communities in west Guangxi where wood for fuel is in short supply and rural electricity was not available. Biogas units turn human and animal waste into a mixture of methane and carbon dioxide gases that can be used for lighting and cooking.
Each household has been assisted in building its own plant to channel waste from the domestic toilet and nearby shelters for animals, usually pigs, into a sealed tank. The waste ferments and is naturally converted into gas and compost, resulting in improved sanitary conditions at home.

The poorest households, with only one pig, built small units that could produce enough gas for lighting in the evening. Households with two or more pigs built larger units that could produce gas for cooking as well as lighting.

The Guangxi project has become a catalyst for other initiatives in the region. To date, 2.73 million biogas tanks have been built in villages, benefiting about 34.2 per cent of the rural households in Guangxi. It is estimated that 7.65 million tons of standard coal and 13.40 million tons of firewood are saved annually in Guangxi because of the use of biogas.

The double bonus of energy and compost motivated poor people to adopt this technology in significant numbers. The project provided more than 22,600 biogas tanks involving almost 30,000 households in more than 3,100 villages. As a result, 56,600 tons of firewood can be saved in the project area every year, equivalent to the recovery of 7,470 hectares of forest.

(ii) The IFAD-supported Gash Barka Agricultural & Livestock Programme is currently piloting a household level biogas plant.

The pilot initiative included the design, the construction and the installation of the biogas plant and it is currently operational. The selected family has several cows kept semi-intensively. The household has methane gas for cooking and lighting. Also, the household uses the digested residues as organic fertilisers in their fields. Current practice dictates that farmers collect animal dung; dry it and burn it as fuel. IFAD and the Government are entertaining the possibility of expanding this initiative (once the pilot has been evaluated) to about 150 000 households in future provided that additional resources will be available.

In addition to accessing “cleaner” fuel and fertilisers to poor households, IFAD and the Government are considering the possibility of getting carbon credits from this project as its implementation could be classified as a “Clean Development Mechanism” by the UNFCCC procedures. Getting carbon credits from the “voluntary market” standards is also a considered option.

**Box 4: Strengthening pastoralists' resilience and adaptive capacity to climate variability and extremes - IFAD activities in Mongolia[19]**

The livestock and NRM component of the Rural Poverty Reduction Programme (RPRP) implemented by IFAD in Mongolia was designed to increase livestock productivity, improve rangeland management and strengthen herder resilience to natural calamities. In a country where climate hazards have substantial effects upon animal husbandry and crop production, with clear indication that their frequency and magnitude are increasing due to global warming, IFAD is building pastoralists' adaptive capacity through a series of interventions.

The organization of herder groups and Rangeland Management and Monitoring Committees (RMMCs), empowered to formulate the local natural resources management maps and associated development plans are having a significant positive impact on pasture and livestock management through joint decision making and collaborative management. RMMCs are playing a key role in representing herders' interests in the planning and regulation of local land use at government level; and herder groups and RMMCs are considered of pivotal importance by project beneficiaries and local government to prepare for and respond to natural calamities such as drought and dzud.

On the other hand IFAD assistance on winter fodder production ameliorates the preparedness to harsh climatic conditions, thus improving substantially survival rates and livestock performance. The establishment of a dzud emergency fund contributes to enhance the resilience of herder households to respond to unusual weather phenomena and mitigate the worst effects on the poorest. Remote unused and underused pasture is now accessible thanks to the rehabilitation and construction of new wells. This strategy allows the use of otherwise inaccessible rangeland in winter and spring, and is resulting in better climate risk management.

RPRP laid the foundations for increasing the resilience of the ecosystem and herder's livelihood to current climate variability and extreme events; however these measures might not be sufficient to reduce the risk of increasing climate change.

IFAD is currently developing a GEF-funded intervention based on the achievements and the lessons from the RPRP by adopting a two pronged approach that focuses on: (i) building the capacity of RMMCs on climate change; and, (ii) supporting activities that will allow herders to manage their natural resources and increase the resilience of their livestock system in a context of increased vulnerability to climate variability. These include: improvement of natural resources management to take into account climate change impacts; climate-proof the pasture water supply; and introduction of a tailored index-based insurance to better respond to climate change risk in the livestock sector.

[19] IFAD, 2009 - E. Distefano. Mongolia case study.

## 3. Livestock grazing and soil carbon sequestration

Experts[20] assessed the value of carbon contained in the soil as more than twice the quantity in the atmosphere and demonstrated that enhancing carbon sequestration into soils might offer a potentially useful contribution to climate change mitigation. Indeed, the Royal Society (2001) suggested that terrestrial vegetation and soils have been absorbing approximately 40% of global $CO_2$ emissions from human activities[21].

Considering the importance of rangelands in land uses (about 40% of the total land surface), herders and pastoralists could play a crucial role in soil carbon sequestration. All over the world there are some 100-200 million pastoralist households covering 5000 Million hectares (Mh) a rangelands in which are stored 30% of the world carbon stocks (Tennigkeit and Wilkes, 2008). Therefore, environmentally sounded rangeland practices have a relevant potential to sequester carbon.

Global studies find that grazing can either have a positive or negative impact on rangeland vegetation and soils, depending on climatic characteristics of rangeland ecosystems and grazing history and effectiveness of management (Milchunas & Lauenroth 1989). Common grazing management practices that might increase carbon sequestration include the following: (i) stocking rate management, (ii) rotational, planned or adaptive grazing, and (iii) enclosure of grassland from livestock grazing.

*(i) Stocking rate management*
Conventional rangeland science suggests that sustainable management of grassland can be achieved by grazing livestock at stocking rates that do not exceed the carrying capacity of grasslands.

*(ii) Rotational, planned or adaptive grazing*
Many grasslands increase biomass production in response to frequent grazing which when managed appropriately, could increase the input of organic matter to grassland soils. However, there have been very few studies of the effects of rotational grazing on soil carbon stocks. Two published reports both indicate that rotational grazing would have limited impacts on soil carbon stocks, despite the benefits for livestock production and/or vegetation. Site-specific planned and adaptive grazing is likely to be more effective in managing soil carbon but no published reports have been identified (Tennigkeit and Wilkes, 2008).

*(iii) Enclosure from livestock grazing*
Enclosure from livestock grazing has different effects depending on the type of land. The US Conservation Reserve Programs and the Chinese 'Return Grazed Land to Grass' Program are large scale programmes that support enclosure of degraded grasslands from livestock grazing for defined periods of time.

Grazing intensity should be properly regulated in view of enhancing carbon sequestration. To this end, it is worth noting that methane emissions, grazing intensity and wood-land increase are all interrelated issues. Therefore, GHG emissions should be also considered along with carbon sequestration when analysing the impacts of livestock on GHG emissions and climate change. Experts (FAO, 2008) suggested a sustainable livestock distribution which includes a rotational grazing system combined with a seasonal use of land. The rational of such proposal is the hypothesis that a reduced grazing intensity would result in increased soil carbon stocks.

[20] FAO, 2009.
[21] The same study assessed the global stocks of carbon in above ground vegetation around 550 petagrams (PgC) whereas in the soil they are about 1750 PcC (including peat) and in the atmosphere around 800 PgC. Further details available at www.royalsoc.ac.uk

However, Gifford (FAO, 2009) demonstrated that reality is more complex and the interaction is not so linear for the following four reasons:

- The woody component has high above ground C stocks and high deep soil C stock;
- Wildfire contributes to the loss of stored C stocks;
- The reduction of grazing for native herbivores is partially compensated by the increased unmanaged herbivores (i.e. kangaroos in the case of Australia);
- Floods and desert storm contribute to the shifting of vast quantities of surface soil characterised by high C stock.

That said, the interaction between grazing and soil C sequestration seems to be a complex phenomenon with different environmental, social and economic issues; therefore, reducing grazing intensity does not necessarily imply an increase in soil carbon stocks.

Indeed, in view of analysing the influence of grazing on rangeland C stock, the following three issues should be taken into account:

- Overgrazing does not mean soil degradation, the two aspects should not be confused and considered as synonyms;
- Overgrazing can both contribute to the increasing of the ecosystem C stocks (i.e. from woody thickening) as well as to the decreasing of soil C stocks (i.e. soil degradation).
- There is a weak basis for estimating C sequestration potential from grazing: little data exist on the impacts of changed grazing intensity on soil C stocks[22].

Finally, Conant (2002) demonstrated that grazing management drives change in soil C stocks by influencing the balance between inputs (what goes into the soil) and outputs from the soil: an effective livestock management systems both in terms of improved feeding practices and use of specific agents and dietary additives has positive effects on food security (i.e. increased productivity as well as meat quality) and soil C stocks.

[22] Conant R.T. and Paustian K. 2002

## 4. Gender issues in relation to livestock and climate change

While it is not within the scope of this paper to provide an exhaustive overview of gender issues, it is important to note that climate change will create different opportunities and challenges to men and women. In many countries the role of women in livestock production systems is significant; in general, women are often responsible for most livestock nurturing activities and play an active role in on-farm livestock duties including feeding, watering, fodder collecting, stable cleaning, milking and milk processing, caring of small and sick animals, poultry raising, wool work, traditional animal health care, etc. Men are generally responsible for marketing, shearing, animal feed purchasing, veterinarian services, and herding. While men’s tasks are seasonal, most women’s tasks are daily (F. Nassif, 2008).

Women are already affected by several issues that make them more vulnerable to food insecurity and environmental change, and affect their capacity to reduce poverty. M. J. Andolan (2008) recognised the following as key issues impacting women: i) Denial of land rights – tenure security; ii) Biased government attitude against women; iii) Lack of access to information and new knowledge; iv) Lack of credibility and access to market and financial services; v) Very limited presence in political power and lobbies and; vi) Lack of opportunity for their voice to be heard.

Given that climate change is likely to further intensify the existing inequalities and affect differently the capacity of women and men to cope with additional stresses, more attention will be needed to ensure that adaptation and mitigations strategies are developed taking into account these differences and the increased needs of women in view of their roles as the most significant suppliers of family labour and efficient managers of household food security (IFAD, 2009). While research has not given much attention to the differences between men and women within at-risk populations (Nelson, S. and Lambrou, Y., 2007), adaptation strategies will need to address the different impacts of climate change on women and must ensure that they also support women empowerment as part of building the community resilience to climate change (IFAD 2009)

## Key issues for project design

The previous sections provided an overview of some of the key issues that relate to livestock in the context of future climatic changes. The following have been identified as key elements that should be taken into account to support the design of development interventions:

- *Collaborative management of natural resources:* participatory approaches to sustainable management of land, forest and natural resources (NRM) are essential to develop long-term sustainable strategies. Decision making processes should be designed in order to include all concerned stakeholders (farmers, pastoralists, herders etc).

- *Community involvement in adaptation strategies*: successful adaptation strategies cannot be developed in isolation. Community involvement in the identification of new solutions is key to ensure the long term sustainability of interventions. At the same time, adaptation strategies need to be developed taking into account cross-cutting issues (i.e. environment, health, social – such as increased migration, conflict).

- *Incentives and tailored responses*: financial incentives and regulations for improving natural resource management and livestock production systems through proper pasture/land management and feeding management can be used as incentives to encourage GHG mitigation and adaptation. Indeed, the introduction of tailored index-based insurance schemes and rural finance initiatives is key to support livestock keepers better cope with climate change risks.

- *Subsidies:* when including subsidies or other enticements in development activities, careful attention will need to be given to their effects. While in some instances they could support adaptation strategies (i.e. promoting the introduction of heat-resistant breeds, subsidizing vaccinations to reduce vulnerability to the spread of new diseases) in others subsidies could negatively affect adaptation/mitigation strategies.

- *Risk management mechanisms:* proper risk management mechanisms and preparedness measures will need to be put in place to cope with the impacts of more frequent and extreme climatic events. Preparedness measures, early warning systems and other risk mitigation activities (i.e. strengthening infrastructures, insurance systems, forecasting, etc) will be needed to reduce impacts of severe weather events to prevent loss of livestock.

- *Awareness and education*: information on climate change is a crucial component of adaptation and efforts should be made to ensure that knowledge is shared with local communities. Understanding the patterns of variability of current and projected climate and seasonal forecasts is crucial to anticipate shock and losses and to enable external agencies to provide targeted assistance to herders.

- *Mitigation*: to support mitigation of GHG emissions efforts should focus on reforestation, improved grazing management, restoration of degraded lands, livestock manure management, improved feeding management, improved energy/feed efficiency, selection of more productive animal breeds and transhumance practices.

- *Innovation, Research and Technology development:* promoting the development of and improved access to technologies, and sharing knowledge on sustainable and climate-friendly farming practices is vital. Country specific research is needed to inform the development of adaptive strategies and more focus needs to be given to 'the development of improved crop varieties and animal breeds, as well as more sustainable and integrated management of crops, animals and the natural resource base that sustain their production, while providing other vital services for people and the environment' (IFAD, 2009) to increase resilience of developing countries.

- *Gender dimension:* adaptation and mitigation strategies should take into account the different roles of women and men and the way in which they will be impacted by climate change.

Climate change clearly offers an opportunity to rethink gender inequities and to involve both women and men in finding innovative solutions that can respond to common environmental challenges.

- *Indigenous knowledge*: the in-depth understanding of the environments that local communities and indigenous peoples have, together with their experience in adapting to climate variability are key for development of adaptation and mitigation strategies.

## Annex I: Climate change and agriculture

Over a billion people worldwide live in extreme poverty, three quarters of them living in rural areas. Agricultural production based on natural resources is the main livelihood for more than 800 million malnourished and food insecure people. Agriculture is therefore the main instrument to lift the rural poor out of poverty in developing countries. In many rural communities, livestock is often the only asset of the poor which is also highly vulnerable to climate variability and extremes.

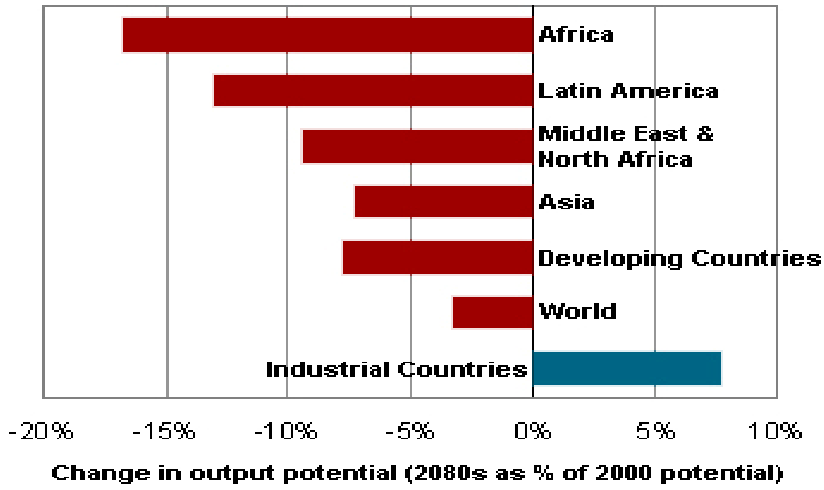
There are significant evidences of increased global average air (by 0.7$^{o}$C) and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (by 25 cm). Human activities result in the emissions of four long-lived greenhouse gases: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$) and halocarbons. The global increase in carbon dioxide concentrations is primarily due to the use fossil fuels (IPCC, 2007).

While climate change is a global phenomenon, its negative impacts are more severely felt by poor people in under developed countries. Although agricultural producers, especially small scale poor farmers, are relatively small contributors of GHG emissions, proper agricultural technology and management systems are crucial to promote and sustain a low-carbon rural path. Livestock production will not be excluded from the impact of climate change. Approximately 20-30 percent of plant and animal species are expected to be at risk of extinction if increases in global average temperature exceed 1.5 – 2.5C degrees (FAO, 2007). As a result of climate change, the potential for food production is projected to decrease due to the high mortality, less productivity and more competition over natural resources. Globally, it would then increase the risk of hunger, especially for those in poor rural communities.

In addition to the changing climate, there are many other factors simultaneously affecting livestock production systems such as rapid population and economic growth, and increased demand for food (including livestock products). Globally, livestock products contribute approximately 30 percent of the protein in human diets (Gill and Smith, 2008), and this contribution is only expected to increase (FAO Stats). How livestock keepers can take advantage of the increasing demand for their products, and how the livestock assets of the poor can be protected in the face of globalization and climate change is uncertain.

Climate change impacts on agriculture are expected to be dominantly negative. Also, the impacts of climate change on agricultural production and livestock are difficult to measure and distinguish from other changes which occur on the natural and human environment. There are many non-climatic drivers that are interconnected with climate change impacts such as migration, over grazing of pasture, change in livestock management, and change in human and livestock population.

**Change in Agriculture Output Potential Due to Climate Change, 2000-2080**




Source: EarthTrends, 2008 using data from Cline, 2007

The following are the major characteristics of climate change impacts on rural livelihood and agriculture systems.

- *Distribution of impacts and vulnerabilities*: Impacts differ across regions and continents. Those in the weakest economic positions are often the most vulnerable to climate change. There is increasing evidence of greater vulnerability of the poor and elderly in the developing countries. According to the Department for Environment, Food and Rural Affairs (DEFRA), climate change threatens about 850 million poor people due to the increased limitation of natural resources for food production and extinction of animals from climatic disasters and diseases.
- A*ggregate impacts*: Climate change effects collectively result in greater impacts. For example, warming of temperature will cause the extinction of animal species due to heat stress, which in turn will lead to reduced food diversity and a shortage of food production. Increased malnutrition and other adverse health impacts will then follow.
- *Risks of extreme weather events*: Increased frequency of hurricanes, tornadoes, droughts, flooding, etc. will likely to result high vulnerability in both developing and developed countries. However, the fragile states will be greater impacted.

**Agriculture contribution to climate change**

Although the agricultural source contribution to climate change through gas emission appears to be proportionally lower than emissions from fossil fuel use, according to the IPCC AR4, by 2020 Sub-Saharan Africa and Middle East and North Africa are expected to experience an increasing emission growth. It will be mainly due to the intensification of agriculture and the extension to marginal lands to satisfy an increased food demand. In East and South Asia, rapid population and economic growth will imply changes in the lifestyle and shift in the diet, especially towards a major consumption of meat, which will imply the need for a larger number of livestock.

Therefore, according to the IPCC, animal sources (enteric fermentation and manure management) are projected to be one of the major causes of non-$CO_2$ emissions in the region. According to FAO, rice production is estimated to increase only of 4.5% by 2030 (IPCC 4AR, WG III); thus, methane's emissions from this sector are not expected to represent a major threat in the coming years.

In Latin America and the Caribbean emissions of $CO_2$ and $N_2O$ in particular are expected to increase because of possible increases in land use and land use change activities and increases in the cattle population and in cropland areas that will also result in a major use of fertilizer.

The following are estimates of agricultural source contribution by percentage (FAO, 2006).

- $CO_2$: estimated 25% contributed from natural resource sources (20% - deforestation, 5% - biomass burning).
- $CH_4$: estimated 70% derived from anthropogenic sources (20% - domestic ruminants, 20% - biomass burning, 20% - rice production/wetlands, 10% other waste products).
- $N_2O$: estimated 75% caused from crop production sources (44% - tillage, 22% - fertiliser, 9% - biomass burning).

Therefore, sustainable agricultural systems can be used to encourage both adaptation and mitigation of climate change.

## Annex II: The impact of climate change on livestock management in Africa[23]

Africa continent is subject to drought and food insecurity. African agriculture has been a serious concern even before the climate change issue become evident. African agriculture has the slowest record of productivity increase in the world. However, at the meantime, agriculture remains the backbone of most African economies[24]. The sector is the largest domestic producer across the continent and employs between 70 and 90 percent of the total labour force. In addition, agriculture supplies up to 50 percent of household food requirements and up to 50 percent of household incomes. There are five primary ones that generated most of the income: beef cattle, dairy cattle, goats, sheep and chickens. Altogether these five animals generated 92% of the total revenue from livestock.

A model is use to study the sensitivity of African animal husbandry decisions to climate. A survey of over 5000 livestock farmers in ten countries reveals that the selection of species, the net income per animal, and the number of animals of a farm are all highly dependent on climate. As climate warms, net income across all animals will fall but especially across beef cattle. The fall in relative revenues also causes them to shift away farm beef cattle and towards sheep and goats.

In general, all species will be hurt by warming, and so there will be fewer animals per farm. Beef cattle are especially vulnerable. It is predicted that climate change will cause beef cattle to decrease and sheep and goats to increase. Consequently, farmers will switch from beef cattle as temperature rises. The net profitability of livestock will be reduced and so farmers will reduce their investments in livestock. Many of climate change predictions suggest that African livestock will be damaged as early as 2020. Even small changes in temperature will be sufficient to have a relatively large effect on beef cattle operations, which potentially lead into protein deficiency or other health issues. In contrast, small farmers who can switch to sheep and goats may not be as vulnerable to higher temperatures compared to large farmers that cannot make this switch. In these circumstances, small farmers in Africa are actually better able to adapt to climate change than their larger more modern counterparts.

Of course, precipitation also plays an important role in the climate change affects. Scenarios with less precipitation are predicted to be less harmful. Although, pasture and ecosystems are more productive with more precipitation, lower precipitation may help reducing animal diseases that are quite significant for livestock in Africa. As long as there is sufficient amount of moisture to support grasslands, reduction in precipitation from large to moderate level appear to be beneficial to livestock. Increasing precipitation causes the probability of choosing beef cattle, dairy cattle and sheep to fall and that of goats and chickens to increase.

In terms of farm size, small farmers and large farmers responded to climate change differently. Small farmers are diversified, relying on dairy cattle, goats, sheep and chickens. Large farmers specialize in dairy and especially beef cattle. As a result of climate change, large farmers shift away from beef cattle and chickens in favour of dairy cattle, sheep and goats. Owners of commercial livestock farms are better able to adapt to warming or precipitation increases be switching to heat tolerant animals and crops. Livestock operation will be a safety valve for small farmers if warming or drought causes their crops to fall.

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