GFAR

The Futures of Agriculture

Brief No. 43 - English
Future Studies
May 2013

This brief series was developed in preparation for the Foresight Breakout Session of the Global Conference on Agricultural Research for Development (GCARD 2012) and the Global Foresight Hub[1]. The briefs were written to communicate to a wider audience, such as policy makers, civil society organizations, researchers, and funders. The briefs were classified into three categories: Future Studies, Regional Update, and Visioning.

Climate change: do we know how it will affect smallholder livestock farmers?

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Based on: Thornton P K, Notenbaert A, van de Steeg J and Herrero M, 2008. The livestock-climate-poverty nexus: A discussion paper on ILRI research in relation to climate change. ILRI, Nairobi, Kenya, 80 pp, online http://www.dfid.gov.uk/r4d/Output/177861/Default.aspx.; and Thornton P K, van de Steeg J, Notenbaert A and Herrero M, 2009. 'The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know.' Agricultural Systems, 101: 113–127.

The story of human settlement and human evolution is very much tied to the fact that the earth's climate has always been changing, and will continue to do so.

What is known about the likely impacts of climate change on resource-poor livestock keepers in the developing world? Relatively little, and the International Livestock Research Institute (ILRI) and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) are working to improve this knowledge. This Brief outlines how a group of scientists at ILRI reviewed some elements of the complex relationship between livestock and climate change in developing countries with a forward-looking approach. The objective was to help set research priorities: to inform the debate as to what research for development organizations such as ILRI could and should be doing in the area of climate change work that could add value to the large amounts of work already being carried out by the Global Change community on cropping systems and natural resources management. Originally designed to guide ILRI's research on climate change, this work has had a broader impact by informing the investment strategies of several other research-for-development organizations, including donors.

Resource-poor livestock keepers: mitigate and adapt

Changes in climate and climate variability will affect livestock production systems in all parts of the world, and will inevitably impact the 1.3 billion poor people whose livelihoods are wholly or partially dependent on livestock. At the same time, livestock production is a major contributor to greenhouse gas emissions. Therefore, livestock keepers will have to mitigate emissions as well as adapt to change. The adaptation and mitigation that are necessary may require significant changes in production technology and livestock production systems, which could affect productivity, incomes and livelihoods. Livestock production systems are highly heterogeneous, however, and different production systems have different capacities to adapt or to take on board the policy and regulatory changes that may be required in the future. In developed countries, livestock systems are generally adaptable and resilient. In developing countries, in contrast, households that are dependent on livestock keeping may be much more vulnerable to changes in climate and climate variability, with the potential for increased poverty and decreased food security. At the same time, there may be considerable growth potential in the smallholder livestock sector, given projected increases in demand for livestock products globally and for biofuels and the land-use changes these may bring about.[2]

[1] http://www.egfar.org/our-work/shaping-future-together/global-foresight-hub

[2] Rosegrant et al. 2009. Looking into the future for agriculture and AKST (Agricultural Knowledge Science and Technology). Chapter 5 (pp 307-376) in Agriculture at a Crossroads (eds. McIntyre et al.), Island Press, Washington DC.

The work highlighted here involved reviewing the existing literature on the future impacts of climate change on livestock systems in the tropics as well as evaluating projected changes in production and consumption trends of livestock products globally. As part of an annual program meeting, the scientists at ILRI (numbering about 80 international staff) were canvassed for their expert opinion on alternative adaptation and mitigation opportunities in different livestock production systems in the coming 10-20 years. Alternatives were then evaluated using the following criteria: importance to the research-for-development agenda; whether there were other providers better placed to deliver the research outputs; and the achievability of research outputs and development outcomes.

Many people in tropical and subtropical regions are wholly or partially dependent on livestock for their livelihood, and livestock keepers will need to adapt to climate change. (Photo credit: ILRI/Stevie Mann)

Knowledge gaps and future research priorities

The process started in 2007 with ILRI funding the drafting of a discussion paper that gave an overview of climate change and its future impacts in general, the impacts of livestock on climate and of climate change on livestock, and possible responses in terms of adaptation and mitigation. The paper was reviewed and discussed widely with colleagues inside and external to ILRI. Subsequently, it was used to help identify major gaps in knowledge of the possible future impacts of climate change on livestock keepers and livestock production systems in developing countries, and how their livelihood options may be affected to the middle of this century. First, gaps were identified in general areas such as feeds, heat stress, water, diseases, biodiversity, livestock systems and indirect impacts (Box 1). They were qualitatively scored as to their relevance to ILRI's mandate and mission. Second, those issues in the research portfolio over the next three to five years were identified where climate change research might be beneficial or where climate change information might be particularly useful. Third, some broad trends were identified that may have a substantial impact on forming public opinion in the North and hence on public funding of research for development issues in the South. Finally, taking all those pieces together, a breakdown was attempted by region and topic area, and criteria were developed by which the candidate activities were quickly and qualitatively assessed.

Box 1. Selected knowledge gaps of climate change impacts on livestock-based systems and livelihoods in the tropics and subtropics

Area	Gap
Feeds: quantity and quality	• Rangelands: primary productivity impacts, species distribution and change due to CO2 and other competitive factors, estimation of carrying capacities. • Mixed crop-livestock systems: localized impacts on primary productivity, harvest indexes and stover production.
Heat stress	• What is the extent of the problem, in a development context?
Water	• Surface and groundwater supply, and impacts on livestock (particularly rangeland systems). • Effective ways to increase livestock water productivity.
Diseases and disease vectors	• How may the prevalence and intensity of key epizootic livestock diseases change in the future? • How may climate change affect diseases as systems intensify?
Biodiversity	• 'Ecological biodiversity': what will happen to numbers of species as systems change? • Animal breed biodiversity: can the animal genetic resources that might be useful in the future be specified?
Livestock systems	• Localized impacts on livelihoods. • How will systems evolve? • Magnitude and effects of systems changes on ecosystems goods and services.
Indirect impacts	• How do human health impacts of climate change intertwine with livelihood systems and vulnerability?

Source: Thornton PK et al. 2009. Agricultural Systems 101: 113-127

At the same time, strategic partnerships were sought with the International Institute for Applied Systems Analysis (IIASA) and the Potsdam Institute for Climate Impact Research (PIK), with the objective of improving our access to expertise in integrated global assessment modelling and to information on possible futures for the smallholder livestock sector and the increasing demand of livestock products globally. While this process was underway, ILRI developed continental-scale analyses of likely changes in crop and biomass productivity under different scenarios of climate change to the 2050s in Africa and Latin America, using high-resolution climate surfaces and crop and biomass models.[3] This was made possible in part by parallel but unrelated work at one of ILRI's sister centres, the International Food Policy Research Institute (IFPRI), and at the UN Food and Agriculture Organization (FAO), which resulted in the development and public release of global distribution maps for the major crops[4] and agricultural livestock species.[5]

The work outlined above, together with the outputs of continental-scale analyses, has helped to identify geographic areas whose agriculture is likely to be particularly sensitive to the effects of climate change. For example, warming temperatures in the coming decades may have damaging effects on crop production in many parts of the tropics, and could trigger livelihood transitions, perhaps to an increasing dependence on livestock as crop production becomes increasingly risky. Areas in sub-Saharan Africa have been identified where such a transition might occur by the 2050s. In the future, schemes that facilitate risk management may be needed in such areas, as well as efforts to broaden income-generating opportunities, where this is feasible.[6] Most recently, these methods have been used to identify populations of people in the tropics that may be particularly vulnerable to the impacts of climate change on food security.[7] That work is being used to help prioritize target regions, countries and sites in the CCAFS, for example.

Influence and impact

There is some evidence that this work had influence within and outside ILRI, the original client for the work. Since its publication in Agricultural Systems, the paper has had 80 citations, according to Google Scholar. Of the ten top-ranked research options, ILRI and CCAFS have extensive work activities in eight of them.[8] While it is difficult to attribute changes in the research agenda to this work in whole or in part, several of these areas of work have been developed and implemented since 2009. One example is a set of new activities that ILRI, CCAFS and partners at Colorado State University, IIASA and McGill University are undertaking to evaluate the impacts of climate change on rangeland distribution and net primary productivity through the remainder of the century (see http://warnercnr.colostate.edu/~rboone/g_range/).

There is also anecdotal evidence that the discussion paper may have been used in some way by donors such as the Department for International Development (DFID), the World Bank, the United States Agency for International Development (USAID) and the International Development Research Centre (IDRC), other agencies such as FAO), IIASA and PIK, and regional and national organizations in Africa such as the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the Kenya Agricultural Research Institute (KARI) and the Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN).

[3] Thornton et al., 2009. Spatial variation of crop yield response to climate change in East Africa. Global Environmental Change 19: 54–65.

[4] You et al., 2009. Generating plausible crop distribution maps for Sub-Saharan Africa using a spatially disaggregated data fusion and optimization approach. Agricultural Systems 99:126-140. Wint W, Robinson TP, 2007. Gridded livestock of the world. Rome, FAO.

[5] Wint W, Robinson TP, 2007. Gridded livestock of the world. Rome, FAO.

[6] Jones PG, Thornton PK, 2009. Croppers to livestock keepers: Livelihood transitions to 2050 in Africa due to climate change. Environmental Science and Policy 12: 427-437.

[7] Ericksen PJ et al., 2011. Mapping hotspots of climate change and food insecurity in the global tropics. CCAFS Report no. 5. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Online at: www.ccafs.cgiar.org.

[8] "Localised impacts & hotspots of climate change on feed resources identified", "Impacts of climate change on livelihoods in livestock systems identified", "Assessment frameworks and targeting tools developed", "Toolboxes of viable options developed and disseminated", "Options to increase livestock water productivity in a changing climate", "Effects of climate change on ecosystem goods and services", "Impacts on rangeland productivity elucidated", and "Risk management options tested in study sites" – see Thornton et al. (2008) for details.

No formal evaluation has been undertaken, but this work certainly had some impact in addressing the lack of information on livestock in several integrated global assessments, despite livestock's being recognized as one of the major drivers of global change. New partnerships have been forged with others working in the realm of global assessment. For example, IIASA expanded its model of the global agriculture and forest sectors (GLOBIOM[9]), with a newly developed livestock module.[10] The model estimates productivity (milk, meat), methane emissions and manure and N excretion, based on regionally and system-specific diets. Together with PIK, research has since been conducted on global climate scenarios and impact assessments across the livestock sector.[11]

The strategic analysis of gaps and opportunities described here had value in at least two ways. First, it assisted in strategic project proposal writing, by responding to donors' needs as well as to internal demand for information on the impacts of climate change. Second, by creating strategic partnerships, considerable steps could be taken to create new information on, for example, the contribution of different livestock production systems to global livestock productivity, methane emissions and nitrogen excretion. Combining qualitative and quantitative information allowed more detail in identifying target beneficiary groups and in matching appropriate research and policy interventions.

Way forward

There are two areas in particular that would benefit from more work. First, in global integrated assessments in general, there is a need for improvement in the kind of indicators that are produced to gauge changes in social factors. Currently, impacts are usually expressed in terms of available calories and prices, for example, but there may be many other critical factors to assess future changes beyond food availability and commodity prices. Second, the recent past has illustrated very clearly that we live in particularly volatile times: price spikes, extreme climatic events and an increasing information base about natural resource use and depletion all indicate the need to undertake priority-setting analyses on a regular basis, linked with other types of foresight and scenario processes. Even more, it highlights the importance of explicitly linking priority setting with monitoring and evaluation, to provide more coordinated planning and implementation of research for development to improve its influence and to better demonstrate its value to the resource-poor of the developing world.

[9] GLOBIOM is a global model to assess competition for land use between agriculture, bioenergy, and forestry. Source: http://www.iiasa.ac.at/web/home/research/modelsData/GLOBIOM/GLOBIOM.en.html

[10] Havlik et al., 2013. Crop Productivity and the Global Livestock Sector: Implications for Land Use Change and Greenhouse Gas Emissions. Am. J. Agr. Econ. 95(2): 442-448. Reisinger A et al., Implications of alternative metrics for global mitigation costs and greenhouse gas emissions from agriculture. Climate Change, in press.

[11] Lotze-Campen et al., Climate change impacts and the costs of adaptation in global livestock production systems. Proceedings of the National Academy of Sciences, in review.

Citation:
Thornton, P., Van de Steeg, J. Notenbaert, A. and Herrero, M. 2013. The livestock, climate change and poverty nexus. *The Futures of Agriculture*. Brief No. 43 - English. Rome: Global Forum on Agricultural Research (GFAR).

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