PLENARY SESSION 5:
EMISSIONS FROM AGRICULTURE AND LAND USING SYSTEMS AND FROM FOOD CONSUMPTION

Grassland/rangelands based livestock production systems: Options and trade-offs between productivity and GHG emissions reductions

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Rangelands comprise over 40% of the landmass of the world and provide valuable grazing lands for livestock and wildlife and contribute to the livelihoods of over 800 million people including poor smallholders (Ben Salem et al., 2011). They are critical to the carbon (C) cycle (Ogle et al., 2004) storing about one-third of the terrestrial soil C pool (Jobbagy and Jackson, 2000) over an area of approximately 3.3 billion ha. The large extent of rangelands, coupled with their propensity to store carbon in soils, suggests considerable carbon sequestration potential and thus opportunities for climate change mitigation.

Most of rangelands are under pressure to produce more animal-source food by grazing more intensively, particularly in the dry areas, which are more vulnerable to climate change and expected to still supply most of the meat and milk needed. As a result of past practices, somewhere twenty percent of the world's rangelands have been degraded by overgrazing (Sundquist, 2007).

Approximately 20% of the grazing lands of the planet are degraded and this percentage is expected to rise until 73% in dry areas (Dregne et al. 1991). Degradation of rangeland has tremendous consequences on the environment mainly, soil erosion, degradation of the vegetation cover, emission of carbon, loss of biodiversity and alteration of the water cycle. According to Ojima et al. (1993) and Sampson et al. (1993), non-sustainable land use practices such as inappropriate plowing, overgrazing of domestic animals, and excessive fuelwood use are the root causes of the degradation of rangeland ecosystems.

Ouled Belgacem and Louhaichi (2013) have demonstrated that global warming is expected to further contribute to the process of rangeland degradation as a result of overgrazing and mis-management and may have significant adverse impacts on range species under high CO_2 emissions scenarios. Already threatened rangeland species are likely to come under greater danger and present a very high vulnerability to climate change. On the other hand, species with low range value and broad ecological niches were favored by the impact of climate change and seemed to be able to survive under future environmental conditions of their adaptation range.

Rangelands are of great interest in terms of sequestering carbon from the atmosphere as a means of mitigating climate change, with estimated sequestration rates of ~ 0.6 gigatons (Gt) CO_2 equivalents yr^{-1} (Gerber *et al.*, 2013). It has been estimated that they account for a quarter of potential C sequestration in world soils (Follett and Reed, 2010). Despite this, they are neglected in terms of inclusion in mitigation strategies.

Increasing carbon stocks in the rangelands will improve water infiltration and cycling, increase productivity and hence biodiversity both below and above ground. Furthermore, rangelands support some of the world's poorest people (Ben Salem et al., 2011) and livestock is growing as a sector, with very important contribution in the GDP of the countries with significant areas of rangeland (World Bank, 2007). This will not only improve the livelihoods but also mitigate the negative impact of climate change. Livestock and rangeland ecosystems have a major role to play in mitigating climate change and mainly, supporting adaptation and reducing vulnerability.

Across these different land use systems, farmers and livestock keepers use a wide range of management practices to primarily achieve profitable gains (food security, livelihoods, income, etc.) but also to improve the "condition/health" of the grazing lands. Most, if not all, of the management practices aim predominantly to a) reduce and combat land

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degradation, b) restore/rehabilitate the land, and c) improve land productivity for livestock production. Therefore, all have a potential impact on carbon stocks in soils and biomass. Among management practices, controlled grazing management practice is considered beneficial in conditions of poor vegetation cover, overgrazing and degraded soils. It is considered as the most promising sustainable land management practice to restore degraded rangelands. Ouled Belgacem et al (2008) have shown that the reintroduction of the traditional management practice called "G'del" or "Hima" system under new arrangement has permitted a considerable increase of the rangeland production in forage units equivalent to more than 352 tons of barley in two years in a 4000 ha communal rangeland in southern Tunisia. It was also demonstrated that in 17-year protection from grazing under semi-arid conditions of China, the increase in C and N stored in soil contributed to more than 95% and 97% of the increases in ecosystem C and N storage. The exclusion of grazing had the potential to increase C and N storage in degraded semi-arid grassland and that the recovery of ecosystem C and N was mainly due to the accumulation of C and N in soils (Qiu et al., 2014).

Rehabilitation of degraded rangelands through reseeding and planting well adapted range species will provide additional benefits to local communities and economies and offer a very attractive opportunity to sequester carbon. Water harvesting techniques such as bunds or micro-catchments have been shown to increase forage production and therefore have potential to increase both above and below ground C in areas with erratic rainfall (Ouled Belgacem and Louhaichi, 2013).

Although rangelands would store an important pool of Carbon, they are a relatively small contributor to the word's anthropogenic greenhouse gas (GHG) emissions. The greatest emissions associated with rangelands likely come from livestock either directly through enteric fermentation and/or manure management or indirectly from feed-production activities, deforestation and overgrazing, etc. (Ben Salem et al., 2011; Ouled Belgacem and Louhaichi, 2013). In fact, livestock contributes to 80% of all agricultural non-CO_2 emissions (Tubiello et al., 2013), which makes it responsible for about 12% of all (GHG) emissions (Westhoek et al., 2011).

Climate change represents a special "feedback loop", in which livestock production both contributes to the problem and suffers from the consequences. Reduction of GHG emissions in the rangelands sector primarily involves the reduction of methane production by livestock, and increasing storage of carbon, which is dependent on improving rangeland health where needed. On the other hand, several assessments agree that increases in the demand for livestock products, driven largely by human population growth, income growth and urbanization, will continue for the next three decades at least (Thornton, 2010). The production will increasingly be affected by competition for natural resources, particularly land and water, competition between food and feed and by the need to operate in a carbon-constrained economy.

Livestock is an invaluable and irreplaceable source of nutrition and livelihood for millions of poor people and is one of the fastest growing agricultural sectors. Therefore, climate mitigation policies involving livestock must be designed with extreme care. It was reported that even within existing systems; autonomous transitions from extensive to more productive systems would decrease GHG emissions and improve food availability. Most effective climate policies involving livestock would be those targeting emissions from land-use change. To minimize the economic and social cost, policies should target emissions at their source—on the supply side—rather than on the demand side.

As mitigation options, reducing livestock numbers will surely reduce emissions but it will negatively affect the net cash income. However, changing the time of lambing, culling unproductive ewes, reducing stock in overgrazed areas, and managing fire frequency led to a significant reduction in GHG emissions without substantial effect on net income (Howden, 1991). Grazing the mix (sheep, goats, dromedaries) of animals may be both ecologically and economically efficient. Changing animal distribution, establishment of shaded areas, development of water sources, or fencing can improve carbon sequestration through some increase in plant cover and improved health of the root system through lighter intensity of grazing. However, the main way to reduce significantly methane emissions is the improvement of the quality of the diet such as providing protein supplements (Dordrecht et al., 1995).

In conclusion, a great deal of research evidence shows that improved grazing management could lead to greater forage production, more efficient use of land resources, and enhanced profitability and rehabilitation of degraded lands (Louhaichi et al., 2013). The tightening linkage between ecosystem services and human well-being in the world's dryland systems acutely demonstrates the need for a new, integrated approach to diagnosing and addressing sustainable development priorities, including maintenance of the supply of critical ecosystem services.

References

Ben Salem, H., Rekik, M., Lassoued, N. & Darghouth, M.A. 2011. Global warming and livestock in dry areas: expected impacts, adaptation and mitigation. In Houshan Kheradmand (editor) Climate change – socioeconomics Effects, INTECH, Open Access Publisher, Croatia. ISBN 979-953-307-277-6. pp 341-366.

Dordrecht A.H., Sathaye J. & Meyers S. 1995.Greenhouse Gas Mitigation Assessment: A Guidebook. Kluwer Academic Publishers, the Netherlands.

Dregne, H., Kassas, M & B. Rosanov. 1991. Desertification Control Bulletin 20, 6-18, UNEP. Nairobi, Kenya.

Follett R.F. & Reed D.A. 2010. Soil carbon sequestration in grazing lands: societal benefits and policy implications. Rangeland Ecol Manage 63: 4–15.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J.; Falcucci, A. & Tempio, G., 2013. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.

Howden, Mark. 1991. Methane production from livestock. Draft Australian Greenhouse Gas Emissions Inventory 1987-1988. Greenhouse Studies 10 (DASET):15-22.

Jobbágy, E.G. & Jackson, R.B. 2000. "The Vertical Distribution of Soil Organic Carbon and Its Relation to Climate and Vegetation." Ecological Applications 10 (2): 423–436.

Louhaichi, M., Chand, K., Misra, A. K., Gaur, M. K., Ashutosh, S., Johnson, D. E. & Roy, M. M. 2014. Livestock migration in the arid region of Rajasthan (India) - strategy to cope with fodder and water scarcity. Journal of Arid Land studies 24(1): 61-64.

Ogle, S.M., Conant, R.T. & Paustian. K. 2004. "Deriving Grassland Management Factors for a Carbon Accounting Method Developed by the Intergovernmental Panel on Climate Change." Environmental Management 33 (4): 474–484.

Ojima, D., Parton, W.J., Schimel, D.S. & Scurlock, J.M.O. 1993. Modeling the effects of climatic and CO_2 changes on grassland storage of soil C. Water, Air, and Soil Pollution 70:643-657.

Ouled Belgacem A. & Louhaichi M. 2013. The vulnerability of native rangeland plant species to global climate change in the West Asia and North African regions. Climatic Change 119:451–463.

Ouled Belgacem A., Ben Salem H., Bouaicha A. & El-Mourid M. 2008. Communal rangeland rest in arid area, a tool for facing animal feed costs and drought mitigation: the case of Chenini community, southern Tunisia. Journal of Biological Sciences, 8(4): 822-825.

Sampson, R.N., Apps, M., Brown, S. *et al.* 1993. Workshop summary statement: terrestrial biospheric carbon fluxes--quantification of sinks and sources of CO_2. Water, Air, and Soil Pollution 70:3-15.

Sundquist B. 2007. Grazing lands degradation: a global perspective. Chater 4. Grazing land degradation: a global perspective. Edition 6. http://home.windstream.net/bsundquist1.

Qiu L., Wei X., Zhang X., Cheng J. 2014. Ecosystem Carbon and Nitrogen Accumulation after Grazing Exclusion in Semiarid Grassland. PLOS ONE DOI: 10.1371/journal.pone.0055433.

Thornton P. K. 2010. Livestock production: recent trends, future prospects. Trans. R. Soc. 365, 2853–2867 doi:10.1098/rstb.2010.0134

Tubiello F.N., Salvatore M., Rossi S., Fitton N. & Smith, P. 2013. The FAOSTAT. database of greenhouse gas emissions from agriculture. Environ Res Lett.; 8(1):015009.

Westhoek H., Rood T., Van den Berg, M., Janse J., Nijdam D., Reudink M. & Stehfest E. 2011. The Protein Puzzle The consumption and production of meat, dairy and fish in the European Union. The Hague: PBL Netherlands Environmental Assessment Agency; 221 pages.