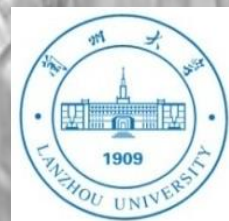


SUSTAINABLE GRASSLAND AND PASTURE MANAGEMENT IN ASIA

Proceedings of a Regional Consultation
held at

Lanzhou University, Lanzhou, China,
27–30 November 2015



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This volume is based on the discussions of the Regional Consultation on Sustainable Grassland and Pasture Management in Asia, held at Lanzhou University, Lanzhou in November 2015 and was planned and coordinated by Vinod Ahuja (Livestock Policy Officer, FAO Regional Office for Asia and the Pacific) and Harinder Makkar (Livestock Production Officer, FAO Headquarters), in collaboration with Ruijan Long (Director, International Centre for Tibetan Plateau Ecosystem Management, Lanzhou University).

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Abbreviations

APRC	FAO Regional Conference for Asia and the Pacific
CACILM	Central Asian Countries Initiative for Land Management
CEPF	Critical Ecosystem Partnership Fund
CSIRO	Commonwealth Scientific and Industrial Research Organisation
cv.	cultivar
CV	Coefficient of variation
FAO	Food and Agriculture Organization of the United Nations
GASL	Global Agenda for Sustainable Livestock
GCA	Greater Central Asia
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gases
HKH	Hindu Kush Himalayas
ICARDA	International Center for Agricultural Research in the Dry Areas
ICBA	International Center for Biosaline Agriculture
ICIMOD	International Centre for Integrated Mountain Development
ICPTM	International Centre for Tibetan Plateau Ecosystem Management
ICRAF	World Agroforestry Centre
INRAT	Institute National de Recherche Agronomique de Tunisie
IPCC	Intergovernmental Panel on Climate Change
JPY	Japanese Yen
KGGRP	Korean-German Grassland Research Project
LW	live weight
LZU	Lanzhou University
MAFF	Ministry of Agriculture, Forestry and Fisheries [Japan]
MAP	Mean Annual Precipitation
masl	metres above sea level
MOST	Ministry of Science and Technology [Gansu]
MS	Milksolids
NARO	National Agriculture and Food Research Organization [Japan]

NIRS	Near-infrared reflectance spectroscopy
PES	Payment for ecosystem services
QTP	Qinghai-Tibetan Plateau
R&D	Research and development
RDA	Rural Development Administration [Korea]
SDG	Sustainable Development Goal
SLM	Sustainable land management

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Background and Summary

Approximately 35 percent of the Asia-Pacific land area (1.2 billion ha) are grasslands, and livestock grazing is the dominant form of land use, providing meat, milk and fibre as marketable products. Although the estimates of the geographical extent and severity of grassland degradation vary, there is a general consensus that in many places, grassland degradation is an issue of serious concern. The causes of grassland degradation are complex, variable and contested, but in most instances grassland degradation is the result of the interplay between climatic factors, herbivorous animal populations and socio-economic forces.

In addition to the very important functions of water regulation and biodiversity maintenance, grasslands are a major carbon sink, with the potential to sequester 1.5 gigatonnes CO₂-eq of carbon annually, if a broad range of grazing, pasture improvement practices were applied to all of the world's grasslands. There are large discrepancies between estimated potential C-sequestration by grasslands and field observations, and realistic levels of achievable C-sequestration under the diverse prevailing circumstances. Furthermore, verification of grassland C-sequestration is extremely difficult, and trade-offs exist between enhancing grassland C-sequestration and other ecosystem and 'productive' functions.

The 32nd FAO Regional Conference for Asia and the Pacific (APRC) noted that degradation of grasslands can have severe negative local impacts and far-reaching consequences, including soil erosion, loss of biodiversity, greenhouse gas emissions, desertification, dust storms, diminished livelihood opportunities, and reduced yields of products and services. The conference also stressed the importance of identifying and addressing the underlying causes of grassland degradation and loss, and urged FAO support for related analyses and the formulation of action plans for addressing such factors. In particular, the APRC requested FAO to support Member Countries in advocacy, awareness raising and engagement of key decision-makers in support of grassland restoration, building technical capacities and formulating policies and measures to create an enabling environment for effective grassland restoration; and exploring opportunities for innovative financing of restoration activities. To discuss the above issues, the meeting reported here was held as a first step towards a regional assessment of the status and prospects of grassland restoration in the Asia-Pacific region, and to identify pathways towards the development of site-specific and holistic policies and programmes for grassland restoration that take into account an array of ecosystem services provided by grasslands and the livelihoods impacts on grassland stewards.

Welcome and Opening Remarks

The welcome and keynote remarks highlighted the challenges and opportunities for sustainable grassland and pasture management – a major land use in the Asia Pacific Region – and the nature of immediate attention and response required for policy guidance. Professor Baotian Pan (Vice President of Lanzhou University, China) welcomed the participants and thanked FAO for bringing experts together to discuss various issues related to the sustainable management of grasslands. Highlighting the global importance of Chinese grasslands, he added that the quantity of carbon stored in the soil of Chinese grasslands represents more than 2.4 percent of total global soil carbon.

The mountain grassland of China is a natural repository of glaciers, snow packs and frozen land, with unique vegetation. These grasslands are a source of usable water for nearly 40 percent of the world population, including China and other countries of the region. However, he drew the attention of the experts to fact that the grasslands are highly fragile, and susceptible to climate change and require urgent attention for their sustainability. He further hoped as an outcome of the meeting to have sound recommendations, including a clear way forward, for grassland development in Asia Pacific.

Mr Chunguang Ouyang (Director of Foreign Affairs Office of Gansu Provincial Science and Technology Department, China) warmly welcomed the participants. Gansu has about 9 million ha of usable pastures and a variety of grassland types, from high alpine meadows to lowland arid and semi-arid grasslands. The future of Gansu's grasslands is of increasing concern for the livelihood of many people; these grasslands are important areas for the conservation of biodiversity, with their many distinctive species. They are the source of many major rivers of the region and what happens in these grassland areas will have important implications for millions of people downstream. He said that the livestock and grassland resources of Gansu coupled with its geographical location can serve as ideal base station for national and international organizations and researchers for collaborative research on grasslands.

Dr Vinod Ahuja (Livestock Policy Officer, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand) welcomed the participants on behalf of FAO. He said that there are almost 1.2 billion ha of grasslands (35 percent of the Asia-Pacific land area) in the region, and livestock grazing is the major use of these grasslands, providing meat, milk and fibre as marketable products. These grasslands also provide vital ecosystem services (e.g. water and climate regulation; biodiversity conservation) in support of agriculture, food security and nutrition. Grasslands have great potential to contribute to climate change adaptation by ensuring long-term contributions to community resilience, livelihoods and poverty alleviation, and capture mitigation benefits through carbon sequestration. He also outlined his vision of working together to plan elements of the future pathway to take forward the sustainable grassland agenda.

Country presentations

Various experts presented country reports on their respective countries. Professor Victor Square shared his experiences on the Rangelands of the Greater Central Asian Region. He gave an overview of the rangelands, their importance, various land uses and potential threats, and identified prioritized actions for grassland restoration in the region.

The detailed country reports covered basic information about extent of rangelands, extent of degradation and restoration, livestock and pastoral counts, key drivers of land use change and degradation, major stakeholders and players, policies, strategies, programmes related to land use, land tenure and restoration; and were presented by Dr Yongfei Bai (China), Ms. D. Dulmaa (Mongolia), Shoji Matsura (Japan), Dr Jong Geun Kim (Korea), Dr Devendra Malviya (India), Dr Abdul Wahid Jasra (Pakistan), Dr Karma Phuntso (Bhutan) and Dr Madan Koirala (Nepal).

Technical presentations

A number of presentations covered recent grassland-associated challenges and issues, good practices, and initiatives from local, national and international perspectives. The presentations highlighted the importance of grasslands for food security and livelihood at household, national and regional levels, and the implications for resource management and ecological sustainability. Short highlights of these presentations are given below:

(1) Professor Ruijun Long. The Qinghai-Tibetan Plateau (QTP) has an average altitude of more than 4000 masl (metres above sea level), has an area of 2.5 million km² and is sometimes termed the Third Pole of the World. The plateau is a world heritage site for biodiversity. The QTP faces a number of challenges threatening the existing grassland ecosystems of the area. Overgrazing and climate change are the major causes of alpine rangeland degradation, leading to lower productivity of the grasslands. A multidisciplinary approach is unavoidable for sustainable management of the plateau grasslands under the current climate change scenario, and herders must be given a high priority role in reaching this objective.

(2) Irene Hoffman. Pastoralism and agro-pastoralism are key production systems associated with livestock and support 44 percent of global sheep, 29 percent of goats and 20 percent of cattle globally. These systems also provide 22 percent of global beef production, and 16 percent of milk. They are facing many challenges that are common around the world among various pastoral communities. Disruption of pastoral migration routes due to political instability and other factors is a major challenge to pastoralism. Stronger participation of pastoralists in policy processes is necessary to combat food insecurity and poverty and ensure sustainable grassland management.

(3) Liz Weddenburg. The World's human population is estimated to reach 9.6 billion by 2050. The demand for meat and dairy will rise to 470 MT and 1050 MT, respectively. Grassland provides 50 percent of the biomass consumed by livestock. Today's population is facing big challenges of climate change, resource degradation, food insecurity and inadequate health. The Global Agenda for Sustainable Livestock (GASL) has three Focus Areas: 1. Resource use efficiency; 2. Restore value to grasslands; and 3. Convert waste to wealth in various regions of the world. Herders should be embedded in the process of supporting practice change through family life cycle, technological innovation and collaborative approaches to influence individual practice change. She added that formation of common interest groups can help sustainable grasslands as a catalyst for delivery of multiple benefits that deserve to be valued and recognized.

(4) Harinder Makkar. Increased temperature, water shortage and salinity impose a challenge for reclamation of degraded land using fodder plants. The situation is likely to be aggravated by ongoing climate change. On the Asian continent, the models project changes in rainfall from falls of 10 to 15 percent to rises of 10 to 15 percent, with a temperature rise of 2–5°C by 2080. The International Center for Agricultural Research in the Dry Areas (ICARDA), Institute National de Recherche Agronomique de Tunisie (INRAT), International Center for Biosaline Agriculture (ICBA), CSIRO Livestock Industries and the University of Western Australia have brought forward excellent work on cactus and buffel grass and unique approaches to managing rangelands based on multiple uses of biomass for grassland restoration. Experts, farmers and pastoralists can replicate these for other regions. Smart feeding strategies and innovations in fodder use can guide farmers to use best

practices, for example to harvest fodder crops when the nutrient yield per unit area is maximum, for getting maximum nutrition from a unit area, extracting maximum profitability.

(5) Dengpan Bu. It has been projected that the demand for ruminant products (beef, dairy and mutton) by 2050 will increase by 80 to 100 percent compared to consumption levels in 2010. In China, raw milk production and cow numbers have increased tremendously in the last 30 years, but China produces only 6 percent of world milk. Heavy reliance on importing more dairy products and low feed conversion efficiency of the domestic animals, using more feed to produce less milk, are major issues to be addressed to encourage positive growth of the dairy industry in China. Grassland-livestock-based agroforestry systems could be a turning point towards an efficient and sustainable dairy industry in China.

(6) John Leake. Grazing management operations, such as using improved species, inputs, cropping rotations to improve soil health and soil carbon content, contribute to improved incomes. It is generally accepted that improving management can increase carbon sequestration potential, but research is needed on technical, financial, institutional and social aspects of carbon sequestration and credit selling.

(7) Xueyong Zhao. The Horqin Sandy Lands are a transitional area from traditional pastoral systems to modern agriculture systems. They were once one of the most severely desertified regions in northern China, and identified as a primary source of sand and dust storms. Since the 1980s, desertification has been reversed through implementation of several restoration projects, such as the “Three-north re-vegetation project”, the “Natural vegetation protection project”, and the “Green for Grain Project” in the Horqin Sandy Lands. The lessons learnt from these include that sustainable desertification reversion should be made without compromising the basic resource capacity for ecosystem succession and economic development in the targeted region.

(8) Sergio Garcia. The Australian dairy industry produces 9.5 billion litre of milk/yr from 1.7 million cows. There are about 6800 dairy farms in Australia and, on average, each cow produces 6,000 L/yr, with 1.8 t/yr of concentrate feed. Of all the feeding systems in Australia, 80 percent were pasture-based systems, in which cows are supplemented with grain or grain-based concentrates. Matching growth and harvest rates is paramount in any grazing system and is key to reducing feed costs by minimizing imported costly supplements and achieving cow efficiency (>1 kg milk solids (MS)/kg live weight) targets. Volunteer species are not always bad, overgrazing is a silent killer and the role of technology in sustainable pasture management is important.

Panel discussions

Two panel discussions were conducted to further elaborate on selected issues that emerged as priorities for further discussion. A brief summary of the discussions in these panels and the broad messages that emerged from the deliberations are given below.

Panel 1, Grassland restoration: causes, solutions and the response

The deliberations related to growing pressure on grasslands resources, the need to enhance efficiency of resource use and to minimize the impact on the biophysical environment, reflected knowledge gaps, uncertainties, and the diversity of stakeholder visions of sustainable grassland

management. These also reflected a sense of sincerity in dealing with climate change, biodiversity losses, value addition, payment for ecosystem services, land tenure, and resource-use efficiency issues. In this context, it was pointed out that there is need to create a balance between various aspects of grassland to reverse negative biological processes with their own biophysical limits. While it is important to discuss ways and means to improve resource use efficiency such discussions must occur within biological limits and respect socio-economic realities.

During the panel discussion related to land tenure issues it was proposed that reintegration of the cooperative in the policy perspectives can give better results. It was highlighted that only positive narratives are brought into the scenes of the initiatives, so negative narratives should be equally considered to maximize the outputs of restoration initiatives. It was further discussed that payment for ecosystem services (PES) should encourage positive behaviour, but the payment system should be clearer. People getting payments must be aware of why they are being paid. It was argued that emotional links should be developed among the stakeholders for maximizing benefits and restoration results.

Panel 2. Grassland management: policy, institution and science

Grasslands ecosystems are fragile and face multiple threats, including climate change, mismanagement, and overuse. At the same time, degradation is threatening livestock production, pastoral livelihoods and downstream ecology. In this context, the panelists discussed how policies can help improve grassland management. The role of institutions and science was also highlighted in this regard. It was argued that good institutions can provide a favourable environment for result-oriented science. Science-based evidence is important as a basis for good policies.

The need to conserve biodiversity was discussed. It was further argued that rangeland policy development processes in Hindu Kush Himalayas (HKH) region countries has started to have a positive impact. While discussing the role of institutions such as ICIMOD in capacity building, it was concluded that science, institutions and policies are interlinked for grassland restoration, and the roles of international institutions like ICIMOD and FAO are clearly recognized in this regard.

Concluding Session

In a group-based intensive discussion in the light of country reports, technical presentations and panel discussions an action plan was prepared. The objective of this session was to formulate key messages to communicate to policy-makers, comprising government officials, international and national organizations, and other institutions and stakeholders associated with policy processes. The main features of the action plan included advocacy, capacity enhancement, demonstration of values on which stakeholders agree, and resource allocation. It was pointed out that the policy-making process is as important as the outcome, and that communication is the key. Some of the key messages and recommendations that emerged from the discussions are summarized below.

- [1] Many significant rangeland and pasture/grassland restoration successes were shared between participants along with the technical and institutional requirements for their success, and these reinforced confidence that realistic options exist, but that they need to be tailored for the particular mix of climatic, livestock and socio-economic forces prevailing in different places.

- [2] There is a need for a more inclusive definition of the target grasslands, rangelands and pasture lands, to include mixed systems, as presented by several speakers, including the significant areas of saline-affected soils now relatively unproductive, although having moisture and otherwise suitable soils.
- [3] A number of countries in the region either do not have rangeland and grassland/pasture management policies, or existing policies are ineffective, and policies related to development goals have unintended negative consequences for grasslands. It is essential for countries to formulate policy and strategic frameworks for sustained management (including conservation and restoration) of grasslands in the broad sense and to take a systemic approach in alignment of policies for regional development and poverty alleviation with resource management. The policies must recognize the multi-faceted functionality of grasslands, including biodiversity conservation, ecosystem services, enhancement of livelihoods and food security, and other socio-economic and cultural values. The policies must also facilitate resource mobilization by stakeholders interested in improved ecosystem services or establishing and servicing markets developed for such services, such as carbon sequestration.
- [4] Attention to policy processes is as important as the policy outcomes. Participatory processes have great potential to contribute to positive outcomes and hence special attention must be given to ensure that the policy processes provide sufficient opportunities for participation of local communities (herders, pastoralists and others) and stakeholders concerned with improving ecosystem services (to reflect their views and concerns in the interests of a smooth value chain from herder through to markets). While the processes should consider regional and international experiences, it is essential that the policy instruments are well grounded in local and market contexts, can be implemented in partnership with local communities, and respect and harness their traditional knowledge. Policies must also ensure that local communities receive a fair share of the benefits from conservation and adoption of good practices.
- [5] There is a need to develop methodologies and tools for real time assessment (quality and quantity) of pasture and forage biomass, and water availability, including development of early warning systems for pastures and water availability. Methodologies, approaches and models are also needed for measuring carbon and nitrogen fluxes above and below the soil (as a precursor to development of methodologies for obtaining tradeable carbon credits from rangelands) and for assessment of eco-services from grasslands and rangelands, and for monitoring overgrazing and land degradation.
- [6] Understanding what urban consumers and communities value (e.g. clean air, safe water) and linking this back to grassland management, with the development of financial systems to incentivize grass managers, and related methodologies to measure state and progress – all these are required to help prioritize where activities need to be focused and to target capacity building in local people.
- [7] Although there are commonly accepted protocols for measuring some ecosystem services, such as carbon in soils, these are not cost effective for dryer areas and are site specific. There

is a need to develop and demonstrate cost-effective monitoring systems for the main biomes that can be calibrated by measurement for specific sites from the work done and specific investigations.

- [8] Water conservation and watering point management must receive due attention in the grassland and rangeland management plans because most land degradation occurs around watering points.
- [9] Forage seed development and distribution infrastructure is very weak in a number of countries in the region, and needs strengthening. There is also a need to strengthen rangeland and agronomy scientific expertise in the region for the range of ecosystem goods and service available locally.
- [10] Agricultural extension services are particularly weak in a number of countries in the region and wherever they exist, they do not address the issues and problems faced by pastoralists and herders. Countries must strengthen extension services that provide guidance to herders and other stakeholders on efficient management of grasslands and rangelands.
- [11] In many countries, in addition to overgrazing, use of biomass as an energy source also contributes to land degradation. Energy security policies need to factor this in to facilitate adoption of non-biomass based energy technologies by pastoralists and herders.
- [12] Failure to restore or rehabilitate grasslands is a significant driver of climate change. There is a strong need to communicate this message (with strong evidence) to relevant decision-makers and financiers by means of examples in each significant biome.
- [13] There is also a need to better demonstrate good practices in grassland and rangeland management. Participants recommended selecting one case per country to demonstrate good practices (in particular, market-based approaches to restoration).
- [14] Development policies and programmes in grassland areas in general should focus on herder-centric solutions and must assure reward for good practices.
- [15] Concerted efforts involving local governments and herders are needed to improve communal lands (also often dismissed as “wastelands”). Equitable and appropriate distribution of land use and management rights need to be also ensured for success.
- [16] There is a need to strengthen transdisciplinary and transboundary approaches to grassland and rangeland management and restoration. Rangeland ecologists, animal production scientists, forage breeders, forage management scientists, extension experts and others need to work together with herders, policy-makers and other stakeholders. International organizations, such as FAO, have a critical role to play in this context.

- [17] The participants specifically recommended following action points addressed to FAO.
- a. Establish and enable an Asia-Pacific Sustainable Grassland Management Network and a web platform with updated scientific information.
 - b. Develop and disseminate advocacy modules aimed at informing policy-makers on the value of rangeland and grassland management and restoration.
 - c. Build links with existing multi-stakeholder initiatives at local and global scales, such as the Global Agenda for Sustainable Livestock (GASL) including the development of a work plan with an emphasis on pilot cases that demonstrate success.
 - d. Facilitate the development of appropriate means and methods for sharing and enhancing the monitoring of ecosystem services, particularly for carbon sequestration, and engage ecosystem service actors as observers.
 - e. Support a regional technical cooperation project aiming at grassland and rangeland restoration and management, considering the transboundary nature of grassland degradation. The focus of this project could be on development of value propositions and models taking into account multiple functions of grassland and rangelands, applying a herder-centric approach.

Welcome Adresses and Opening Remarks

Welcome address I

Professor Baotian Pan
Vice President, Lanzhou University, China

Distinguished Guests, Ladies and Gentlemen

It is my pleasure to welcome you all on the occasion of this Regional Consultation on Sustainable Grassland and Pasture Management in Asia, organized by Lanzhou University, China, in collaboration with FAO. I appreciate highly the international scientists who have come here from around the world to attend this meeting. I am also thankful to the Chinese researchers who are attending this meeting.

Ladies and Gentlemen, China has 40 percent of its land area as grasslands, ranging from alpine grasslands on the Tibetan Plateau, through temperate grasslands on the Inner Mongolian Plateau, to mountain grasslands in the Xinjiang area, and these form the third largest grassland ecosystem in the world. These grasslands not only feed the millions of livestock but also support the livelihood for more than 9.8 million people on the Tibetan plateau, comprising the largest nomadic human population in the world. The quantity of carbon stored in the soil of the plateau represents more than 2.4 percent of total global soil carbon. The mountain grassland of China is a natural repository of glaciers, snow packs and frozen land, with unique vegetation. The area accounts for 52 percent of total lake area and 80 percent of the glaciers of all China. Being the source of major rivers of Asia, including the Yangtze, Yellow, Indus, Mekong and Ganges Rivers, it has been considered as the world's largest river runoff from a single location. This is a source of usable water for nearly 40 percent of the world's population, including China and India. The atmospheric moisture movement from the global water tower influences the global environment, and most obviously monsoon circulation. Currently the grasslands are highly fragile due to climate change, and require immediate attention for sustainability.

Founded in 1909, Lanzhou University (LZU) is one of the top universities directly administered by the Ministry of Education, China. The university maintains high standards of education and research, and most its applied science departments are highly regarded in China. The college of Grassland Agriculture of Lanzhou University holds the highest ranking in China. The University operates a key laboratory of Grassland Agro-ecosystems of the Ministry of Agriculture. Lanzhou University is outstanding in the basic theoretical research and has made great achievements in applied research. The university's achievements are recognized at national and international levels.

The Nature Publishing Group issued the *Nature Index 2015 (Asia-Pacific)* in March, 2015, and listed the top 200 universities and research institutions in the Asia-Pacific region. The total number of published papers of China topped the list in the Asia-Pacific region in 2014. LZU is the 8th largest contributor to the Nature Index overall in China, LZU and other intuitions in China are doing their best for the sustainable management of grasslands, but a lot still needs to be done in this direction. I am happy that we have the opportunity to sit with the grasslands scientists from different parts of

the world. I hope that this meeting will help Chinese scientists with good ideas to step forward to achieve the goal of sustainability of Chinese grasslands, which are biggest in the region.

I am sure that all the participants in this consultation can contribute new ideas, concepts as well as discuss experiences to further expand our pool of grassland knowledge in the region. Moreover, I believe that this event can serve as our venue towards strengthening sustainable Grassland and Pasture Management in Asia. Taking this meeting as an opportunity, I would like to propose that you consider establishing a formal network among the scientists of the region under the umbrella of FAO for future communication and collaboration to achieve the goals of sustainable grassland management in the region.

I would like to express my sincere thanks to FAO who collaborated with LZU to organize this very important workshop. I wish you well with the meeting and look forward to have sound recommendations, including a clear way forward for grassland development in Asia Pacific.

Thank you all.

Welcome Address II

Mr Chunguang Ouyang

Director, Foreign Affairs Office, Gansu Provincial Science and Technical Department, China

Honorable Guests, Ladies and Gentlemen: Greetings,

I am pleased to welcome you on the occasion of this “Regional Consultation on Sustainable Grassland and Pasture Management in Asia” on behalf of the Ministry of Science and Technology, Gansu Province. I really appreciate the foreign delegates and Chinese experts who have come here to attend this event.

Ladies and Gentlemen, Gansu province is situated at the northern end of the Qinghai-Tibetan Plateau and borders Qinghai province to the south and the Inner Mongolia Autonomous Region to the north. It is flanked in the north by the western stretches of the Great Wall of China. This central location of Gansu province in the grassland zone of China, makes it an ideal base for national and international organizations and researchers. Gansu Province has the fifth-largest pastoral area of China with about 900,000 yak population. Agriculture contributes 19.3 percent of the GDP in Gansu, and livestock production is its major component, contributing about 28.8 percent to the agricultural sector GDP.

Gansu has about 9 million ha of usable pastures and a variety of grasslands, from high alpine meadows to the lowland arid and semi-arid grasslands. The future of Gansu’s grasslands is of increasing concern for the livelihood of many people; these grasslands are important areas for the conservation of biodiversity, with their many distinctive species; the headwater for many major rivers are found in these areas, and what happens in these grassland areas has important implications for millions of people downstream. In spite of their extent and importance, Gansu’s grasslands are subject to many forces of degradation, and difficult decisions will have to be made to reduce the extent of land degradation and loss of biodiversity, and to safeguard this vital resource for China’s future generations.

The Ministry of Science and Technology (MOST) is aware of the need for a stable ecological environment to provide the basis for sustainable economic and social development. MOST Gansu is actively working with national and international partners for the conservation and management of grasslands of Gansu Province. MOST Gansu has started many initiatives in collaboration with LZU for the restoration and sustainable management of the grasslands of the Province.

I hope that findings of the work will guide MOST Gansu to define its programme and plans for grassland sustainability and ecological stability, not only for the province, but also for China and the Region. MOST Gansu will extend its full support to FAO, LZU and others to implement recommendation of the meeting as and when required.

I would like to thank FAO and LZU for organizing this very important workshop, and for giving me the opportunity to be with you all. I wish you well with the meeting and look forward to have concrete solutions for grassland development. Thanks to all of you.

Opening Remarks

Dr Vinod Ahuja

Livestock Policy Officer, FAO Regional office for Asia and the Pacific, Bangkok, Thailand

Distinguished delegates, colleagues, students, ladies and gentlemen,

On behalf of FAO and on my own behalf, I have great pleasure in welcoming you to this Regional Consultation on Sustainable Grassland and Pasture Management in Asia. I also wish to thank the LZU team for their partnership, leadership and hard work in organizing this very important meeting. I am also thankful to all the experts and participants for their time and contributions in preparing the background papers and presentations, and for taking the time to come to this meeting.

When I look at the list of participants I realize that probably I am the one with the least experience in working with grassland-related issues. So I am really looking forward to learning from the enormous experience and expertise we have managed to bring together in this room. Let me however take a step back and share with you the perspective or the point of departure we in FAO had when we considered organizing this meeting.

For us, from an institutional perspective, the point of departure really goes to the rapid rise in the demand for food of animal origin. As we are well aware, the Asia region has experienced dramatic increases in the production and consumption of livestock products in recent decades.

On the supply side, technology has been the most important factor behind the rapid growth in livestock output, with the introduction of higher-productivity breeds, new feeding systems and rearing facilities all playing a role in improving production efficiency. This has been accompanied by a rapid expansion in large intensive livestock systems, characterized by a shift from ruminants to pig and poultry, and concentrating near urban demand centres.

One of the consequences of historical and recent rapid growth of livestock consumption and production is tremendous pressure on the capacity of existing food production and distribution systems, with major implications for natural resource use and consequent socio-economic impacts and human, animal and environmental health. The degradation of natural resources in general has severe negative local impacts and far-reaching consequences, including soil erosion, loss of biodiversity, greenhouse gas emissions, desertification diminished livelihood opportunities, and reduced yields of products and services;

Coming to the grasslands, the estimates I have seen indicate that there are almost 1.2 billion ha of grasslands (ca 35 percent of the Asia-Pacific land area) in the region, and that livestock grazing is the dominant form of land use of these grassland, providing meat, milk and fibre as marketable products. These grasslands also provide vital ecosystem services (e.g. water and climate regulation, and biodiversity conservation) in support of agriculture, food security and nutrition; offer vast potential to contribute to climate change adaptation by ensuring long-term contributions to

community resilience, livelihoods and poverty alleviation; and capture mitigation benefits through carbon sequestration.

Although estimates of the geographical extent and severity of grassland degradation vary greatly, there is a general consensus that grassland degradation, due to increased pressure from livestock – as a result of growing demand for livestock products – is an issue of serious concern, particularly in Asia. I do not mean to suggest that livestock keepers are the reason for grassland degradation and I do recognize that the causes of grassland degradation are complex, variable and contested. But still, it is evident that, in most instances, grassland degradation is the result of interplay between climatic factors, animal populations and socio-economic forces. While we can debate the reasons, what is also clear is that there is an urgency to take action and to employ measures to achieve environmentally sound, economically viable and socially acceptable management of grasslands that restore and enhance their productive capacities in support of food security and livelihoods, while at the same time contributing to climate change mitigation and adaptation.

So, for us, the context really is that of food security, nutrition, livelihood support, community resilience, and social, economic and ecological sustainability, and considering how we can strengthen the role and contribution of grasslands in this narrative, recognizing the notion of sustainability in its full complexity. But somehow it seems to me that the ‘sustainability and grassland narrative’ has not been as mainstream as it needs to be, and much work is needed to recognize and strengthen that role.

Just to take the context of Sustainable Development Goals, the first sustainable development goal states “end poverty in all its forms everywhere”. In this context, there is increasing evidence that agricultural growth, and in particular growth in the livestock sector, makes large contributions to poverty alleviation due to multiplier effects in the economy. But, there is relatively little recent empirical evidence on the relevance of these trends for livestock keepers in grassland systems: There has been little research on poverty incidence in grassland-based livestock systems and relatively little is known about poverty dynamics in grassland-based livestock systems in the last 15 years.

The second Sustainable Development Goal (SDG) talks about Food security and sustainable agriculture, and SDG 12 addresses sustainable production and consumption. In this context, livestock are expected to make increasing contributions to national and global food provision by responding to growing demand. From the supply side, there is a growing interest in ‘sustainable intensification’ which looks beyond production. But the relative impacts of policies and programmes to promote sustainable intensification in extensive grazing systems on livestock keepers’ food security status, as opposed to aggregate livestock product supply, has not been examined. Given that production of small ruminants on grassland resources is more resource efficient than production of other types of red meat, grassland-based livestock husbandry is recognized as a grain-saving approach to protein supply. A recent modelling study by FAO examined whether grassland-based livestock production can meet expected growth in demand for livestock products, and found that it can do so only if there is a reduction in per capita meat consumption, and a corresponding increase in consumption of plant-, poultry- and fish-based protein. Demand-side interventions to reduce the environmental impacts of diets have also been discussed in relation to other issues, such as greenhouse gas (GHG) emissions.

So we need to look at grassland management within a broader set of social policies. These include land tenure legislation and policies, employment policies, social protection and assistance policies. And although there is some documentation and research on grasslands in relation to some of these policy issues, there are gaps in knowledge or lack of systematic research addressing grasslands for many of these policy domains; Also when you look at the investment patterns, grasslands are not very visible in existing data or analysis of investment trends, be it government investments, Overseas Development Assistance, etc.

So what we are looking for is guidance on various policy options and action points for sustainable management of grasslands and development of the livestock and the development of locally-adapted strategies for improved management of grasslands; measures needed to create an enabling environment for grassland rehabilitation and restoration, including through support to the development of sound policy and regulatory frameworks for enhancing biodiversity conservation and productivity through landscape restoration approaches; review and revision of tenure arrangements; measures to enhancing community resilience by strengthening community capacities to restore and rehabilitate grasslands; assisting efforts to link communities to markets for grassland-based products and services; building awareness and engaging key decision-makers in support of grassland restoration, especially considering the potential long-term benefits for food security, poverty alleviation and livelihoods.

I am sure, with your expertise and experience, we should be able to work out elements of the future pathway, and how we work with various stakeholders in taking the sustainable grassland agenda forward.

I wish to welcome you once again to this meeting, and look forward to the deliberations over the next two days.

Thank you.

Country Papers

Rangelands of the Greater Central Asian Region

Victor R. Squires
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Greater Central Asia (GCA) region is located in the middle of the vast Eurasian continent, with its particular meteorological patterns that cause a high degree of aridity in the region. The significant distance from the oceans, presence of high mountain systems, and high temperatures along with a long dry period, are the major factors contributing to aridity in GCA.

The GCA Region can be divided into four bioclimatic zones: a sub-humid zone with 400–800 mm of rainfall, represented by a chernozem steppe; the semi-arid zone, with precipitation of 200–300 mm, and dominated by bush vegetation communities with patchy herbaceous cover; an arid zone having 100–200 mm of rainfall, with sparse vegetation is represented by annual and perennial xerophytic species; and the extra-arid zone, with less than 100 mm precipitation and is devoid of vegetation, except for shrubs and ephemerals along watercourses. Natural pastures constitute about 90 percent of the region's agricultural lands. The total area of pastures in Central Asia is about 594 million ha, which is about 65 percent of the region's total land. About 84 percent of pastoral lands are located in China, Kazakhstan and Mongolia. The other states have about 16 percent of pastureland; this portion varies from 0.4 percent in Tajikistan to 5.4 percent in Uzbekistan. The central Asian steppes of NW China and Mongolia, albeit physiognomically similar, have a distinct flora and are have a summer-rainfall regime. There are several factors contributing to land degradation in Central Asia, including:

- significant remoteness of the region from the ocean;
- climate aridity;
- uneven distribution of water resources and their scarcity,
- vulnerability of drylands;
- underdeveloped infrastructure; and
- high population growth rates and urbanization processes.

Any medium- and long-term changes in temperature and precipitation regimes lead to disturbance of equilibrium in the fragile ecosystems of the region. Droughts, although not causing desertification, are nevertheless catalysts for vegetation and soil degradation processes under excessive pasture exploitation. The entire territory of Central Asia has significant anthropogenic pressure, including overgrazing, irrational use of water and land resources, cutting of trees and shrubs for fuelwood, mineral surveys and exploitation, roads and urban construction. All these, together with natural factors, lead to degradation of land.

The Mean Annual Precipitation (MAP) is variable within and between years, rendering range and rainfed crop productivity very erratic and uncertain, so agricultural management is risky. This inter-annual variability, expressed by the MAP coefficient of variation, is important in arid and semi-arid zones. In Uzbekistan, for example, the MAP coefficients of variation (CV) for the period 1980–1989, ranged between 27 percent and 34 percent in the low precipitation zone. It barely reaches 30 percent at the desert stations in the Kyzylkum that receives around 100 mm MAP, while areas with a similar rainfall in the northern Sahara exhibit a CV of 60–80 percent and above. It attains about 15–20 percent for the 200–600 mm MAP zone vs. 30–50 percent in the Mediterranean Basin, and 10 percent in the high rainfall regions receiving above 600 mm MAP vs. 20–25 percent in the Mediterranean Basin.

Pastures play a very important role in the economy of all the Central Asian countries. In addition to their direct function, pastures are also sources of fuel and medicinal plants, and serve as recreational sites. They ensure carbon absorption, playing a vitally important role in decreasing greenhouse gases. Vegetation degradation is the most widely distributed type of desertification in Central Asia. It results from overuse of pastures and cutting of trees and shrubs. At the same time in some areas of the region (Turkmenistan, Kazakhstan, Uzbekistan), due to overgrazing, formation of biogenic crusts consisting of mosses, lichens and cyanobacteria, is observed. This process can develop in the absence of grazing by domestic or wild animals and leads to degradation of native vegetation communities and disappearance of valuable palatable species. Vegetation degradation is a part of the integral process of desert ecosystem degradation in Central Asia under the impact of human activities. There is a connection between political and social factors and degradation of desert environments within a historical perspective. Fragile desert ecosystems suffer first of all from the loss of vegetation. Wildlife is reduced, productivity of desert rangelands fall and the people also suffer from a shortage of food. The after-effect of this process is catastrophic, not only for the desert itself but also for the people living in the desert.

The Global Environment Facility (GEF) is helping to address challenges in this region by investing in a multi-country partnership programme: the Central Asian Countries Initiative for Land Management (CACILM), in Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan. CACILM is a 10-year, multi-country, multi-donor programme promoting Sustainable land management (SLM) to restore, maintain and enhance productivity of drylands. The goal of CACILM is to combat land degradation while also improving rural livelihoods across the region.

The recommended ways forward to sustainably restore GCA grassland and pastures include: (i) evaluation of the current state of the native flora and the qualitative and quantitative condition of the vegetation cover of fragile rangelands for grazing and to further avoid their degradation; this is more than ever important during the delicate transition period to the market economy that the GCA countries are currently pursuing; and (ii) taking advantage of the agronomic and rangeland scientific expertise and know-how available in GCA, and using this without further delay, before experienced people retire or die.

Grassland and Pasture Management in Bhutan

Karma Phuntsho

Bhutan, is a small country in South Asia at the eastern end of the Himalayas. Bhutan's landscape ranges from subtropical foothills in the south to alpine Himalayan heights in the north. Its total area is almost 39 000 km² with 20 administrative districts and 205 sub-districts. Total population of the country was almost 760 000 in 2014. There are three distinct types of large-ruminant production systems in Bhutan. The transhumant yak system is limited to the alpine-cool temperate areas, and the migratory cattle system operates in the temperate to subtropical area. These two systems take advantage of the variations in climate and vegetation as herders migrate with their animals according to the season.

The third large-ruminant production system is the sedentary livestock rearing system in semi-urban and other rural settlement areas. Grassland ecological zones in Bhutan include alpine grasslands, cool temperate, warm temperate, moist subtropical, dry subtropical and open areas. Natural grasslands contribute about 30 percent towards national fodder requirement in Bhutan. Based on key species, grassland in Bhutan can be categorized as *Cymbopogon* grassland, *Schizachyrium* grassland, *Danthonia* grassland and *Kobresia/Carex* alpine meadows. The livestock-based grazing systems in Bhutan include yak-based alpine and sub-alpine to temperate, at altitudes from 5100 to 2700 masl. There are about 1400 households with 8500 people, to be found in 10 of 20 districts in this system. The cattle-based system ranges from temperate to sub-tropical and is often termed inter-district cattle migration. It is found in three districts: Bumthang, Haa and Paro. The number of animals involved in the inter-district migratory grazing system is estimated at around 50 000 head, owned by about 1400 households. Because of its topography and altitude, Bhutan has inherently limited resources of productive land. Moreover, the predominantly steep slopes make land degradation even more of a serious threat in Bhutan than in most places.

The major livestock include cattle, mithun, yak, zo-zomo, buffaloes, equines, sheep and goats. The cattle form the largest part of the ca. 302 500 domestic animal population of Bhutan. About three-quarters of households in Bhutan rear cattle for their livelihood. Grassland degradation prevails in Bhutan, as in other countries of the region. Overgrazing and climate change are among the major factor leading to grassland degradation. The high-altitude grasslands are grazed in autumn and spring, giving no opportunity for improvement, while temperate grasslands are grazed by yak and cattle, with high grazing pressure leading to their degradation. The same occurs with communal grazing lands, as communities do not take responsibility for grassland improvement. At the same time, the extent of grassland is contracting, for several reasons. The major drivers behind grassland reduction are land use change, include infrastructure development, power transmission lines, road construction, housing, hydropower plants and mining.

The formal policy initiative to regulate rangeland use and management in Bhutan dates from 1957. The Thrimzhung Chenmo¹ granted ownership of rangelands and grazing lands. The Land Act 1979 abrogated private and community ownership of rangelands and granted to them only the use rights; no management rights or responsibilities were assigned. The Land Act 2007 further nationalized the ownership of rangelands, promulgated buying back of the use rights and contracting the use rights only to those who depend on livestock for livelihoods. The Forest Acts 1969 and 1995 prohibit setting fire in forests and grassland, ban the traditional practice of burning rangelands and pasturelands, lopping of trees, and grazing in the degraded portion of the grassland, rangeland and forest ecosystem. Also cattle trespassing in the GRF for grazing is treated as an offence.

Currently, grazing and rangelands for which use rights are given account for only 13 percent of the total area of the country, and only 5205 households out of a total of 120 910 registered households have rangeland use rights. In other words, only 4.1 percent of all households have use rights and the rest practice de facto grazing in the forests or use grazing lands for which the State has granted use rights to communities, or a combination of these two practices apply. So equitable sharing of grazing resources is an important issue.

The draft Pasture Policy 1985 has been approved only for piloting, aimed at:

- improving the quality of fodder for improved breeds;
- stopping migratory systems by providing enough pasturelands locally;
- equitable distribution of pasture land among farmers;
- controlling degradation of pasturelands;
- nationalization and rationalization of pastureland use rights;
- improvement of grasslands and pastureland;
- introduction of progressive taxation on unproductive cattle; and
- promoting improved breed and pasture management.

To improve systematic conservation and restoration of grasslands, the following strategies should be implemented:

- harmonize forest and land legislation;
- make distribution of rangeland use rights rational and equitable;
- impose management responsibilities on the rangeland and pasture land use rights holder;
- promote scientific management of rangelands; and
- rationalize grazing and forestry land use.

¹ The Supreme Law of Bhutan.

Sustainable grassland management in China: status and prospects

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Grassland ecosystems cover 52.5 million km², accounting for 40.5 percent of the world land surface. The Eurasia Steppe is the largest contiguous biome of the world. The total grassland area in China is 4 million km², accounting for 41.6 percent of the total land area. The grasslands have various functions: they provide forage and food for livestock, wild animals, and birds; provide meat and milk for humans; they act in carbon sequestration, being a major carbon sink among terrestrial ecosystems; have ecological regulative functions such as water cycling, nutrient cycling and erosion control; and support habitat conservation and biodiversity maintenance, with 6,704 forage species.

Grassland Resources in China (million ha)

Geographically, about 80 percent of the grasslands in western China are in major grassland ecosystems, including temperate grassland in arid and semi-arid regions; alpine (mountain) grassland on QTP; warm grassland in warm temperate regions; tropical grassland in tropical regions; and lowland grassland in lowland and coastal regions. Total forage production is about 300 million t/yr, with large variations across grassland types, years and seasons. In 2014, total livestock numbered 423.38 million, which is four times that of 1950. Changes in livestock number were mainly driven by state policy and market factors. The most rapid increase occurred during the mid-1980s to 1990s. By 2006, the average rate of overload was 34 percent for natural grasslands. Some seasonal pastures were overloaded by 50 to 120 percent. Cattle, goat and sheep populations increased rapidly from the mid-1980s to 1990s; the number of cattle declined after 2000. Horse, donkey and mule (farming animals) numbers decreased after the mid-1990s; camel numbers remained unchanged. Although the livestock numbers and overload rate reduced in recent decades, beef and lamb production kept on increasing. The proportion of beef in total meat production increased in the 1980s, and then stabilized after the mid-1990s, influenced by state policy and market factors.

Grassland degradation is a major ecological problem in China, attributed to factors, such as human activities, climate change, policy and management, among others. Grassland degradation developed very quickly after the 1980s. In recent decades, 90 percent of the total national grassland is degraded to various degrees. Moderately and heavily degraded areas account for 43 percent. The drivers of degradation include human population, overgrazing, farming, mining, digging and drought, rats and insects. Rapid increase in demand for animal products increased livestock numbers, which has led to degradation of grassland due to overgrazing. Mining and digging for natural resources have also resulted in grassland degradation. Many studies have predicted that more frequent extreme precipitation and drought events will happen under global climate change, leading to decreased

grassland productivity. Destocking, rest grazing and rotational mowing practices are fundamental for restoring degraded grassland and augmenting productive and ecological functions.

The policy process in China has a long history. Before 1980, a feudalistic system and commune system were the norm and productivity was very low. From the 1980s, households received ownership of livestock; however, freely used common pastures by herdsmen has led to overuse of grassland. In order to use grassland properly, pastures were contracted to households in 1995.

Meantime, the government has introduced many policies and programmes to protect grassland ecosystems. Policies for conservation and restoration in China include fees for grassland protection in Inner Mongolia (75–450 ¥/km²/year, 1980) and Sichuan (75–300 ¥/km²/year, 1995). Overloading fines were imposed at 10 ¥/sheep-unit in 2000. Government has also established many grassland restoration projects including “Beijing-Tianjin sandstorm source control” project and “Natural grasslands protection” project. These projects include no grazing, rest grazing and rotational grazing. In 2011, the government introduced “Grassland ecological protection reward-compensation mechanism”. For not grazing pasture, herdsman can get 9000 ¥/km²/yr. For not overloading pasture, they can get 2250 ¥/km²/yr. For planting high-quality forages, they can get 15 000 ¥/km²/yr. As a result of increasing financial investment from government, levels of livestock overloading have decreased since 2005. By 2014, the average overloading rate had fallen to 15.2 percent.

In future, the restoration of grassland for their sustainable management in China will require:

- decreasing stocking rates, rest grazing and rotational mowing practices, as they are fundamental for restoring degraded grassland and optimizing productive and ecological functions;
- promoting legislative processes to protect the basic pastureland and strengthen investigation and punishment of illegal actions;
- improving the subsidy and incentive systems for grassland protection and establish strict supervision mechanisms;
- innovating pastureland contract systems and grassland management practices (household association);
- developing modern animal husbandry, strengthening the guidance and training of herdsmen and continually increasing productivity; and
- adapting grassland management to local conditions, according to local climatic condition, biodiversity, social and economic development, as well as different cultures.

Indian grasslands

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India has geographical area of 3 287 263 km² of which land is 3 090 846 km². The grassland area in India consists of 80.51 million ha (535 441 km²; 17.32 percent) and the forest area is 768 436 km². With only 2 percent of the world's geographical area, India supports 20 percent of the world's livestock, with 16 percent of cattle and 55 percent of the world buffalo population, and the world's second largest goat (20 percent) and fourth largest sheep (5 percent) populations. The share of forages in cultivated land has remained <5 percent in the country for many years. The fodder resource from grasslands is also quite small due to denuded grazing lands owing to heavy grazing pressure. Indian grazing lands have a grazing pressure of 3.42 Animal grazing units/hectare.

The Indian sub-continent presents a wide spectrum of eco-climates, ranging from humid tropical to semi-arid, temperate and alpine. Five hundred and fifty tribal communities of 227 ethnic groups are spread over ca 5000 forested villages. Agro-bio-diversity in India is distributed in eight very diverse phytogeographical and 15 agroecological regions.

India is reported to have five types of grass cover, *i.e.* *Sehima-Dichanthium*; *Dichanthium-Cenchrus-Lasiurus*; *Phragmites-Saccharum-Imperata*; *Themeda-Arundinella*; and Temperate Alpine. These naturally maintained grasslands are beautiful examples of conserving large number of genera represented by various species and genotypes. However, most grasslands in arid and semi-arid regions of the country are considered poor, with productivity ranging from 0.5 to 1.0 t/ha. The species composition and the areas dominated by different types of grasslands are:

- *Sehima -Dicanthium* type: Found throughout Peninsular India, including the central Indian Plateau and Aravali ranges, and the coastal region. Dominant grasses are *Dichanthium annulatum*, *Sehima nervosam*, *Chrysopogon fulvus*, *Heteropogon contortus*, *Iseilema laxum*, *Themeda* spp., *Bothriochola pertusa*, and *Cynodon dactylon*.
- *Dicanthium-Cenchrus-Lasiurus* type: Sub-tropical and semi-arid regions in the states of Gujarat, Rajasthan except–Aravali ranges, western UttarPradesh, Delhi, Punjab and Haryana. Dominant grass species are *Cenchrus ciliaris*, *Cenchrus setigerus*, *Dichanthium annulatum*, *Cynodon dactylon* and *Lasiurus* spp.
- *Phragmites–Saccharum-Imperata* type: Spread over the Gangetic plain (Uttar Pradesh, Haryana, Bihar and West Bengal states) and Brahamaputra valley in north eastern states.
- *Themeda-Arundinella* type: Entire sub-mountain tract of northern-western parts (Uttar Pradesh, Punjab, Himachal Pradesh, Jammu and Kashmir and Haryana states). Principal species are *Themeda* spp., *Anathera* spp., *Arundinella benghalensis*, *Chrysopogon* spp., *Cynodon dactylon* and *Heteropogon contortus*.
- Temperate Alpine Type: High hills of Uttarakhand, Jammu and Kashmor, Himachal Pradesh, North Bengal and north eastern region (above 2000 msasl).

Indian Grasslands are very rich in biodiversity and are centres of origin for many crops, with wide plant diversity. This diversity includes about 141 genera belonging to 47 families of higher plants that are endemic. Approximately 1256 species of Gramineae in 245 genera are found in Indian grasslands, and, of these, about 21 genera and 139 species are endemic. These grasslands are maintained and conserved by 550 tribal communities of 227 ethnic groups, and are in fact sources of subsistence for these communities. About 50 wild relatives of grass crops in the southwestern Ghat region are documented, which is a habitat for several endangered species. Additionally, Kerala state, the land of backwaters, also has a rich diversity in its wetland ecosystems. High species diversity and endemism among grasses in the form of 230 species of 22 genera are inhabited. Important genera conserved in the region are *Aeluropus*, *Echinochloa*, *Elytrophorus*, *Hygroryza*, *Hymenachne*, *Leersia*, *Leptochloa*, *Phragmitis*, *Pseudoraphis*, *Sacciolepis*, *Acroceras*, *Spinifex*, among others. The Ashoka Trust for Research in Ecology and the Environment (ATREE) and the Critical Ecosystem Partnership Fund (CEPF) are working for biodiversity conservation in the western Ghats. In five conservation and community reserves covering more than 80 000 ha a number of endangered and critically endangered species of mammals, birds, fishes and plants are being protected.

Some of the grasslands in India have a long history with great ethnic value, including the Terai-Duar Savanna and Grasslands (ecoregion at the base of the Himalayas, about 25 km wide contiguous with the Gangetic Plain. Characteristic species include *Saccharum spontaneum*, *S. benghalensis*, *Phragmitis kharka*, *Arundo donax*, *Narenga porphyracoma*, *Themeda villosa*, *T. arundinacea*, and *Erianthus ravennae*, and shorter species such as *Imperata cylindrica*, *Andropogon* spp. and *Aristida ascensionis*). The Banni Grasslands (maintained by Kutch pastoralists and spread over some 2400 km²); and Kangayam grassland (sustainably managed for >150 years, primarily *Cenchrus* sp., in association with 8 perennial, 6 annual grass species, 9 legumes and 16 forbs).

For increasing fodder availability, forests are also being looked at as a resource because forests and forest fringe area are important grazing lands. However, there is need to focus on decentralized forest management for profitable economic returns for communities because most have long traditions of forest use and a sense of customary rights. While formulating policies for common property land resources (CPLRs), points to be considered include diversity for types of CPLRs, spatial distribution and changes over time due to physical degradation, conversion of CPLRs and declining local interest. By one estimate, even if 75 percent area under *Sehima-Dichanthium* cover is improved in terms of a productivity increase from the present 0.65 t/ha to 1.75 t/ha, the fodder availability is likely to increase from the current 83 million ton to 224 million ton. Other means of increasing forage resources include popularizing alternative systems such as those based on horti/silvi/agro-forestry systems.

The potential of some systems has been reported to be:

- Silvi-pastoral System: important for increasing fodder production from marginal, sub-marginal and other wastelands (comprises 50 percent of land area). Production can be increased to 5–7 t/ha of green fodder against only 2–4 t/ha without a tree component.
- Agri-horti-silvicultural system: fruit trees + fodder crops + fast growing nitrogen fixers. Tree lopping fodder (2.5–3.0 t/ha) and fuelwood (1.8–2.5 t/ha).
- Horti-pastoral system: Horti-pasture up to an elevation of 2000 metres above sea level is becoming common, e.g. introduction of fescue in apple orchards gave 83.50 percent higher fodder yield over local grasses in Himachal Pradesh.

Indian grasslands are facing major threats that lead to their degradation:

- conversion to agriculture (or urban areas);
- habitats being marginal for plant growth hence vulnerable to climate change;
- invasive species;
- competition for light, water, nutrients;
- annuals vs perennials; and
- excessive grazing pressure.

Thus, there is an urgent need to revegetate these vast grasslands. However, several factors constrain grassland restoration. The most important constraint is availability of funds. These grasslands are huge areas, mostly considered a common property resource. Hence, funds need to be allocated by Government, but with local people's participation. Respecting socio-cultural values and people's participation, in both planning and implementation, for such schemes is also of great importance. The environment has to be created in such a way that the communities feel responsible for restoration of these grasslands. Even if there is a plan or scheme for restoration of these grasslands, the availability of the large quantity of seed of range grasses and legumes is likely to prevent implementation because of non-availability of seeds. To overcome the seed-related issues, research initiatives have been taken in India and some technologies have been developed such as *in vitro* maturation of grass seeds and their de-fluffing.

Hence, to restore the grasslands in India following actions are proposed:

- mission mode projects to revegetate the denuded grazing land;
- community participation;
- Obtaining the support of international agencies (FAO and other UN Organizations) considering these as global resources;;
- most tropical grasses are C₄ types or intermediate – hence a better source for carbon sequestration; and
- promotion and adoption of horti-agro-silvo-pastoral systems.

In this context, some of the recommendations of 23rd International Grassland Congress held in New Delhi, India in November 2015 are quite relevant:

- savanna and traditional grasslands have great cultural significance and are sources of subsistence to millions, and should be conserved;
- establish a Grassland Authority of India;
- generate real-time remote sensing data on biomass availability;
- promote market oriented business plans for grassland management, involving community participation; and
- use rural assessment of goals, skills, resources, climate change and socio-cultural modifiers.

Current status of livestock production, grasslands and grassland management policies in Japan

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Livestock production

Agricultural production in Japan is valued at JPY 9.07 trillion, and in 2012 agriculture accounted for 0.9 percent (JPY 4.36 trillion) of gross domestic product (MAFF, 2015a). Livestock farming was 31 percent (JPY 2.82 trillion) of agricultural production, comprising: dairy 29 percent; beef cattle 15 percent; pigs 10 percent; broilers 18 percent; and eggs 26 percent.

The number of farms has decreased significantly over the past several decades (Table 1). However, at the same time, changes in the number of livestock have been relatively small. In 2014, the number of farms rearing dairy decreased to 18 600 (29 percent of the number in 1990) and beef cattle to 57 500 (25 percent of 1990 numbers). The number peaked in 1994 at 2.02 million dairy and 2.97 million beef cattle, but by 2014 these had fallen to 1.40 million dairy cattle (69 percent of the 1994 peak value) and 2.57 million (87 percent) head of beef. As a result, by 2014, the average numbers of dairy and beef cattle per farm household steadily increased to 75.0 milch and 44.6 beef, indicating an increase in farm size.

Table 1 Changes in the number of households raising livestock and the livestock number per farm household (MAFF, 2015a)

	Livestock farms				Livestock number per farm			
	1990	2000	2010 [†]	2014	1990	2000	2010 [†]	2014
Dairy cattle	63 300	33 600	21 900	18 600	32.5	52.5	67.8	75.0
Beef cattle	232 200	116 500	74 400	57 500	11.6	24.2	38.9	44.6
Pigs	43 400	11 700	6 890	5 270	272.3	838.1	1436.7	1 809.7
Broilers ×10 ³	5 529	3 082	2 392	2 380	27.2	35.2	44.8	57.0
Layers ×10 ³	87 200	5 330	3 220	2 640	2.1	35.2	56.2	66.2

NOTES: [†]Pigs, broilers and layers: 2009 values.

In Japan, agricultural production is based on small farm units (less than 15 percent of total land area), with a majority of the area used for rice production. Consequently, the Japanese livestock industry depends on an enormous quantity of imported feed. The feed self-sufficiency rate in Japan is quite low, 26 percent in 2013 (roughage 77 percent and concentrate feed 12 percent), and has remained steady for more than 25 years (MAFF, 2015a).

Grassland area

The Japanese islands stretch over 3 500 km from north to south and have a varied climate, from subarctic to subtropical. Since the climate is generally temperate and humid, with the mean annual temperature about 5–25°C and the mean annual precipitation about 1 000–4 500 mm, the vegetation in Japan shifts toward forest as a climax community, except in the coldest areas. To maintain vegetation as grasslands, some management is therefore necessary.

Grasslands in Japan are roughly classified into either native grasslands or cultivated pasturelands (sown grasslands). Native grasslands include natural grasslands and semi-natural grasslands. Natural grasslands are found mostly in high altitude mountainous areas above the tree line and cover less than 1 percent of Japan's land area (Matsuura, Sasaki and Kohyama. 2012). Semi-natural grasslands occur mainly in hilly areas and are maintained by extensive management practices, such as cutting, grazing or burning. Cultivated pasturelands, where non-native grasses are grown, are subject to intensive management, such as fertilization with chemical fertilizers or manure, regular re-seeding and weed control.

Native grasslands were 1.21 million ha in 1960, decreasing to 405 000 ha by 1990, alongside the mechanization and modernization of agriculture (Figure 1). Some areas were converted to cultivated pasturelands to increase forage production, while other areas were abandoned, coinciding with the decline in the need for draft animals fed native grasses with relatively low nutritive values. The extent of cultivated pasturelands increased after the 1960s to reach 661 000 ha in 1994. Since native grasslands and cultivated pasturelands gradually fell to 384 000 ha in 2010, and then increased to 613 000 ha in 2012. Recent decreases are linked to fewer livestock farms or less public or cooperative pastures (see later), both a result of socio-economic changes.

The area of Japanese grasslands (both native and cultivated of ca 1 million ha (Figure 1), is not sufficient to fully support the domestic cattle herd (ca 4 million dairy and beef), as indicated by the low feed self-sufficiency rate. The proportion of cattle raised on grasslands averages 9 percent countrywide (MAFF, 2015a). Regionally, the proportion is highest in Hokkaido (20 percent), followed by Tohoku, Okinawa and Chugoku districts (4–5 percent each).

Many public or cooperative pastures, which were developed in the 1960s to 1970s, are operated across the country by local governments, agricultural cooperatives, etc. Farmers contract out cattle feeding to the operators to save on labour and other costs. Public or cooperative pastures account for 13 percent of grassland areas in Japan, and they also have an important role in producing and supplying domestic feed.

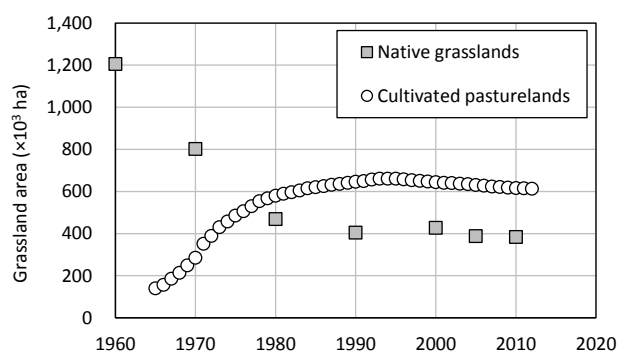


FIGURE 1. CHANGES IN GRASSLAND AREA (MAFF, 2012a, b).

Grassland degradation

Unlike Mongolia and Australia, land degradation arising from overgrazing rarely occurs in native Japanese grasslands, because of the vigorous re-growth under abundant rainfall and the controlled stocking density that avoids overuse. In contrast, public or cooperative pastures developed on native grasslands have been increasingly underused, due mainly to changes in socio-economic conditions. This has led to a decrease in grazing capacity and extinction of various grassland-dependent indigenous flora and fauna through succession of grasslands to forests. For example, lack of livestock grazing decreased plant species diversity due to dominance of competitive species (Yoshihara *et al.*, 2014). Since forest is the major climax community in most of Japan, grazing lands cannot be maintained as grassland without major periodic management interventions, such as cutting, grazing or burning.

In cultivated pasturelands, weeds, which lead to grass production decline, are the major grassland degradation problem. Weeds tend to invade cultivated pasturelands following summer depression. In areas where the mean annual temperature exceeds 12°C (from Kanto district south), temperate grasses are generally short-lived (≤ 5 years), due to high temperature and drought in mid-summer. Weeds invade the gaps created by grass die-off and gradually spread. Since vegetation is less stable in cultivated pasturelands than in native grasslands, intensive management of grass species composition, fertilization, cutting and grazing schedules, and grazing intensity are recommended to maintain grassland productivity. Recently, summer depression areas of temperate grasses are expanding due to frequent heat waves. Use of cultivars and species with greater heat tolerance, or a shorter re-seeding cycle (3–4 year cycle) or grassland renovation (cultivation), are recommended as countermeasures against this problem. However, these alternative measures have drawbacks, such as poor acceptability as animal forage, low cold-tolerance or high cost. Effective measures must be found to counter the losses of temperate grasses linked to more frequent heat waves. The situation is especially serious in hilly pasturelands, where intensive managements (fertilization, weed control and renovation) are difficult, and some of these pasturelands are abandoned or degraded. For example, in public or cooperative pastures, both productivity and forage nutritive values decreased significantly after pasture abandonment. This is due to loss of soil nitrate-nitrogen content, likely due to leaching and the replacement of sown grasses by native species (Furusawa, Yoshihara and Sato, 2013). Other problems in cultivated pasturelands are soil erosion, soil compaction caused by grazing animals or equipment passage, and soil acidification caused by chemical fertilizer application. In fact, these are common problems in cultivated pastureland worldwide. Countermeasures for these problems include grassland renovation and balanced fertilization.

Policies and programmes

“The Basic Policy for Modernizing Dairy and Beef Cattle Production” was established in 2015. The policy goals are to improve livestock farming profitability, promote domestic feed production and utilization (increasing the feed self-sufficiency rate) and expand exports of livestock products. As part of these efforts, improvement of pasturelands and grazing in abandoned farmlands are promoted. Government subsidies for weed control in grasslands, the improvement of grassland productivity and the enhancement of domestic feed production (including the promotion of grazing) were introduced in 2015.

“Good Management Practices for Grasslands” have been compiled into a series of six books commissioned by MAFF and published in 1981. Guidance is provided for management and utilization of grasslands/pasturelands for promoting livestock farming based on domestic feed production. The documents were written and reviewed by national experts.

“Direct Payment to Farmers in Hilly and Mountainous Areas” was introduced in 2000 to stem the increasing land abandonment and to maintain agricultural production in less-favoured rural areas. The payment is made on a per hectare basis (including native grasslands and cultivated pasturelands) to groups of farmers whose farming techniques bring diverse benefits, such as preventing soil erosion, preserving biodiversity or promoting recreational activities.

Pastureland management contributing to carbon sequestration

The Japanese livestock industry, which is dependent on an enormous quantity of imported feed, faces environmental problems associated with inappropriate handling of livestock excreta. Accordingly, the Japanese government urges livestock farmers to properly treat or make effective use of livestock excreta based on the “Act on the Appropriate Treatment and Promotion of Utilization of Livestock Manure” enacted in 1999. This is achieved by composting manure with amendments such as sawdust or straw, and then applying it to farmlands appropriately. Application of livestock manure on grasslands should increase carbon sequestration. Changes in soil organic carbon content or ecosystem carbon balance associated with livestock manure application have been investigated at several grassland sites across Japan. Soil carbon monitoring revealed that soil organic carbon concentration of the surface layer (0–5 cm) tended to increase with increasing latitude and the amount of manure applied (Matsuura *et al.*, 2013). According to carbon dioxide flux measurements with the eddy covariance technique, grassland plots without manure application lost carbon whereas manured plots accumulated carbon (Hirata *et al.*, 2013). These results indicate that appropriate livestock manure application can increase carbon in grassland ecosystems and is a recommended practice for sustainable grassland management.

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The Present Situation of Grassland for Sustainable Agriculture in South Korea

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The history of grassland research

Historically, improved pastures were not present in Korea until 1900s. In 1906, grassland research was initiated by introducing improved grasses in Kwonupmobeomjang and yield evaluations were conducted in early 1910s. In early periods, the studies were conducted mainly on native grasses, including *Dystaeniatakeshimana*, *Miscanthussacchariflorus*, *Phragmitescommunis*, etc. Pasture establishment research was conducted mainly in the 1960s. The law for grassland was established in 1969 and research on the seeding methods, cutting management (frequency, height, interval, etc.) were conducted in the 1970s. In order to initiate new farming systems based on forage crop-cattle industries, the governments of Korea and Germany agreed on a bilateral “Grassland Research Project”. The joint research project between Korea and Germany was started in 1973. The Korean-German Grassland Research Project (KGGRP) conducted a systematic study of grassland and is thought to be a renaissance period for grassland research. This project lasted until 1993.

In the 1970s, researchers of the Livestock Experimental Station, Rural Development Administration (RDA), started breeding programmes for orchardgrass. The breeding programme soon resulted in release of a synthetic variety, cv. *Hapseong 2 ho*. Studies on fertilizer management, topography improvement and selection of seed mixture were promoted in the 1980s and grazing trials were conducted to reflect increasing labour costs in rural areas. In the 1990s, research on application of animal manure was carried out and research trials related to organic pasture establishment and utilization were conducted in the 2000s. Since the 2000s, grassland research has gradually lessened while forage crop studies have received more attention.

Current status of grasslands

The grassland area has shrunk from 11 942 ha in 1967 to 4 419 ha at last census. New establishments of grassland areas were about 500 ha/year in the 1990s, but after the 2000s fell to less than 100 ha/yr. Arable land for forage has gradually decreased from 271 000 ha in 1990. Recently, forage production areas are being increased in paddy fields. The cultivated forage areas and cow numbers in Korea are presented in Tables 1 and 2.

Table 1. Cultivated forage areas in South Korea ($\times 10^3$ ha)

	1980	1985	1990	1995	2000	2005	2010	2012	2013	2014
Grassland	48	81	90	66	52	44	39	38	39	38
Upland	40	79	138	140	26	27	45	43	49	45
Paddy field	38	86	43	24	47	70	160	187	210	214
Total	126	246	271	230	125	141	244	268	298	297

Table 2. Mature cattle herd in South Korea ($\times 10^3$ head)

	1990	2000	2005	2010	2013	2014
Beef cattle	1 622	1 590	1 819	2 922	2 918	2 759
Dairy cattle	504	544	479	430	424	430
Total	2 126	2 134	2 294	3 352	3 342	3 189

Grassland establishment project

After the Korean War, a grassland establishment project was promoted using foreign aid and managed well by a public agency (National Agricultural Cooperative Federation, Hanwoo Experimental Station, Animal Genetic Resource Station). However the established grassland failed in the 1980s and 2000s owing to mismanagement. In 1989, the government had promoted establishment of large-scale demonstration grasslands in Yeosu province. The project was led by the RDA Livestock Experimental Station, but conflict among the farms stopped animal grazing, and the grassland had reverted to forest by 1993.

In 2000, there were massive fires throughout Samcheok in Kangwon Province. Some grassland was established in damaged districts, about 5 ha for possible application of grassland for recovering vegetation and preventing soil erosion. The grassland establishment succeeded in this region but over-grazing by deer caused deterioration.

Grassland policies

By 2013, South Korea's grassland-support policies were based on balancing distribution to remove dissatisfaction among regions. As a result, most of grassland areas are less than 1 to 5 ha (70.6 percent), while areas of >10 ha of grassland form a mere 12.4 percent of total area.

Table 5. Distribution of grassland areas and holdings by size group

Item	Total	1–5 ha	5–10 ha	10–50 ha	50–100 ha	>100 ha
Area (ha)	53 783	10 721	8 245	14 432	5 398	14 987
Proportion of total area in each size group	100	19.9	15.3	26.8	10.0	27.9
Number of holdings	7 154	5 053	1 206	761	82	52
Proportion of total holding in each size group	100	70.6	16.9	10.6	1.1	0.7

SOURCE: MAFRA, 2000

The government supports the cost of grassland establishment and infrastructure. The grassland establishment cost is differs between intensive sowing and surface sowing methods. Grants may cover renewal of established grassland. The infrastructure cost includes water, electricity, road and fencing, etc. From 2014, government plans to encourage sustainable agriculture in hilly pasture and to extend support to grassland areas.

Development plans in future

Hill-based livestock projects being currently proposed by government are is a new approach to sustainable livestock husbandry, respecting the environment and farm income at same time. The new paradigm emphasizes the importance of sustainable livestock production based on hill pasture, and it will expand the use of hill pasture. Initially it needs greater acceptance, and technical assistance for improving hill pastures.

Development of new cultivars

Korea's climate has four distinct seasons. Due to the high temperature and heavy rain in summer, cool season grasses do not grow well. Hence a need to develop suitable new cultivars. Fortunately, a new plant breeding project has started in the RDA National Institute of Animal Science, and new varieties are being released.

Table 6. Dry matter yield of new developed domestic cultivars in regional productivity trials (kg/ha).

Trial location		Cheonan	Pyeongchang	Jinju	Jeju
Orchardgrass	cv. Amba	9 586	12 452	10 440	17 612
	cv. Onnuri	12 109	13 463	14 197	19 330
Tall fescue	cv. Fawn	12 001	12 947	24 518	19 543
	cv.	13 784	15 284	26 740	20 817
	Greenmaster				

NOTES: Orchard grass was tested in Jinju from 2009 to 2011. Tall fescue was tested in Iksan from 2005 to 2007.

Tall fescue has improved forage quality and productivity; orchard grass has good disaster tolerance; and cold-tolerant Italian ryegrass has replaced imported forage species (Choi *et al.*, 2010; Ji *et al.*, 2013). However, development of new cultivars should be accelerated and extended to additional species. In addition, climate change implies a need to introduce warm season grasses through selection from local material. If tests show adequate cold tolerance, the utilization of warm season grasses in the southern region will be expanded.

Conclusion

The grassland area peaked in 1990, at 90 000 ha and now continues to shrink. Fortunately, government has introduced various policies related to sustainable livestock using hill pastures. To invigorate sustainable grassland agriculture, they also promote several policies that provide a basis for profit creation, lifting restrictions on grassland establishment, strengthening consulting and public-relations for hilly pasture. The new paradigm emphasizes the importance of sustainable livestock production based on hill pasture and it will expand use of hill pasture. As a first step, it needs greater appreciation and the activity needs new models for sustainable farming based on hill pasture grazing that is profit generating. It is necessary to develop the new cultivars suitable for Korea's ecosystems. We have to become aware of forage production and the plural functions of grassland and move to co-existence within agriculture value chains. Also it need the extension service to meet on-farm needs and development of profit-creation models. Farmers must have a positive attitude that they can make a profit from sustainable grassland management in the future.

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Rangeland degradation and new approaches to conservation in Mongolia

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Mongolia is a landlocked country in east-central Asia. It is bordered by Russia to the north and China to the south, east and west. While they do not share a border, Mongolia is separated from Kazakhstan by less than 40 km. The country has 3 million people with a density of 1.7/km². Total number of livestock is about 52 million. Livestock husbandry accounts for 14 percent of GDP, 81 percent of the total agricultural GDP, engages 28 percent of the employed workforce and contributes 7.4 percent of export income of the country. In addition it is one of the bases of Mongolian traditional nomadic culture and civilization. The major grasslands include high mountains, steppe zone, lowlands and desert ranges. About 72 percent (112.8 million ha) of the territory is pasture land, and 70 percent of pastureland is degraded. Drivers of pasture degradation are natural factors, human induced, rodent infestation and urbanization and infrastructure development. The degradation phenomenon has adversely affected biodiversity as the number of plant species has halved in the forest steppe. Pasture yield halved in forest steppe and steppe, and by 30-35 percent in desert region.

Pastureland degradation in Mongolia has had major negative consequences:

- decreased economy and livestock production;
- increased unemployment, poverty, crime, theft; and
- ecological degradation and desertification.

Traditional nomadic herding approaches are still set deeply in the minds and daily practices of herders. Herders have indigenous knowledge and skills for livestock and rangeland management. It is difficult to change all these traditional and customary norm and indigenous knowledge and skills. Local animal breeds are more adapted to the harsh condition over the long term. It is hard or impossible to change that without solid evidence or demonstration. Protection and fencing of allocated pasture land costs are very high for herders and also for the government.

The first concept is a top-down approach based on government organizations because pasture land is owned by the State. The owner is the manager of pastureland. Herders are only users. This concept was reflected in existing Land Law, other legislation and resolutions. But policy and decisions have been poorly implemented for the last 20 years. Were implementation better, we would have much less degradation of pasture in Mongolia. It is impossible to implement this policy at a grassroots level in face of actual herding practices. One reason is that it is difficult to realize all these centrally in a situation of a sparsely distributed pastoral herding system.

The advantage of the herder groups is that a few members of a group are able to jointly operate and coordinate their activities for short periods (easy to communicate with each other, and to share labour).

They can earn more income and receive benefit. The main weakness of the Herder group system is that pasture land is fragmented and distributed to a small group, which leads to loss of the flexibility of traditional nomadic herding practice, deterioration of resilience and adaptation of pastures, making them unsuitable for pasture rehabilitation. They are not interested in protecting and improving the pasture land. The herders' interests and practices get more income in the short time. It leads to pasture degradation. So effective mechanisms should be devised and implemented.

Present status of grassland in Nepal, and future prospects

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Extent of rangeland and status

Nepal's total rangelands are estimated to cover about 1.75 million ha, or nearly 12 percent of Nepal's total land area. The key sources of rangeland in Nepal are primarily the high mountains and high Himal areas, which form about 80 percent of Nepal's total rangeland.

Table 1. Distribution of rangelands in Nepal (km²)

Physiographic Region	Total Land Area		Rangeland		
	ha ×10 ⁶	%	ha ×10 ³	% of Total Land	% Rangeland
Tarai	2.1	14.4	49.7	0.3	2.9
Siwaliks	1.9	12.7	20.6	0.1	1.2
Middle Mountains	4.4	29.5	292.8	2.0	17.2
High Mountains	2.9	19.7	507.1	3.4	29.8
High Himal	3.5	23.7	831.5	5.6	48.9
TOTAL	14.8	100.0	1701.7	11.4	100

SOURCE: Kenting Earth Sciences Ltd. 1986

Rangeland ecosystems in Nepal comprise grasslands, pastures and shrublands that cover about 1.7 million hectares, or nearly 12 percent of the country's land area. About 80 percent of the rangelands are located in the High Mountains and High Himal areas; 17 percent in Middle Mountains; and the remainder in the *Siwalik* and *Tarai* (Kenting Earth Sciences Ltd., 1986) The country's rangeland ecosystems can be broadly grouped into five categories: (i) tropical savannas; (ii) subtropical rangelands; (iii) temperate rangelands; (iv) subalpine rangelands; and (v) alpine meadows.

Rangeland degradation and causes

"Kharka" is the common term used by the herders of eastern and middle Nepal, whereas in Western and Far eastern region they call it "Patan". When the capacity to hold the animals in a given area reduces they consider it degraded. Factors underlying the causes of degradation are rather complex, with some a threat to the overall biodiversity, including rangeland.

They include a mix of social, political, economic, technical and cultural factors operating at various spatial levels (GoN, 2012).

- Demographic: Increasing population over the decade increased extreme pressure on the natural resources, including forest and rangeland.
- Poverty and Other Economic Factors: Widespread poverty, combined with a lack of or very limited alternative livelihood opportunities and a general underdevelopment situation, has led to high dependency on natural resources – forests, wetlands and rangelands – thereby increasing pressure on those resources.
- Poor Governance: Weak enforcement of the law and regulatory mechanisms is considered to be one of the major underlying factors behind deforestation and forest degradation.
- Unclear Administrative Jurisdictions: Unclear responsibilities and overlapping jurisdictions between the Department of Forests and Department of Livestock Services have negatively affected management of rangelands outside protected areas. Conflict between traditional tenure systems (e.g. *kipat* system in the eastern mountains) and contemporary forestry legislation has undermined enforcement of forest law in some areas.
- Other Factors: The civil strife in the country during 1996–2006 had an unseen impact in the rangelands of mountain. The rebels stayed much of their time in the forests and their war training took place in the rangelands.
- Environmental change: Climate change is a threat in the longer term.

Method of rangeland measurement

Nepal applies the World Overview of Conservation Approach and Technologies (WOCAT) in assessing the degradation area of rangelands.

Number of pastoralists and the number of livestock (by species) kept by them

The latest official publication of Department of Livestock of the Ministry of Agriculture and Cooperative reports.

Livestock Population, 2011/12

SN	Species	No. (Million)	% of HH keeping Species
1	Cattle	72	~ 60
2	Buffalo	50	~ 50
3	Yak and crosses	0.06	~ 1.4
4	Sheep	0.8	~0.3
5	Goats	9.0	~ 75
6	Pigs	1.0	~7
7	Poultry	40	~34
8	Horse/Mules	0.01	

(Source: MoAC, 2011)

Agriculture is the major contributor to GDP ((65.6 percent in 2001), and most households keep livestock for subsistence purposes.

Drivers of rangeland land use change and degradation

Most of Nepal's initiatives have been approached through forage research and development. In the early 1950s, cheese factories were established in central and eastern Nepal. A temperate cultivar evaluation–*cum*–forage production programme was launched in 1953, and an FAO implemented Pasture, Fodder and Livestock Development Project in Nuwakot and Rasuwa Districts in the late 1960s. Similarly, establishment of a Pasture and Fodder Development Farm at Rasuwa in 1971, and a Pasture Development Project at Khumaltar in 1978 strengthened rangeland improvement programmes. As external assistance continued until the 1980s, USAID's Resource Conservation and Utilization Projects (RCUP) and Swiss-funded forage improvement works in Dolakha and Sindhupalchowk (Basnyat, 1995) were implemented.

The political changes in Tibet (China) after 1959 disrupted centuries-old transhumance patterns. Since then, there were several negotiations on issues related to rangeland availability for both Nepali and Tibetan herds. In 1983, the two governments agreed that animal migration from both countries would be completely stopped by April 1988. Realizing the severe impacts of such closure, as well as shortage of fodder, Nepal initiated the Northern Areas Pasture Development Programme in 1985, focusing on range management and fodder development in four "critical" districts: Humla, Mustang, Sindhupalchowk and Dolakha; and six "emerging" forest and feed crisis districts: Manang, Dolpa, Gorkha, Mugu, Sankhuwasabha and Taplejung. Between 1987 and 1990, the High Altitude Pasture Development Project (1987–1990) provided extension support, while the Himalayan Pasture and Fodder Research Network (1987–1990) supported research. These two FAO/UNDP activities supported the government's district-level forage improvement programmes to ease the fodder crisis. To alleviate poverty and restore degraded hill slopes in 12 districts through access to credit, inputs and technological assistance to poor farmers, the Hills Leasehold Forestry and Forage Development Project (1992) was jointly implemented by the Department of Forest, Department of Agriculture, Nepal Agriculture Research Council and the Agriculture Development Bank of Nepal. Institutional interactive relationships between researcher, technicians and farmers, the public and private sectors are being developed (Yonzon, 1998).

The increasing human migration from Himal to mountain, and mountain to Tarai, has led to anthropogenic pressure in the tropics, and the rangelands in Tarai are under massive pressure. The Land Use Policy 2012 categorized rangelands as agricultural land and banned the conversion of agriculture land for other use. The act was still awaiting approval at the time of writing, and with the promulgation of new constitution it may take another 2 or 3 years for implementation in the federal structure. Grazing fees for the herds are decided by the herders at a local level. Normally, grazing blocks are divided among the herders either by time or space. In rangelands and meadows within the community forests, grazing blocks are delineated and allocated among the members of the community. If fees or subsidies are to be charged it is decided by the General Body Meeting (GBM), or provision is mentioned in the Management Plan. *Kipat* is one of the major issues for rangeland practices towards the eastern mountain. Mining, especially for construction materials, has also put pressure on the rangelands over the years. The devastating earthquake of April 2012 has left many

scars in the rangelands of Langtang National Park of Central Nepal, which may take several years to recover.

Stakeholders and players and how they interact

The major stakeholders and players related to the rangeland management and issues are the pastoralists and herders in the hills and mountains. Community Forest Managements are another stakeholder; they interact as per the decision of the AGM and the provisions mentioned in the management plan of the Community Forestry User Group (CFUG). *Kharka* Management Committee and *Kipatiya* (Owner or local leader managing *Kipat*) are other stakeholders. At government level, the Pasture and Fodder Research Division of Nepal Agriculture Research Council conducts research on areas such as;

- winter fodders specifically recommended for different agro-ecological regions, from the tropics to alpine.
- Using inoculum and summer fodder, terrace riser improvement, with hedgerow spp. in the mid hills,
- temperate species growing in the temperate region,
- growing grasses and fodders in degraded areas are other activities conducted by the division.

Similarly, under the disciplinary research programme, the cattle, goat and sheep research programmes of NARC are also indirectly linked with the rangeland issues. Regional offices of NARC looking after cattle, sheep and goat are the participating stakeholders at local level. District Livestock Offices and local service centres provide service to the local farmers on issues related to the nutrition status of the rangelands and fodders.

Policies, strategies and programmes related to rangelands use

The major policy instrument related to rangeland use is the Rangeland Policy 2012. So far, this is the comprehensive policy that addresses the concerns based upon which strategies and programmes are in the process of formulation. The first policy mentioned in the Rangeland Policy deals with "Productivity enhancement through the quality improvement of rangelands" and incorporates land tenure, including communal and private lands. The same policy covers the interest of pastoralists, farmers (associations, grazing groups), etc. Though not documented and managed by indigenous and cultural institutional mechanisms, practices differ by ecoregion and land type (rangelands within the community forests, *kipats*). There is provision for grazing within the buffer zone rangelands of some protected areas in Tarai and Hills. Community Forestry has provision for grazing within the forest rangelands as defined by the Management Plan. Transboundary movement of livestock in association with transhumance in the alpine region is facilitated at government level.

Policies, strategies and programmes related to rangeland conservation and restoration

Rangeland Policy 2012 has come into effect. It deals with needs and background to bring the policy, the classification of land types lying under rangeland category (grazing land, grass land, and shrubland), and past attempts made regarding rangelands and present status. The policy has mentioned the problems and threats and requirement of new policy to address those. With the defined vision, mission and objectives the policies are set to achieve the following:

- productivity enhancement through the quality improvement of rangelands;
- promotion and expansion of rangeland-based entrepreneurs; and
- facilitate to maintain the environmental balance through biodiversity conservation, promotion, and scientific sustainable use of rangeland resources.

A detailed action plan has been developed to implement the policy and institutional management has been designed.

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Country Paper on Rangelands of Pakistan

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The Country

Pakistan extends between the latitudes 24° to 37° North and longitudes 61° to 78° East. The climate is arid, with low rainfall, less humidity and high solar radiation over the larger part of the country (ICIMOD 2011).

Figure 1. Map of the rangeland resource of Pakistan as generated based on FAO (2013)

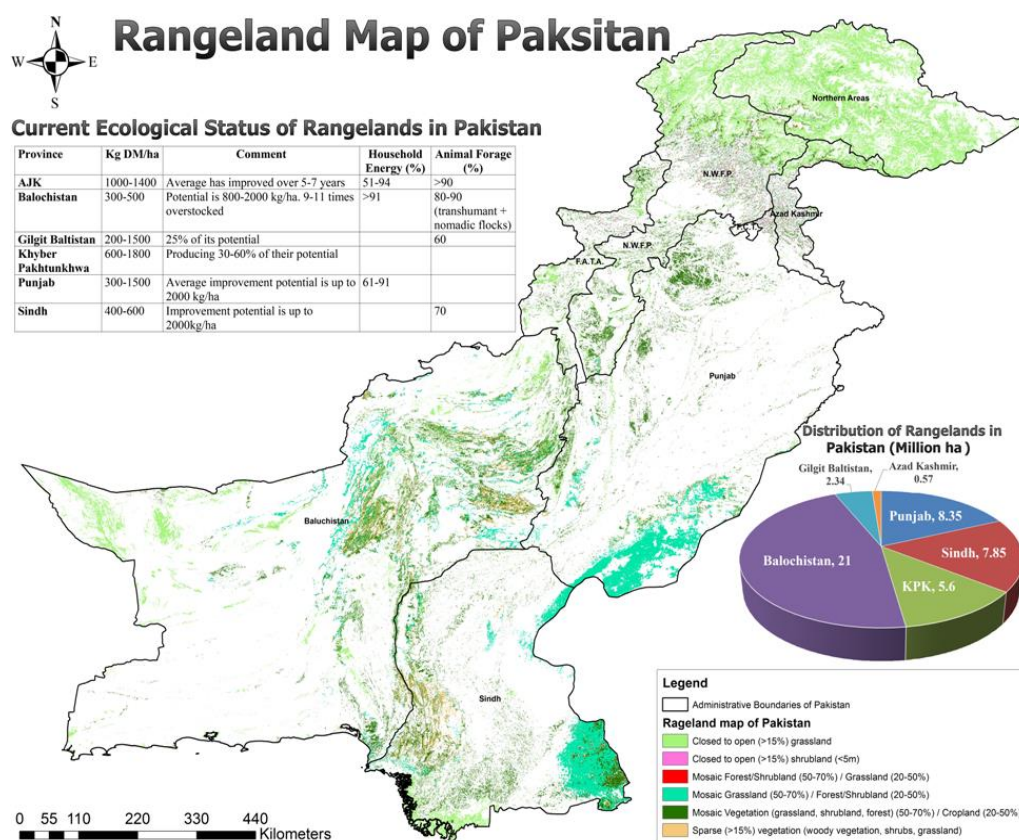


Figure 1 illustrates how 52 percent of Pakistan's rangelands are geographically spread over 88 million ha (453 776 km²) (Gilani *et al.*, 2013; ICIMOD, 2011) whereas Mohammad, (1989) estimated over 60 percent of total land (796 096 km²) as rangeland.

Table 1. Distribution of rangelands in Pakistan ($\times 10^6$ ha; FAO, 2013)

Unit	Total Area $\times 10^6$ ha	Rangeland $\times 10^6$ ha	Rangeland %
Punjab	20.63	8.35	40.48
Sindh	14.0	7.85	56.07
Khyber Pakhtunkhwa	10.12	5.6	55.34
Azad Kashmir	1.33	0.57	42.86
Gilgit-Baltistan	7.04	2.34	33.24
Balochistan	34.72	21.0	60.48
Total	87.98	45.71	51.95

Ecological trends and drivers of change

Unfortunately, there has been no systematic assessment, and therefore no reliable data on ecological health and change in plant species and communities on rangelands under various utilization scenarios. However, crude estimates of ecological trends over the rangelands are summarized in Table 2.

Table 2. Ecological trends for rangelands in various administrative units in Pakistan, based on FAO (2013)

Administrative Unit	Rangelands ($\times 10^6$ ha)	Average yield (kg DM/ha)	Comment	Household Energy (%)	Animal Forage (%)
AJK	0.57	1000–1400	Average has improved over 5–7 years	51–94	>90
Balochistan	21.0	300–500	Potential is 800–2000 kg/ha. 9–11 times overstocked	>91	80–90 (transhumant + nomadic flocks)
Gilgit-Baltistan	2.34	200–1500	25% of its potential		60
Punjab	8.35	300–1500	Average improvement potential is up to 2000 kg/ha	61–91	
Sindh	7.85	400–600	Improvement potential is up to 2000kg/ha		70
Khyber Pakhtunkhwa	5.6	600–1800	Producing 30–60% of their potential		

In general, deterioration in the condition of rangelands is a historical trend in Pakistan. Zafaruddin (1996) believed that 86 percent of rangelands in Pakistan were in poor and degraded condition, while 90 percent of high mountain pastures in Karakoram are severely degraded (Khan, 1996). Rangelands in Balochistan are overstocked by 10 to 11 times their carrying capacity. In addition, severe droughts (1998–2004) badly deteriorated this resource. In Pakistan, >35 million people were deriving 40 percent of total household incomes from livestock, and 2.5 million families directly depended on grazing their livestock on rangelands. It was further estimated that 70–79 percent of Pakistani households use fuel biomass from rangelands as a main source of energy (Arshad, 2013). Rangeland-based pastoralism remains a major ecosystem service in all Pakistan, with 150 000 Pastoral Households in Khyber Pakhtunkhwa and 310 000 in Sindh.

As a result, pastoralists – particularly in mountain areas – are very vulnerable, with:

- Poverty: 32 percent below poverty line and 39 percent reported outmigration (ICIMOD 2011)
- Food security: Over 90 percent of the pastoral households reported insufficient local food production (ICIMOD, 2011)
- Household energy: 42 percent depended on animal dung for household energy to meet per capita need of 22.7 GJ (ICIMOD, 2011)

Historically, rangelands of Pakistan were of secondary importance, not only at policy level but also at the community level, and it was believed that range resources warranted little input from research and development perspectives. It is important to understand why enabling rangeland policy becomes critical. Because most rangelands issues can only be addressed through enabling policies, ICIMOD is supporting the provincial governments to develop and pilot enabling provincial rangeland policies.

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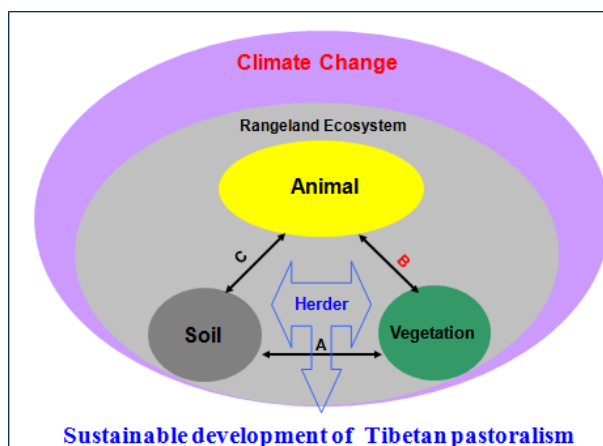
Transdisciplinary approaches to sustainable management of grassland ecosystems under global change: the case of Tibetan grasslands

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The Qinghai-Tibetan Plateau (QTP) with an average altitude >4000 masl, has an area of 2.5 million km² is sometimes called the Third Pole of the World. The plateau is a world heritage site for biodiversity, and the source for 9 major river systems in Asia. Over 51 percent is covered by rangelands and 1.3 billion people depend on 'the water tower'. Due to the high altitude and harsh environment, agricultural cultivation is not possible on most areas of the plateau. The only way the land can be used is for livestock grazing all the year round. Yak is the key and unique animal found in the QTP. Yak is a multipurpose animal for providing milk, meat, wool, transportation, essential nutrients, fuel, etc. to the nomads. Yak milk food plays a key role in maintaining nomadic herder health; yak herd size shows a herder's social status; and the yak is a key element in Tibetan culture. The 10th Banchan Lama said that if there were no yaks, there would be no Tibetan people.

The QTP faces a number of challenges threatening degradation of the grassland ecosystem of the area. Overgrazing and climate change are the major causes of alpine rangeland degradation leading to lower productivity of the grasslands. Poor productivity leads towards poor above-ground biomass and poor livestock health, and hence poor livelihood for the people. In addition, the natural ecosystem services cycle is disturbed and the water and nutrient losses result in the absence of perennial vegetation, and bare land appears. Improper implementation is also regarded as one of the key reasons for negative consequences for grassland health.



Transdisciplinary approaches to improve rangeland ecosystem can be a long-term viable management strategy. In general, biological approaches based on plants + animals are applied to reverse the grassland degradation phenomenon due to overgrazing and climate change, without integrating the social (herders) and livelihood (economic) disciplines. As a result it does not provide optimum output. At the International Centre for Tibetan Plateau Ecosystem Management (ICPTM), Lanzhou University, a team is working on various applications for grassland restoration, ecological sustainability and improved livelihood of the region. Sown pastures have been established using a participatory approach. Vegetables and fodder production is carried out in greenhouses, resulting in livelihood improvement as an alternative opportunity. The grassland population in the Qilian Mountain has been successfully controlled with the help of poultry instead of chemical sprays. The

intervention has not only reduced the annual cost of chemical spraying, the chickens can be culled and sold at a profit, contributing to the economic well-being of the herders. High quality chicken meat sells for US\$16–20 per bird in the market, so with small effort adds to other benefits of grassland productivity. The reduced use of chemical sprays mitigates adverse effects on plants, animals and even on human health. Consequently the land becomes more productive and proven livelihood opportunities become available to pastorals. It is pertinent to mention here that these ideas and motivation come from the herders, and are hence more output oriented.

The Tibetan rangeland ecosystem in the current scenario of climate change demands not only that the issues of animals, soils and plants be addressed for ecosystem sustainability, but there is also an urgent need to put herders in the centre of all these models and initiatives for sustainable development of pastoralism in the region.

Empowering Herders and Pastoralists: Sustainable Rangeland Management Conservation, Livelihoods & Governance

Irene Hoffmann, Oliver Mundy and Yon Fernández de Larrinoa

Pastoralists are livestock keepers around the globe. There are several hundred million pastoralists worldwide, including in China, India, Nepal, Pakistan, Afghanistan, Bhutan and elsewhere. They are the managers of the rangelands, shrub lands and forests that cover about one-third of the earth's land surface. Pastoralist livelihoods depend on rangelands and livestock. Pastoralism and agro-pastoralism are key production systems associated with livestock, and support 44 percent of global sheep, 29 percent of goats and 20 percent of cattle. These systems also provide 22 percent of global beef production, and 16 percent of milk. In addition, rangeland hosts a diversity of wildlife and plant genetics resources, whose products contribute to rural income and development. It is estimated that 0.6 Gt of CO₂ can be sequestered over 20 years by grasslands. Rangeland catchments can capture 50–80 percent more water than uncovered soils.

Although pastoralists have a rich legacy of traditional knowledge and cultural heritage, they also provide many benefits. They are facing many challenges that are common around the world among various pastoral communities. Disruption of pastoral migration routes due to political instability and other factors is a major challenge to pastoralism. They always have poor access to public health and education facilities, posing a big challenge to pastoralists for their survival. Pastoralists due to their mobile life style are excluded from political dialogue and political processes, getting less chance to communicate their voices to policy-makers. So in a more connected world, this poses a challenge, as participation is increasingly required.

The Pastoralist Knowledge Hub is a first comprehensive initiative bringing pastoral voices to the global stage and provides a platform for a pastoralist network to connect each other while providing opportunities for policy dialogue. The Hub is coordinated by FAO. The Hub aims to be a facilitating mechanism for bringing together pastoralist networks and organizations working with them in order to promote cooperation and coordination and enhance pastoral development and policy interventions. Under hub pastoral networks are being established. Networks are regional pastoralist gatherings to discuss issues such as food sovereignty, land tenure, environmental issues, pastoral culture and organization through thematic working groups. Develop a mechanism – transparent, inclusive and democratic – for pastoralists to nominate their own representatives at global forums.

In South Asia (Gujrat, India) and Central Asia (Hustai, Mongolia) regional gatherings of pastoralists were organized in March 2015.

Observations by Asian pastoralists

The major threats identified by the Asian Pastoral group include land tenure; disruption of mobility routes; mining and associated land grabbing; land degradation triggered by wrong land use; competition over grazing lands, including with nature conservation; lack of access to markets; and

lack of services for animals and humans. The proposed solution to the identified threats by pastoralists are strengthening pastoralists networks; mapping of pastoralists; evidence-based research for pro-pastoral land, food and livestock policy; develop a knowledge bank on best pastoral practices; build capacity of pastoralists in understanding global policy initiatives; and effective participation of pastoralists in regional and global policy dialogues. FAO is providing technical and intergovernmental policy support for sustainability and development of pastoralism.

Finally, pastoralists are the most important stakeholders and actors when it comes to rangelands, grasslands and mountains. A stronger participation of pastoralists in policy processes is necessary to:

- fight food insecurity and poverty;
- protect and manage rangelands and related ecosystem services;
- avoid and manage conflict; and
- obtain favourable policies, technical support services, and access to markets, to fully express their potential as custodians of rangelands.

Valuing grassland for social, cultural, economic and environmental solutions

Dr Liz Wedderburn

The World's population is forecast to reach 9.6 billion by 2050. The demand for meat and dairy will rise to 470 Mt and 1050 Mt, respectively. Grassland provides 50 percent of the biomass consumed by livestock. Livestock have a huge contribution to make in achieving the sustainability development goals on which global governments are focused.

The Global Agenda for Sustainable Livestock (GASL) has three Focus Areas:

1. Resource use efficiency;
2. Restoring value to grasslands; and
3. Convert waste to wealth in the various regions of the world.

Today's world is facing big challenges of climate change, resource degradation, food security and health. This needs multi-stakeholder and transdisciplinary partnerships committed to sustainable livestock sector development. GASL has a focus on themes that have a high potential for change; recognizes that practice change occurs at all scales and across all actors and will require evidence to build confidence to make change and supports innovation and investment into viable sector solutions.

The primary objective of Focus Area 2 (FA2) "restoring value to grasslands", is to maintain, restore and enhance environmental and economic value of grasslands, while promoting their social and cultural functions globally. The theme takes account of not only the biological state of grasslands but also the functions from grasslands related to rural livelihoods, cultural practices, and also ecosystem functions such as food and fibre production, carbon sequestration, water quality and erosion control.

Participants in FA2 met in Montpellier in 2014 to share knowledge and lessons from 22 pilot sites. This was to assist in the build up of evidence for the use of grasslands and livestock, and to identify some common themes for future focus.

Common to all sites is that it is where research and local actors are already connected and engaged in collaborative arrangements; to understand the present dynamics of farming and socio-ecological systems; and to co-design approaches for innovative futures for livestock within their territories. Analysis of the pilot sites resulted in the emergence of four themes.

Theme 1 focused on the institutional challenges and opportunities that emerged from the sites. Although in many instances there are weak legal frameworks in place with regard to sustainable livestock production, a range of institutions are in place within the pilot sites, including informal tribal partnerships, and collectives concentrated around villages (Kenya, China and Tibet). Household

contracts exist between families, the community and government, where the government may put in place policies that will incentivize collective behavior.

An example of cooperatives for product supply is *laiterie du berger*. It was created in 2006 by a young Senegalese veterinarian, with the goal to valorize local dairy produce of small-scale producers, offering good quality dairy products to urban consumers. There are now 1800 small-scale stakeholders involved.



Payment for ecosystem services has been touted as a means of valuing grasslands, with a particular focus on carbon sequestration. In a Mongolian case, they have designed a measurement, reporting and verification system to build evidence and confidence that CO₂ is being sequestered for use in trading systems. Other cases demonstrated the benefits of grassland for increasing native biodiversity and enhancing water quality.

Theme 2 capacity building has a focus on education, both formal and informal. One of the most important aspects is to educate pastoralists and improve their capacity. Institution and schools can be set up to educate the young. Similar transfer of knowledge from the seniors to the younger can help to share and apply indigenous knowledge. Canada has in place a Sustainable Grazing Mentorship programme. Experienced graziers, act as mentors and help producers identify available options, select first steps and develop ongoing strategies. This allows neighbours to mimic the success of others, and rather than a focus on the number of producers being mentored, the focus is on the number of hectares that are influenced, and, in natural grassland systems, gains made in increasing biodiversity through the programme can go towards evidence for payment for ecosystem services

Theme 3. Supporting Practice Change. Stakeholder motivation is extremely important to understand and support practice change. Understanding the family life cycle to support practical change to monitor motivation programmes is extremely important.

Theme 4 was resource management, including measuring, monitoring, reporting and verifying grassland status, and the design of different grassland systems, including silvi-pastoralism and introduced supplements.

The following are key lessons identified from the pilot cases:

- The formation of common interest groups can help.
- Increase visibility of pastoralists and multiple benefits to policy-makers and communities.
- Tools such as community pasture plans and resource mapping aid effective decision-making and action.
- Build confidence of herders and farmers through diverse mechanisms.
- Understand motivation of the individual, family and community.
- Importance of consumer requirements and the link with production.
- Simplification is necessary, but context important.
- Sustainable grassland is a catalyst for delivery of multiple benefits that need to be valued.

Opportunities for reclamation of degraded grassland using fodder plants

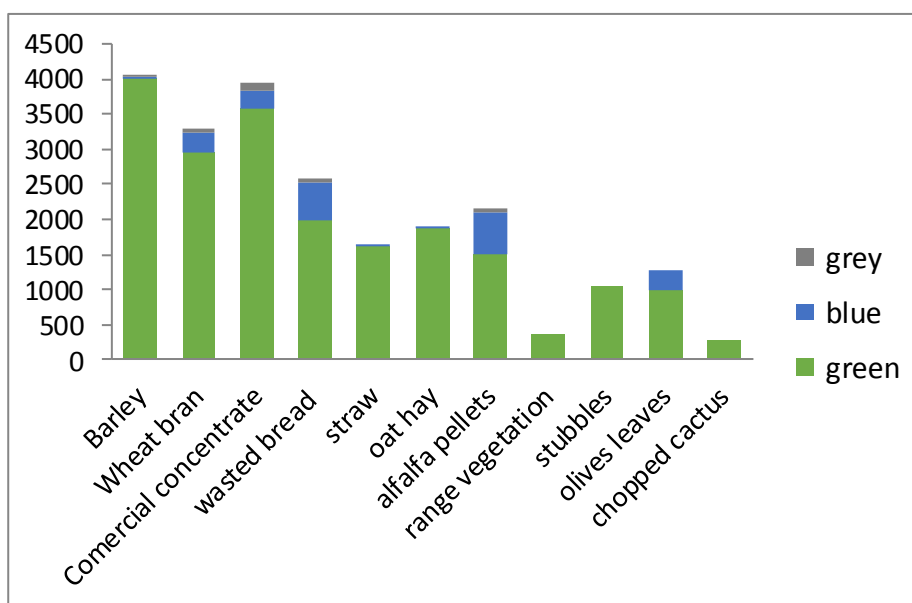
Harinder Makkar

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Increasing temperature, water shortage and salinity impose a challenge for reclamation of degraded land using fodder plants. The situation is likely to be aggravated due to ongoing climate change. For the Asian continent, models project changes in precipitation of between a decrease of 10–15 percent and an increase of 10–15 percent, and a temperature rise of 2–5°C by 2080. Restoration, Rehabilitation and Re-allocation are the promising ways to mitigate the situation. Restoration using approaches such as rotation grazing and zero grazing is beneficial where the degradation is reversible. Rehabilitation is the re-introduction of indigenous plants into the grasslands, while Re-allocation is planting fodder plants or shrubs. Some success stories based on the excellent work of the International Center for Agricultural Research in the Dry Areas (ICARDA), the Institute National de Recherche Agronomique de Tunisie (INRAT), the International Center for Biosaline Agriculture (ICBA), CSIRO Livestock Industries, and the University of Western Australia, are discussed here. These fall under Rehabilitation and Re-allocation and deal with:

- Cactus
- Buffel grass
- A unique approach of managing rangelands based on multi-uses of biomass

The cactus (*Opuntia ficus-indica*; known as Indian fig, Barbary fig, cactus pear, and nopal) is a drought tolerant, evergreen plant, which is easy to establish and maintain. Its centre of origin is considered to be Mexico. It is a multipurpose range species, having a wide spectrum of uses; from cosmetics and food production to livestock feeding. It can grow where other plants cannot grow and has the ability to sequester a large amount of carbon. It has a low water foot print. Only 250 L of water are required to produce 1 kg of cactus cladodes.



Liter of water required to produce one kg biomass (Source: Hichem Bensalem, Tunisia)

Each and every part of the plant has a use. Cactus cladodes and waste fruit can be used for livestock feeding. Brazil is pioneer among the cactus growing countries, having 600 000 ha of plantations. Likewise, Tunisia has a similar acreage under cactus plantation. In the last six to seven years Tunisia has rapidly increased its area under cactus due to favourable government policies. The yield of cactus on a fresh weight basis in Tunisia is about 30–100 t/ha while in Brazil the yield is higher, 200–260 t/ha. Cactus can be grown both as monoculture and in alley cropping. Alley cropping is one of the promising approaches to increase forage yield and economic returns. Alley cropping of cactus and barley has shown a substantial increase in the production of both cactus and barley, giving higher profit to the farmers than that obtained by growing barley or cactus alone.

The cladodes have high palatability and are high in soluble carbohydrates. Cladodes, after cutting in small pieces, can be fed to both ruminant and monogastric animals. Cladodes, with or without waste cactus fruits, can be converted to a good quality silage. The waste cactus fruits can also be used as a substitute for molasses in the production of urea-multi-nutrient blocks. As feed, cactus has an important place both in small-scale as well as large intensive farms. In Brazil, cows fed a diet containing 70 percent cladodes and 30 percent concentrate yield as much as 25 L of milk/day. Cladodes can be a good source of energy for livestock and can replace barley in the diet.

Buffel grass (*Cenchrus ciliaris*) is another promising species for grassland rehabilitation under water deficit conditions. In addition, Buffel grass can also tolerate salinity to a substantial extent. Currently, Rhodes and Panicum grasses are widely used in the dry areas for animal feeding. However, these have a high water requirement. Under water deficit conditions, the yield of Buffel grass has been found to be approximately 56 percent higher than that of Rhodes grass. The chemical composition and nutritional value of Rhodes and Buffel grass are similar. So for a given amount of biomass yield, use of Buffel grass rather than Rhodes grass can save a substantial amount of water.

A unique approach has been adopted for management of rangelands in Western Australia. It is based on the use of water-efficient, drought-tolerant perennial forages and shrubs providing multiple potential benefits such as diet diversification, climate resilience, risk reduction, protection against wind erosion, with anthelmintic and enteric methane reduction effects due to the presence of bioactive compounds, among others. The approach aims at enhancing whole farm profitability and targets the period during which the nutrients are most needed by livestock.

Smart feeding strategies and innovations in fodder use can guide farmers to use best practices, for example to harvest fodder crops when the nutrient yield per unit area is maximum, for getting maximum nutrition from a unit area, translating to greater profitability. The use of Near Infrared Reflectance Spectroscopy (NIRS) *in situ* can assist achieve that. Similarly *in utero* exposure to a forage can predispose the off spring to consume that forages more efficiently.

Developing an integrated system for sustainable dairy industry in the context of grassland restoration

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With continuing growth in the world population, the demand for animal-source food is increasing. Livestock account for about 40 percent of global agricultural gross domestic product, provide approximately 26 percent of human global protein intake and 13 percent of total calories. It has been projected that the demand for ruminant products (beef, dairy and mutton) by 2050 will be increased by 80 percent to 100 percent compared to consumption levels in 2010. In China, raw milk production and cow numbers have increased tremendously during the last 30 years. Despite the rapid growth in the number of cows, total production still falls short of the milk needed to satisfy market demand. China produces only 6 percent of world milk and dairy consumption per capita is only 32.4 kg/year.

Raw milk production in China-30 year's History

The demand for dairy products in China has experienced a steady increase over past years. Consumers in China are demanding access to safe food and the dairy industry must take measures to ensure the safety and quality of the product that reaches the consumer. However, China's dairy sector faces a number of underlying challenges. Research has shown that significant investment in new technology and genetics has not brought about the improvements in terms of output or quality that might have been expected over the past ten years. Aside from dairy product imports, feed and livestock imports are at record, and arguably unsustainable, levels. China is actively looking for new approaches to these challenges, which could be integrated with domestic resources.

China aims to improve the efficiency and quality of its dairy industry, to improve farm incomes and reduce reliance on imported human food and animal feed. Improving feed conversion efficiency will be one of the promising steps toward a sustainable dairy industry, and another step would be to develop an integrated crop-livestock-agroforestry ecosystem. Within this system, crop rotation management (like whole maize silage) and residues utilization, pasture management, together with high quality forage cultivation, will be essential for improving forage productivity and utilization. Raising regionally appropriate animal breeds and supplementing feed with smart supplements like plant extracts from agroforestry, can give more profits not only to farmers but could also improve animal health and give other ecological benefits.

Potential for carbon sequestration through grassland restoration

John Leake

Grazing management options, such as improved species, inputs, cropping rotations improved soil health and soil carbon, contribute towards improved income, but all these need investment. Estimation of pastures and grassland areas are confounded by definitional issues. Some authors include silvi-pastoral systems since many types of grassland are interspersed with crops, and are then seen as integrated systems. Salinized grass- and crop-lands are increasing and many can be restored and use brackish water. These amount to 70 percent of agricultural area, holding 20 percent of carbon stock.

It has been known for decades that grasslands store significant carbon. It is accepted that improving management to increase sustainable production also sequesters carbon. According to the Intergovernmental Panel on Climate Change (IPCC), improving grassland management and reversing degradation offers the most important technical mitigation solutions in agriculture. But grassland restoration is still not mainstream development action that poses many challenges in implementation.

The biggest challenges to meeting the objectives of grassland restoration and carbon sequestration are multidimensional in nature, including Technical, Financial and Institutional. Land restoration requires responses that are multilateral and multi stakeholder, to provide secure land use rights, and demand transdisciplinary research. Technically, measurement of carbon fluxes in soils remains a challenge (FAO 2010) and needs to take into account:

- sampling errors are significant in small, highly variable and uncertain sources and sinks, so a cost effective sampling system is needed;
- pastoral livestock impacts need accounting for (NH₄ emissions); and
- R&D is needed to combine modelling and measurement until relationships are clear by class.

One financial aspect we need to focus on who is who is the payee, and for what are they going to pay. Many sources for payment for ecosystem services (PES) may be available, who can finance both public and private organizations. PES income can only offset some investment, and may conflict with poverty alleviation goals. Therefore, it will be necessary to build long-term partnerships for supplier-buyer value chains, with willingness of the poor to supply the credits.

The best management practices are of vital importance, but depend on both individual activity or group action. Because managing small shifting herds in China succeeds much better with groups rather than individual management (proposed Allied Household Responsibility System, Hua Limin *et al.*, 2015). Similarly, group collaboration improves the negotiating power of small-scale producers for inputs, markets and service supply, including government services.

Moving forward in the direction of sustainable livelihoods for pastoral-related PES, it is highly recommended to:

- look for projects with co-benefits, such as carbon plus livelihood/productivity – “No regrets investment strategies”;
- raise awareness among stakeholders, providing incentives to ‘kick start’ a process to enhance livelihoods and sustainable carbon gain; and
- develop cost-effective means to model carbon and nitrogen flows to enable carbon marketing.

It is further recommended that each country design its own project to make use of what has been learned to build tested cases for possible World Bank or private sector funding so the eventual large-scale investments can be justified on medium-term livelihoods grounds.

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Losses in pasture productivity in intensified pasture-based systems

Professor Sergio C (Yani) Garcia

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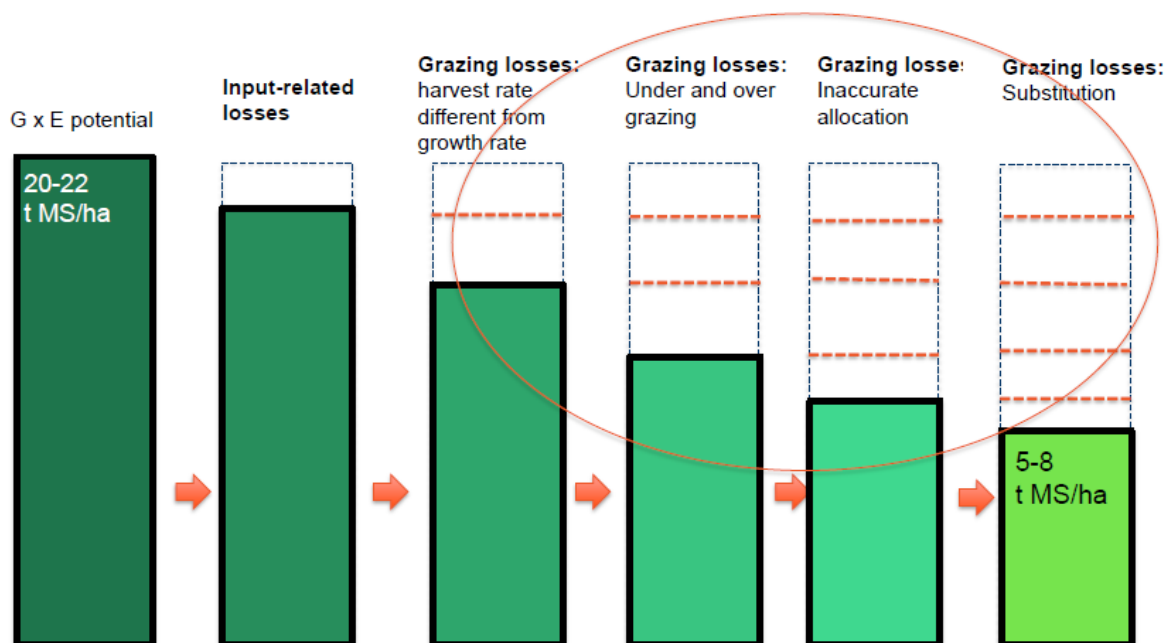
Low cost, pasture-based production systems are a key competitive advantage for the wool, meat and milk commodity industries of Australia. In Australian pasture-based dairy farms, feed produced on farm (home-grown feed, HGF) is typically less expensive than bought-in feed, and as a result the profitability of pasture-based systems is intimately linked to the amount of pasture converted into animal product (Garcia and Fulkerson, 2005).

The Australian dairy industry produces 9.5 billionL milk/yr from 1.7×10^6 cows. There are about 6 800 dairy farms in Australia and, on average, each cow produces 6 000 L/yr, eating 1.8 t/yr of concentrates. Pasture-based systems, in which cows are supplemented with grains or grain-based concentrates, comprise 80 percent of all the feed systems in Australia. In spite of this, average pasture utilization in Australia and total conversion of pasture into milk both continue to be significantly lower than their potential (DFMP, no date)

In a recent review (Garcia *et al.*, 2014), the Dairy Science Group (Camden, NSW, Australia) proposed that the gap between what is possible and what farmers typically achieve is due to a series of inefficiencies (“losses”) with cumulative effect (Figure 1).

Figure 1. A conceptual model to explain individual and/or cumulative losses in pasture utilization. Notes: For illustrative purposes and due to the lack of data to quantify these losses properly, they are assumed to be all of equal magnitude. Based on FutureDairy’s data, losses can exceed 60 percent of potential pasture utilization for irrigated systems (Garcia *et al.*, 2014). G×E = Genotype by environment interaction.

Key losses in pasture utilisation



The University of Sydney

Garcia et al 2014
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The first level of “losses” or pasture wastage relates to a reduction of growth potential due to inadequate management of inputs, particularly nitrogen (N) and water in irrigated pastures, which are a key to achieving water use efficiency targets (1 t DM/ha per 100 mm rainfall or irrigation). Potential losses due to inadequate N application can be large on commercial farms. While maximum production of perennial ryegrass and kikuyu pastures (>25 t DM/ha) were achieved with fertilizer application levels 3 to 5 times greater than industry average (Henzell, 1968; Neal *et al.*, 2009; Neal, Fulkerson and Campbell, 2010). high levels of growth can be achieved through better understanding of plant requirements (when and how much to apply). Similarly, potential losses due to insufficient or inadequate irrigation can be large. García *et al.* (2008) estimated that 1 t DM of utilized kikuyu-based pasture requires 0.6–0.8 ML water, with measured water use efficiencies (WUE) ranging between 2 and 2.5 t DM/ML irrigation water. However, N-use efficiency (NUE) and WUE decrease as N and water input increase, and maximum NUE is achieved with unlimited irrigation and vice versa (Islam and Garcia, 2012). In practice this means that both N and water inputs (or N in relation to W availability in dryland) should be managed to achieve a target of >1 t DM of utilized pasture (or HGF)/ML water. The increasing cost of water and N and decreasing availability of water in Australia, together with growing environmental concerns, will require better fine-tuning of the interactions between forage productivity, utilization, N and water inputs.

To significantly increase levels of HGF utilization, nutrients (particularly N) and water (in irrigated pastures) must be adequately managed. This requires advanced knowledge of both sequential pasture growth rate and herbage accumulation at the individual paddock level; and key principles of

N and water management. Acquiring such level of advanced knowledge is difficult and time demanding.

The second form of pasture wastage is to inadequate or suboptimal grazing management, including matching growth and harvest rates; rotation management; management of pre- and post-grazing pasture covers; and supplementation of grazing animals.

Matching growth and harvest rates is paramount in any grazing system and is key to reducing feed costs, by minimizing imported costly supplemental feed and to achieve cow efficiency (>1 kg MS/kg LW) targets. This is due to the dynamic nature of plant tissue growth, a process in which carbon fixed by photosynthesis can be lost by respiration and senescence if the new tissue is not harvested (utilized) in time. As non-harvested tissue will inevitably senesce and die, net growth is equivalent in practice to the amount of biomass harvested by animals. From a farm-management viewpoint, the way to minimize losses by senescence and maximize net growth is to match average rate of harvest as closely as possible with average rate of pasture growth (García and Holmes, 2005). In practice, this can be achieved by (i) systematically monitoring pasture biomass, and from this estimating pasture growth rate, on a weekly basis; (ii) grazing pastures in line with plants' optimal growth stage (rotation management); (iii) managing allocation and residuals to maintain growth rates and pasture quality; and (iv) using supplements to cover true pasture deficit.

Growth rate can be estimated by measuring pasture biomass, either at frequent intervals (ideally weekly) or before and after each subsequent grazing (García and Holmes, 2005). Thus intensification of pasture management through controlled grazing and monitoring helps to avoid hidden losses in pasture productivity. In addition supplementation with complementary forage rotation during periods of low growth, compensates for or relieves the pressure on pasture during the off-season to avoid overgrazing.

To significantly increase levels of HGF utilization, well known principles of pasture management must be applied, that ensure both growing the maximum possible for a given level of inputs (i.e. no restriction to pasture growth due to management); and harvesting the maximum possible amount of plant tissue grown. This requires knowledge of both sequential pasture growth rate and herbage accumulation at the individual paddock level; and key principles of pasture management.

Extensive grasslands and pasturelands present logically different challenges, but the biological principles underpinning grass growth and pasture production and utilization are universal. The key point is that bad management (particularly overgrazing) "kills" pasture and grassland productivity and consequently carbon sequestration. Nutrient inputs and management present an opportunity for a controlled intensification of certain parts of grasslands that can be used to relieve the pressure on the grassland as a whole during critical periods of the year (e.g. winter or dry seasons). Recent advances in remote sensing and robotic technology (eg. Pipunic, Ryu and Walker, 2014) provide an opportunity to improve real-time monitoring of grasslands and pasturelands and their ecologically sustainable productivity.

In summary:

- “Hidden” losses are common to both grassland and intensified systems and their management and recovery is unavoidable for grassland restoration and profitable dairy farming.
- Overgrazing is the “silent killer”. Controlled and rotation grazing can be helpful to minimize damage related to overgrazing. Range productivity monitoring before and after grazing can help to devise grazing management plans.
- Strategic or controlled “intensification” for sustainable grassland management is a key principle for grassland restoration.
- Technology can play a very important role in sustainable management. GPS and remotely sensed data on a long or short-term basis can help to devise grassland management operation plans with flexible application and good results.

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Towards sustainable desertification reversion and food security -A case study in Horqin Sandy Land

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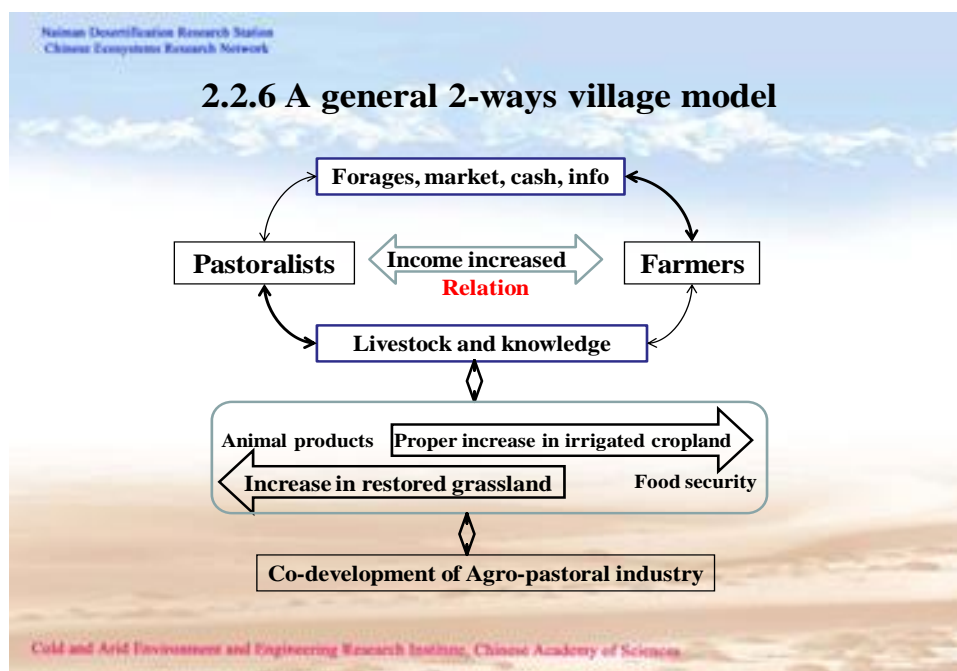
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The Arid region is one of the important biomes in the world and mainly distributed in Western China, western and central Asia, northern Africa, Australia, northwestern United States of America and east coast of south America. The ecotone between grassland and forest land is very fragile vis-a-vis human activity and climate change, and mostly desertified due to over-cultivation, over-grazing and excessive fuelwood collection, as well as excessive water use. It covers about 600 000 km² in China. So sustainable desertification reversion is of the greatest importance, requiring the immediate attention of scientists, local government and people, and related organizations.

The Horqin Sandy Land is a transitional area between traditional pastoral systems and modern agriculture systems, and once was one of the most severely desertified regions in northern China. It was identified as a source of sand and dust storms in northern China. Since the 1980s, desertification has been reversed through implementation of several restoration projects, such as "the Three-north re-vegetation project", "the Natural vegetation protection project", and "Green for Grain Project" in Horqin Sandy Land. In parallel with these projects, considerable capital has been invested in research and demonstrations. While making progress, reducing water availability has become a challenge to desertification reversion and development. Sustainable desertification reversion has therefore been put on the agenda for government attention and the people's consideration and action. The Cold and Arid Environment and Engineering Research Institute (CAREERI), Chinese Academy of Sciences, is engaged in desertification research, monitoring and demonstration of research findings, with the following achievements towards sustainable desertification restoration:

- Water consumed by most of the aboriginal species was less than the annual mean precipitation of 360 mm, and tree density plantings should be in the range of 225 to 375/ha, much lower than the density of 1425–1575/ha proposed by government departments.
- Restore degraded areas by applying with dry organic matter, in the form of fast fibre decomposers in a mixture of sand and organic wastes.
- Encourage intercropping: between maize and grass; fruit tree and grass; bushes and grass; for food and fodder production and cash income.
- A general two-way village model was developed where farmers and pastoralists mutually share a good working relationship for co-development of agro-pastoral industry and risk reduction.

Figure - A two-way model approach



- Long-term monitoring of grasslands to provide recommendations and guidelines for the managers and policy-makers for restoring grassland and promoting sustainable development.
- Human-aided restoration of desertified land is more sustainable than human-made restoration.
- In short, sustainable desertification reversion should be promoted, but aware that desertification reversion should be made without compromising the basic resource capacity for ecosystem succession and economic development in the targeted region.



Panel Discussions

Panel 1: Grassland restoration – causes, solutions and the response

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Panellists:

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The 1.2 billion ha of grasslands constitute approximately 35 percent of the Asia-Pacific land area and livestock grazing is the dominant form of land use of those grasslands, providing meat, milk and fibre as marketable products. However, these grasslands are under pressure and face the risk of further degradation due to multiple local and wider factors.

Tenure security is one of the important issues that needs to be addressed for sustainable restoration of grasslands. China's Grasslands Contract policy, after 30 years, threatens the ecology, income, pastoral production system, society and culture. Land tenure should match the natural and social conditions. Similarly, long-term bans on grazing do not work for sustainable grassland and output. Rangelands without pastoralists lead to overexploitation and degradation.

Subsidies are generally taken as tool to restore grasslands, in the form of compensation to the pastoralists or payment for ecosystem services (PES). However, it does not always attain the desired objective of sustainable grasslands. The reason is obvious: the pastoralists are not aware of why they are being paid and what they are expected to do in return. Subsidies without education can bring short-term change but are not sustainable.

Climate change is one the major causes of degradation of grasslands around the world. Similarly, Mongolian grasslands are under threat from degradation attributable to climate change. Rising temperatures and rainfall fluctuations lead towards the melting of glaciers and destabilization of grassland. This degradation not only affects livestock production systems but also decreases the availability of forage. The degradation of grassland associated with climate change also affects wildlife and biodiversity.

This critical scenario demands practices to promote desirable ecological, economic and cultural outcomes related to grassland ecosystems. The following recommendations could facilitate achieving these goals:

- Alternative livelihoods like ecotourism and value addition of the livestock products are fundamental for reducing stocking pressure on grassland.
- There is no “one size fit all” and land tenure institutions should match the natural and social conditions.
- Develop a balance between ecological restoration and pastoral culture.
- Transform to a “culture of sustainability” through the development of social awareness.
- Climate change impacts need to be monitored and studied. Scientific solutions are urgently needed to reverse degradation phenomena.
- Climate change adaptation is of utmost important for sustainability of grasslands.
- Support community empowerment in the process of decision-making and policy formulation, to lead toward grassland restoration.

Panel 2: Grassland management – Policy, Institutions and Science

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Sustainable grassland management is fundamental to restore grassland in the Asian region. Sound policies require science-based evidence. Science-based policies support and strengthen institutions, and institutions help to implement policy in an effective manner. There is therefore a strong need to bridge the gap between policy-makers and scientists, and to develop sound and effective policies in order to achieve the goals of sustainable grasslands management and pastoral livelihoods.

Science provides the baseline evidence that needs to be applied for policy development and grassland management. It is clearly accepted that biodiversity contributes to the stability of various functions and services provided by ecosystems. However, farmers engaged in intensive agriculture, tend to ignore the contribution of biodiversity to their agro-economic activities. Scientists therefore need to produce clearer evidence to demonstrate to farmers and policy-makers the benefits of biodiversity in agro-ecosystems.

Environmental contamination, water shortage, air pollution, animal diseases and grassland degradation are among the collective issues confronting not only Central Asia, but also widely elsewhere in the world. Similarly, food safety, animal welfare in relation to their health, feed availability and fair trade in terms of markets and economic wellbeing are also demanded worldwide. Efficient grassland management and sound policy support could be an effective factor in minimizing the problems. Policies focusing on pasture development and monitored by consulting teams, with sound decisions on planning for grassland development, can give promising results.

Over 60 percent of the HKH region countries and other countries are used as rangeland resources, mainly for pastoral uses. These rangelands have multiple functions and issues. In short, the grasslands have low productivity and are degraded. So options based on sound policy, institutional measures and science based technical innovations can present an ideal scenario for grassland restoration and management. From the perspective of range management policy options, actions research to identify the policy issues, national policy dialogues, rangeland policy formulation and

implementation, are significant initial steps. Capacity building is a broad process engaging transdisciplinary stakeholders, including pastoralists, scientists and policy-makers, and needs to initiate and be strengthened through technical demonstrations in the field of the success stories, through bilateral visits.

Based on the panel discussion, the following points were identified as critical for the policy formulation process:

- The gap between policy-makers and science needs to be bridged.
- Extend the voice of the pastoralist by celebrating festivals like World Grassland Day.
- Capacity building is needed for both the scientists and policy-makers.
- Support knowledge dissemination through demonstrations and bilateral visits.
- Responsible tourism can help reduce pressure on land, restore grasslands and improve pastoral livelihoods.

Concluding Session

The concluding session focused on producing and fine tuning key messages from the two-day technical presentations and panel discussions, suitable for communicating to policy-makers.

Key messages to policy-makers

- It was recognized that science-based policy advocacy is essential to support sound policy development for grassland management and restoration.
- Adequate resource allocation is critical for policy implementation. So funds need to be allocated for this purpose.
- Failure to restore and rehabilitate grasslands is a significant driver of climate change. So it should be given due consideration in the policy formulation process.
- Each country should have one project that demonstrates how to characterize the values that both sellers and buyers can take into account.
- Local people are environment service providers. They should benefit from conservation processes, and their concerns should be given due attention in policy-making.
- Develop mechanisms and find ways to connect science and research to farmers in an effective way in policy guidelines.
- International organizations should play more pronounced roles in the policy process at international, regional and national levels
- The transboundary nature of the problem should be recognized and addressed in the policy-making process.
- Rangelands have multiple functions, including biodiversity conservation; ecosystem services; socio-economic and cultural values. Formulate appropriate policies implementable on the ground through local people, respecting their traditional knowledge and culture.
- Ways to sustain the process are needed to devise appropriate mechanisms to empower the pastoral and local people, and to recognizing them as the custodians of rangeland resources.

Way forward

It was generally recognized by all the participants that this meeting is the beginning of a process that they hope to be continued. For continuation, it was urged that participants should remain interconnected and communicate actively with each other, and it was further proposed to set up a forum for this purpose. It was further suggested that international forums, such as the Global Agenda for Sustainable Livestock and Pastoral Hub could be used for this purpose. ICIMOD could also play an important role because it has formal collaboration and strategic partnerships with policy-makers and research organization in the HKH region.

It was further advised that Lanzhou University could set up its own forum and could play an important role for communication and dissemination of information in the region, reflecting its specialty in grassland research in China.

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