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Resilience of agricultural systems against crises

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systems against crises

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Looking Ahead: Mega Trends in the Rice Sector

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Contrary to earlier predictions, global consumption of rice has hovered around 65 kg per capita since the early 1990s. So far, the global rice equation has not changed much yet: for every additional 1 billion people on Earth, we need to produce another 100 million tons of rice (paddy). Future demand, but also how rice and other food will be grown, will depend on structural transformation processes such as a declining share of agriculture in gross domestic product and employment, rural to urban migration, the rise of an industrial and service economy, and demographic transitions from high rates of birth and death to low rates.

Some mega trends are already emerging in the rice sector. Land is scarce and inputs costs have risen, requiring further increases in productivity as well as greater efficiency of labor, water, fertiliser and energy. This also provides an incentive for more skilful, more precise agriculture through one can also better adapt to the environment, or even control parts of it. Rural to urban migration has made labor in the agricultural sector scarce and expensive, driving mechanisation as well as the development of new service sectors. Traditional smallholder farm management is being replaced with outsourcing of farming operations or the formation of small enterprises. Rice value chains are becoming more tightly integrated because processors and consumers demand more information and control over how food is being produced. Farmers increasingly turn to the private sector as a source of information, but also as a direct buyer of rice and other products, requiring to produce agricultural raw materials with new, higher standards. Access to interactive, tailored information is greatly increasing, creating wider communication networks.

Rice science needs to be re-oriented towards these mega trends. We need to anticipate what is needed 10 or 20 years from now, and we need to take full advantage of these new opportunities, particularly in developing countries.

Keywords: Agriculture, mega trends, rice, transformation

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Soils and Resilience, Much More Than a Slow Variable

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In resilience science soil properties are classified as a 'slow variable' or a factor that changes slowly in response to long-term processes. These slow variables in part determine the resilience of an ecosystem. The slow variable concept in resilience is much too limited a lens to understand the role of soil in resilience of agricultural systems and livelihoods. Panarchy theory enriches this simple concept by using the metaphor of the adaptive cycle, that better explains why apparently stable systems may become unstable quite rapidly and how drivers from other domains (social, economic, institutional) may critically affect ecological processes. In this paper we explore the role of soils in resilience by taking a view through the holistic lens of ecosystem services. A whole range of services depends on soil function - water cycles - carbon cycles - nutrient cycles. These ecosystem services, in cases where human and ecological systems are closely coupled, such as small scale farming communities in developing countries, directly impact the resilience of the population. It is possible to understand resilience and the role of soil function and soil health better by breaking down the elements that can be considered contributing to resilience - response diversity, adaptive capacity and ecological buffering capacity.

Keywords: Resilience science, soil science

Agrobiodiversity Management for Food Security

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World population increases by approximately 78 million people annually. About 1 billion humans suffer from hunger and 3 billion malnourished people live with <US\$ 2 daily. Anthropogenic climate change continues affecting food output and quality while the world continues facing an increasing demand for nutritious and quality food, feed, fiber and fuel. There will be 1.7 billion more people to feed by 2030, but with a declining ratio of arable land between 40 and 55 %. Agriculture needs eco-efficient and resilient systems to meet end-user demands. Such agro-systems should provide enough and safe food, enhance human health through better nutrition for the poor and well-balanced diets for the rich, diminish the use of fossil fuels, adapt to extreme weather and water stresses, reduce environmental degradation and decline in the quality of soil, water, air and land resources in an increasingly urbanized world, and be a source of raw materials for bio-energy and a bio-based economy in this 21st Century. Agro-biodiversity components act similarly in agro-systems than biodiversity in other ecosystems: genetic diversity or genetic variation within the species, species diversity or variation existing for species in a specific region, and ecosystem diversity comprising variation between agro-systems within a region. Agrobiodiversity provides means for intensifying sustainably crop yields and for adapting crops to climate change, *e.g.* genetic broadening helps introgressing new genes in breeding populations, intra-specific crop diversification (*i.e.*, mixture of landraces or cultivars) provides a means for controlling effectively pathogens and pests over large areas, and genetically enhanced seed-embedded technology contributes to adapt to variable environments due to changing climate. Sustainable crop genetic enhancement consists of Identifying a useful character, manipulating its genetic variation, putting genes into a usable form, using DNA markers to monitor chromosomal changes and as selection aid, and genetic engineering to enhance useful variation if not available in crop gene pools.

Keywords: Genetic engineering, genomics, germplasm enhancement, plant breeding

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Pastoralism and rangelands

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Strengthening Resilience of Pastoralists through Improved Economic Integration

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Many arid and semiarid environments are rapidly approaching a precarious ecological state. The session on ‘Pastoralism and Rangelands’ will look at potential solutions for a range of problems that affect pastoralist livestock production at present; these include:

1. The need for an ecologically balanced Natural Resource Management in the face of rapidly increasing human and livestock numbers in the drylands, sustainable utilisation of tropical rangelands being a major focus for this session
2. The need to improve market access and provide a more robust marketing infrastructure (agricultural value chain approach, public-private partnerships in the management of livestock markets)
3. Workable mechanisms to buffer pastoralist livelihoods against external shocks (Early warning systems, Livestock insurances)
4. Full utilisation of new opportunities created through the advance of modern communication technology, banking services and electronic cash transfer systems in remote regions

This paper proposes that increased and more stable incomes are a major contribution to buffer pastoralist households against external shocks and to strengthen the resilience of pastoralist communities. Too little has been done to improve market access, to lower transaction costs and to improve the profitability of producing and selling animals and livestock commodities in pastoralist regions. Insufficient economic integration and poor market access perhaps pose the same risk to pastoralist livelihoods as the losses related to environmental degradation, recurrent natural disasters and climate change. Based on experiences by VSF-Germany, KARI and other development actors in the pastoralist regions of Kenya and Somalia we review selected development interventions in terms of their economic viability and their impact on economic integration and incomes of pastoralist households.

Keywords: Agricultural value chain approach, early warning systems, livestock insurances, natural resource management

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Increased Climate Change Resilience of Semi-Arid Regions Based on Collective Environmental Governance with Landscape Approach

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For 20 years seasonal grazing has been discontinued in semi-desert areas of Uzbekistan. As a result the region faces significant loss of important perennial shrubs and forage plants. Rangeland degradation puts livelihoods at risk. Additionally climate change 40 % above global average indicates rapid governance changes. Current production systems are already and will be even more threatened by water scarcity, increasing number of days with very high temperature causing partial crop failure, hails and strong rains effecting devastating mudflows from eroded foothills. Present coping strategies are commuting of men in labor age and out migration of youth, as an individual adaptation is hardly possible.

Facilitated by participatory research, local communities in three villages overcame their deep rooted fatalistic acquiescence in the tragedy of the commons leading foreseeable to an environment that cannot sustain livelihoods anymore. Local population is now ready to introduce new collective governance systems including share of tasks and benefits, enforcement of rules and management tools in common rangelands and on foothills. Villages developed a common purpose to collectively rehabilitate their ecosystems. Results from two participatory socio-economic research projects in different areas of Uzbekistan are presented. One village decided to introduce spatial planning, reforest foothills, stop free grazing, start collective forage production on rangelands based on social fencing and start alternative income options. Two other villages decided to establish pastoral user groups, fenced seed isles and seasonal grazing on limited rangelands based on strictly prohibited free grazing. In these two villages during last 15 years rangeland degradation had induced a shift from collective use of rangelands for small ruminants towards individual cattle rearing based on forage production on up to 80 % of the household plot. This will be terminated by climate change induced severe future water scarcity. Now villagers try to shift back to collective rangeland use for sheep and towards diversification on their household plots.

The findings show (1) critical importance of an integrated ecosystems research and development approach with clear focus on collective landscape governance, (2) remarkable self-help-potential of local communities if it is addressed adequately, (3) importance of a process of social learning over some period.

Keywords: Climate change adaptation, fenced seed isles, pastoral user group

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Nomadic Pastoralism in Southern Iran

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The nomadic pastoralist system in Baft district, Kerman province, is well known in Iran for producing cashmere from Raeini goats. However, there is little information on the production system. Interviews were carried out with 30 Siahjel nomad families of Raen origin in proximity of about 20 km to Baft in 2010 to characterize the production system considering family labor force, work sharing, livestock numbers, management and marketing practices, and diseases. The nomads move their livestock over large distances within the rangelands of the region from May to November and the majority migrates to the South during winter and early spring. 87 % of nomad families stay and manage their animals together with one or more other related families. All household heads are males, and only 17 % at maximum 30 years old. All family members are involved in raising livestock; male family members and hired labor dominate the physically harder jobs like shepherding and breeding, and women are involved in milking and caring. 80 % of the animals are owned by adult or young males, none by daughters. Siahjel nomads mainly rely on goats and average proportion of goats, sheep and monodactyl per family are 89 %, 8 % and 3 %, respectively. Adult breeding females constituted with 44 % the largest group within the goat herds, female yearlings, bucks and male yearlings constituted 12 %, 8 % and 7 %, respectively. The rationale for keeping a high number of males may be related to their higher production of cashmere. Diseases accounted for 57 % of adult and 88 % of young animal deaths. The most prevalent diseases were enterotoxaemia, foot and mouth disease, pneumonia, agalactia and diarrhoea. Animal sales, meat, cashmere and milk production are the major reasons for keeping goats. Nomads sell their animals directly to abattoirs or butchers whenever cash is needed. While 41 % and 32 % of nomad farmers receive cashmere marketing information from traders and neighbouring farms, 14 % and 13 % of farmers receive their information from livestock associations and markets, respectively. Rangeland is the main source of feeding (85 %), the remaining 15 % are provided by stubble grazing.

Keywords: Livestock, herd management, nomads, products, rangelands

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Collective Management on Communal Grazing Lands: Its Impact on Herbage Production and Land Degradation in the Upper Blue Nile Basin, Northwestern Ethiopia

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Collective action on communal grazing land has evolved in the highlands of northwestern Ethiopia to mitigate the critical problem of land degradation caused by overgrazing and to ensure sustainable production of natural pasture mainly for draught oxen feeding. However, large portions of the communal grazing lands are still managed under free grazing which has been practised continuously in the past. This study was undertaken to assess impacts of three different types of grazing land management (GLM) viz. a) freely open communal GLM, b) traditional collective management of communal grazing land locally named as ‘yebere sar’ GLM and c) private holding GLM. These were coupled with two slope gradients (<10%; 15–25%). Parameters studied were water erosion and vegetation dynamics at Maynet Kebele in the upper Blue Nile basin, Ethiopia. The interaction effect of GLM and slope was found significant ($p < 0.05$) for hydrological responses. The average runoff coefficient was more than 20% implying that about a quarter of the rainfall amount turns to surface runoff on grazing lands. Freely open communal GLM on a steeper slope of 15–25% resulted in consistently highest cumulative runoff and soil loss amounting to 491 mm and $32 \text{ t ha}^{-1} \text{ y}^{-1}$, respectively. When the vegetation cover was below 40%, runoff and soil loss dramatically increased. This suggests that freely open communal GLM is typically having a higher risk of water erosion in the study area. As expected, yebere sar GLM appeared to reduce surface runoff by more than 40% and curb the rate of soil erosion by more than 50% compared to freely open communal GLM. Its vegetation cover persisted above 70% all the time, meeting a threshold level recommended to keep surface runoff and soil loss to minimum. Ground cover was the most significant factor determining the level of runoff and sediment loss on pastureland. Adequate resting of a pasture from grazing at the right time is an extremely important component to improve vegetation cover and herbage production that in turn arrest land degradation for which any grazing land management practice needs to give due emphasis.

Keywords: Collective action, communal grazing land, herbage production, land degradation, northwestern Ethiopia, vegetation cover, water erosion

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Responses of Communities Plant Functional Traits Along Grazing Gradients on South African Rangelands

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Vegetation communities fulfill certain tasks in the ecosystem which can be expressed by their plant functional traits. By representing species of plant communities with their trait attributes rather than by species names, one can focus on the ecological functions and on the adopted plant strategies of communities which success under imposed conditions of the environment. In rangelands of South Africa we studied the response of Community Plant Functional Traits (CPFT) to grazing gradients on transects which started at the water point on grazing land. One transect per farm was established and along each transect, six plots (5 m × 5 m) were placed at equal distances.

We found that the trait-line sampling, a taxon-free method, was appropriate to record 15 CPFT in both standing biomass and on the regrowth. Close to water points grazing was more intense. Here, plant communities exhibited higher specific leaf area and higher leaf nitrogen content suggesting a higher photosynthetic capacity. Furthermore, communities close to water points exhibited less cell wall components (cellulose, hemicelluloses, and lignin) similarly favoring capture of photosynthetically active radiation. Communities exposed to intense and frequent grazing are successful by possessing quick-return strategy of nutrients invested into leaf tissues via higher rates of light capture.

We conclude that in these so-called “sacrifice areas” on livestock farms (or piosphere) there is an ecological niche for vegetation communities with quick-return strategies which are not only well adapted to intense and frequent grazing but also provide forage of high quality to the benefit of animal husbandry.

Keywords: Piosphere, plant strategies, taxon-free method, vegetation communities

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Strategies of El-Kababish Camel Herders to Cope with Adverse Climate Conditions in Sudan

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The study aimed to study strategies of El-Kababish camel herders to cope with adverse climate conditions in North Kordofan State, Sudan. A total of 122 farmers owing 10,386 heads were randomly selected and a semi-structured questionnaire was applied in 4 different areas (Sodary, Jabra, Umgrfa and Almuwelih) dominated by camel herders. The results indicated that 59 % of camel farmers were owners, while 41 % were shepherds. Illiteracy among camel owners and shepherd was 49 % and 56 %, respectively. Camel herders divided their camels in small herds with an average size of 85 ± 37.2 heads which were distributed into different regions as a mean of avoiding diseases and nutritional crises. Herders tended to keep high percentages of breeding females (74.2 %) while breeding males amounted for 25.2 % in the different herds. The majority of herders (49.2 %) were found to rear camels only while some herders raised sheep and goats separately besides camels. Seasonal migration to the northern and southern parts of the state lasted on average 6 ± 1.2 months, depending on the availability of water and pasture. The watering interval was long during winter and short during summer which enabled wide utilisation of rangeland. Castration of males was practised for fattening purposes by 40 % of the farmers. The interviewees reported the presence of twelve camel diseases, and local knowledge was extensively practised to combat diseases.

Keywords: Camel, climate conditions, El-Kababish herders, seasonal migration

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Can an Improved Dual Purpose Groundnut Cultivar Increase Milk Production in Crop-Livestock Systems in India?

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Groundnut is an important crop in dry areas of South Asia where it is grown for oil production. In addition, it also serves as valuable source of livestock fodder. In Anantapur, one of the poorest districts in southern India, groundnuts occupy 70-80 % of the cropped area. A new groundnut cultivar ICGV 91114, developed by scientists from ICRISAT1 and ILRI2, with superior grain and fodder traits, was introduced to this district in 2003. The present study was designed to capture the impact of this new cultivar on milk production on farm compared to the dominant traditional cultivar TMV 2.

Two participatory feeding trials were conducted with 52 farmers from 4 villages, animals with average milk yield of 2-5 l day⁻¹. First, 17 dairy animals were fed with groundnut fodder harvested in the rainy season (July to November) together other common feeds (rice straw, rice bran, broken rice etc.). The animals were offered one groundnut fodder variety for 10 days and then fed with the other groundnut fodder variety for the following 10 days, keeping the overall feeding regime constant. Subsequently, a similar experiment was conducted with 37 animals and groundnut haulms harvested during the winter season (January to April). Milk yields and feed amounts were recorded daily. Milk composition was analysed locally while feed samples were analysed by Near Infrared Reflectance Spectrography at ILRI.

The results show no significant effect on milk yield of groundnut cultivars based on kharif fodder. However, for winter fodder a significant increase in milk yield (400 g) can be attributed to feeding ICGV91114. This is supported by the laboratory analysis which for this season shows higher levels of nitrogen, metabolisable energy and lower lignin and fibre content compared to the traditional cultivar. In contrast, the quality of haulms from both cultivars harvested in the rainy season was poor, possibly because of rain damage. The results highlight the potential of including the nutritional quality of crop residues in crop breeding programmes. However, the results of the present study may not be generalised due to the small scale of the trials.

Keywords: Dual purpose crop, feeding trial, groundnut, mixed farming

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Effects of Management Practices on Carbon Allocation in the Semi-Arid Savannahs of the Borana Region, Ethiopia

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Grassland systems cover 3.9 billion ha, 25 % of the earth's terrestrial area, and could, according to FAO (2009), sequester up to 2 GT CO₂ equivalents worldwide if appropriate management of vegetation and soil resources would be applied. Carbon is stored in different pools: dead and alive biomass like plant roots in the soil, and living biomass (grasses, shrubs and trees) and litter aboveground.

Livestock production has been a major source of income generation and food security in the semi-arid savannahs of the Borana region, Ethiopia, ever since. The dependency on traditional livestock-based pastoral and agro-pastoral livelihoods under ecological and economic pressures (droughts, population growth, overgrazing, etc.) is no longer sufficient to sustain food security. To overcome vulnerability of these communities, diversification of income is of crucial importance. Payment for environmental services (PES) based on reduction of carbon emissions and carbon allocation linked to livestock production could be one tool to diversify income of the vulnerable group of Borana pastoralists. Range and herd management may have exceptional impacts on carbon fluxes in the grass- and bush-land savannahs of southern Ethiopia.

Four vegetation types; namely grassland, tree savannah, bush land and tree-grass-bush savannah, have been distinguished in the research area. The pastoralists differentiate between year-round and seasonal grazing by installing "enclosures". Seasonal grazing patterns were found in grass and tree savannah. Therefore, five 900 m² plots each were located in year-round grazed and seasonally-used grass and tree land. Soil samples were taken in four different depths up to 100 cm to analyse for total carbon, soil organic matter and soil organic carbon content as well as to examine bulk density, pH and texture of the soil. Aboveground biomass was harvested and tree biomass was calculated by using allometric equations. A regression analysis was run to portray changes in organic carbon pools and allocation across vegetation type, management practice and soil depth.

The results will help to evaluate the impact of management practices on carbon fluxes in the soil and on aboveground biomass production. Carbon allocation processes will be better understood and information can be used to improve these grazing systems towards higher sustainability and crisis resilience.

Keywords: Carbon allocation, enclosure, grazing, savannah, vegetation type

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Mammalian Herbivores as Designers of African Savannah Ecosystems

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African savannahs support a large proportion of the world's human population, heavily relying on resources provided by an intact savannah. Mammalian herbivory is one of the major factors regulating savannah ecosystems. However, research quantifying and comparing the impact of domestic and wild mammalian herbivore assemblages and their densities on the vegetation is rare. In the Kruger National Park (KNP) and adjacent communal grazing lands we assessed the vegetation under different grazing and browsing regimes in a close-to-natural savannah *versus* communal grazing land. We studied woody plant species composition and structure under browser presence and absence. We additionally analysed herbaceous vegetation and soil properties to understand the role of grazer densities and assemblage types.

We found that herbaceous species richness was higher on communal farmlands compared to protected areas inside Kruger Park, as was forb cover. The lowest Shannon Wiener diversity index was found under mono-specific grazing at wildlife and livestock sites. Grass leaf nutrient content was significantly higher and annual grass species were less abundant under multi-species wildlife and livestock herbivory. Inside KNP, the mono-specific site showed with 311 trees ha⁻¹ and 140 trees ha⁻¹ the highest density of bushes and small trees. In contrast, bush density at the livestock sites was found to be higher under multi-species herbivory, whereas small tree density was significantly lower there.

Our research showed that certain grass species were strongly resistant against high mono-specific grazing pressure. Multi-species herbivory in contrast decreased pressure on herbaceous vegetation, enhanced biodiversity and improved grass quality. Bush and small tree growth could efficiently be suppressed by multi-species herbivory. Different herbivore assemblages show strong impacts on vegetation and soil conditions, thus, play an important role as designers of savannah ecosystems.

Keywords: Biodiversity, bush encroachment, herbaceous community, herbivore assemblage, savannah

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Comparative Analysis of Ruminant Grazing Itineraries and Foraging Behaviour Across Three Agro-ecological Zones of Burkina Faso

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Mobility is key for livestock production in the agro-pastoral systems of West Africa. Population growth and increased climatic risk of crop failure lead to cropland expansion which affects herd mobility and access to forage resources to varying degrees across agro-ecological zones. Therefore we studied the spatio-temporal variation in the use of grazing areas and the foraging time of ruminants in the southern Sahelian, northern and southern Sudanian zone of Burkina Faso by monitoring three herds each of cattle, goats and sheep in three village territories during a one-year cycle. Grazing routes were tracked using a Global Positioning System; coordinates logged at 10 s intervals were overlaid on land use maps from where time and activity on different land units was derived.

Maximum itinerary lengths (km/d) were observed in the hot dry season (March-May); they were longer for sheep (18.8) and cattle (17.4) than for goats (10.5, $p < 0.05$). Total time on pasture (h/d) ranged from 6–11 with cattle staying longer on pasture than small ruminants ($p < 0.05$). Feeding time accounted for 0.52–0.72 of daily time on pasture irrespective of species. Herds spent longer time on pasture and walked farther distances in the southern Sahelian than the two Sudanian zones ($p < 0.01$), while daily feeding time was longer in the southern Sudanian than in the other two zones ($p > 0.05$). Proportional time spent resting decreased from the rainy (June-October) to the cool (November-February) and hot dry season ($p < 0.05$), while in parallel the proportion of walking time increased. Feeding time of all species was to a significantly high proportion spent on wooded land (tree crown cover 5–10%, or shrub cover $> 10\%$) in the southern Sahelian zone, and on forest land (tree crown cover $> 10\%$) in the two Sudanian zones, irrespective of season.

We conclude that with the expansion of cropland, remaining islands of wooded land, including also fields fallowed for 3 or more years, are particularly valuable pasturing areas for ruminant stock. Measures must be taken that counteract the shrinking of wooded land and forests across the whole region, including also active protection and (re)establishment of drought-tolerant fodder trees.

Keywords: Agro-pastoral system, global positioning system, livestock, Sahelian zone, Sudanian zone

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Cattle and Sheep Foraging Behaviour in a Heterogeneous Subtropical Grassland

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Analysis of foraging behaviour is central to understand grazing distribution and to optimise grassland management. Our objective was to analyse the effects of environmental variables upon foraging behaviour of cattle and sheep co-grazing heterogeneous grasslands of tall and short grasses. Three cows and ewes grazing in a 130 ha paddock of north-eastern Argentina (INTA Mercedes) were fitted with GPS collars during 6 consecutive days in fall, winter, spring and summer 2009. Stocking rate was 0.67 AU ha⁻¹ (cattle:sheep ratio = 3:1). Foraging behaviour was assessed by daily foraging time, speed, sinuosity and daily displacement. Climate and vegetation were also characterised. Behavioural variables were analysed by ANOVA, and its relationships with environmental covariates were explored. Daily foraging time was similar for cattle and sheep in all seasons (10.9 ± 1.5 hours). Cattle moved faster than sheep in spring and summer (7.8 ± 1.8 vs. 4.5 ± 1.8 m min⁻¹), showing similar speeds in fall and winter (6.4 ± 1.2 and 5.7 ± 1.7 m min⁻¹). Displacements were predominantly straight, irrespective of speed. Daily displacements were higher for cattle during spring and summer (5439 ± 1979 vs. 3114 ± 1090 m day⁻¹), being similar between herbivores in fall and winter (4122 ± 770 and 3611 ± 896 m day⁻¹). Since there were no variations in daily foraging time, the displacements were a consequence of the speed, which was confirmed by its positive correlation ($r_{\text{cattle}} = 0.77$, $r_{\text{sheep}} = 0.71$). Cattle walked faster when soil vegetation cover of the tall grasses was 90 %, decreasing above and below this value. On the other hand, sheep walked faster when standing dead biomass of short grasses increased. This could suggest that both herbivores increased their speed tending to increase the encounter rate of the preferred forage as it becomes less abundant. For cattle, lower speeds when soil vegetation cover decreased below 90 % could reflect a threshold where speed increments are not enough to efficiently graze preferred forage, probably causing changes in diet selection to sustain the daily intake. Our results may help to develop criteria based on seasonal herbivore's foraging behaviour to optimise grazing management.

Keywords: Argentina, GPS collars, grazing distribution, mixed grazing

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Ecological and Economical Aspects of the Intensity of Sheep Grazing in the Inner Mongolian Steppe

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An increasing human population and the growing demand for food of animal origin intensified sheep production and lead to widespread overgrazing of the grassland in Inner Mongolia, China. Hence, strategies for a sustainable livestock husbandry that protect the steppe vegetation and at the same time, satisfy farmers' economic interests are strongly needed. We therefore analysed the effects of different grazing intensities (GI) on herbage organic matter intake (OMi) and liveweight gain (LWG) of grazing sheep.

During July to September 2005–2010, a grazing experiment was conducted in the Xilin River Basin (E 116°42'; N 43°38') using 15-months-old, female sheep (31.5 ± 2.0 kg liveweight). Six GIs were tested on two plots each. Plots were alternately used for grazing and hay-making year-by-year. Stocking rates ranged from very light (GI1: 1.9 ± 0.3 sheep ha⁻¹) to very heavy grazing (GI6: 9.7 ± 1.6 sheep ha⁻¹) and were monthly adjusted to maintain similar herbage allowances. In six animals per plot (2009–2010: 4 animals plot⁻¹) titanium dioxide was used to determine fecal excretion, while digestibility of ingested organic matter was estimated from fecal crude protein concentrations. Feces samples were collected on 5 d each in July, August, and September every year. Sheep were monthly weighed to determine their LWG.

Daily OMI ranged between 68 and 89 g kg^{-0.75} liveweight and was not affected by GI ($p = 0.120$). Nevertheless, LWG decreased from GI1 (101 g d⁻¹) to GI6 (70 g d⁻¹; $p < 0.001$) maybe due to higher physical activity of sheep at highest GIs. GI effects differed between years ($p < 0.01$ for both parameters) depending on the amount and distribution of rainfall. Across all years, mean daily LWG per hectare linearly increased from GI1 to GI5 ($p < 0.001$), but was similar at GI5 and GI6. Moreover, OMi of GI5 and GI6 sheep during the 90-d-grazing period reached 763 and 985 kg ha⁻¹, equivalent to 58 % and 75 % of the mean annual herbage production, respectively.

Increasing GI raises output per unit of land area and hence, income for farmers. However, herbage mass at the end of the grazing period limits further increases in LWG at very high GIs and is insufficient to prevent soil erosion during winter months, and thus to maintain long-term grassland productivity.

Keywords: Grazing, inner Mongolia, sheep, stocking rate

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Effects of Alternating *versus* Continuous Grazing on Feed Intake and Performance of Sheep in the Inner Mongolian Steppe, China

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Many studies evaluated the effects of different grazing management systems (GS) on biomass production and the nutritional quality of the rangeland vegetation. Less work has been done on their effects on feed intake and performance of grazing animals. We therefore analysed the effects of two GS on digestibility of ingested organic matter (dOM), organic matter intake (OMI), and liveweight gain (LWG) of sheep in the Inner Mongolian steppe and whether they may differ between grazing intensities (GI) due to differences in the amount and quality of herbage on offer.

A grazing experiment was established in the Xilin River Basin of Inner Mongolia (E 116° 42'; N 43° 38') in 2005 that tested two different GS and six different GI from very light to very heavy grazing. While in the alternating grazing system, grazing and hay-making were alternated annually between two adjacent plots, sheep grazed the same plots every year in the continuous grazing system. In July, August, and September 2009 and 2010, four sheep per plot were selected to determine feces excretion on 5 d per month using the external marker titanium dioxide, while dOM was estimated from fecal crude protein concentrations. Sheep were weighed at the beginning of each month to determine their LWG.

Across both study years, GS did not affect dOM ($p = 0.101$), OMI ($p = 0.381$), and LWG of sheep ($p = 0.701$). However, LWG of sheep decreased with increasing GI ($p = 0.014$). Nevertheless, there were no significant interactions between GS and GI for all measured parameters ($p > 0.05$), indicating that differences between GS were similar at all GI and/or that alternating grazing was not able to compensate for the negative effects of very high GI on animal performance.

In summary, our study showed that despite positive effects on herbage, alternating grazing does not increase dOM, OMI, and hence, LWG of sheep irrespective of GI.

Keywords: Feed intake, grazing system, growth rates, ruminant

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Variety, Harvest Date after Planting, and Fraction of Napier Grass Influence *in vitro* Gas Production

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An experiment was conducted to assess the effect of variety (V), harvest date (HD) and plant fraction (PF) on *in vitro* gas production (IVGP) of Napier grass cultivated and harvested in the humid zone of Ghana. The varieties were Local, 16798, 16786 and 16840. Except for the Local variety, all were improved varieties from ILCA (now ILRI). The HD was at 60, 90 and 120 days after planting and leaf and stem fractions were tested separately. A randomised 4*3*2 factorial design was used to evaluate the amount and rate of IVGP using the automated AnkomRF system.

The results from IVGP showed multi-phasic curves indicating differential microbial degradation rates. Therefore the results were separated into three phases (0–7, 7.5–24.5 and 25–48 hours) based on the mean rate of gas production. Effects of V, HD and PF and interactions on amount and rate of IVGP were tested with linear models (significance: $p < 0.05$). There was significant difference in the rate of IVGP in phase III among varieties with V16798 showing highest values. Rate of V and HD significantly interacted in phases II and III. V and PF interaction was significant in phase III for rate. There was a significant difference in absolute IVGP after 48 hours, with V16798 highest. There was significant difference in the rate for HD in all 3 phases. The rate was highest for HD120 in phase I and HD60 higher in phase II and III. Interaction between HD and PF was significant in phase I and II for rate of IVGP. Total amount decreased with increase in HD (60>90>120). The difference in absolute IVGP was significant for HD after 48 hours. There was a significant difference in the rate of IVGP for PF in all 3 phases. The rate of IVGP was higher for stem in phase I and II, with the leaf taking over in phase III. The overall IVGP for the PF was higher for the leaf but the difference was not significant.

The study revealed that improved and local varieties degraded differentially with large differences in PF and HD and could potentially provide complementary fermentation substrate throughout 48 hours.

Keywords: AnkomRF gas production system, mean rate of gas production, napier grass variety

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Influence of Plantation Species on Quality and Quantity of Honey Production

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This study was carried out to assess the influence of tree species on the quality (taste, aroma, ash content, protein content, moisture content, density and viscosity) and quantity (yield) of honey production. Three mono-species plantation (*Tectona grandis*, *Cassia siamea*, *Eucalyptus glubulus*) situated at the Forest Research Institute of Nigeria, Ibadan, Oyo State, were used for the study. Kenya Tor bar hives replicated three times were placed in each of the plantations for a period of 20 weeks. Monitoring of the hives was carried out at two weeks interval. At the end of 20 weeks the honey combs were harvested. Extraction was carried out manually and proximate analysis was conducted to test for the taste, viscosity, aroma, ash content, protein content, and moisture content. The result of the analysis revealed that the yield of honey was significantly ($p \leq 0.05$) higher in *E. glubulus* plantation (522 ml) while the yield was significantly ($p \leq 0.05$) lower in *T. grandis* plantation (322 ml). The honey obtained from *T. grandis* plantation had the best taste, aroma and texture, while the honey obtained from the *E. glubulus* plantation had the least acceptable taste, aroma and texture. The ash content of the honey from the *E. glubulus* plantation was significantly higher (1.8 cp). The viscosity of the honey from the *T. grandis* plantation was significantly higher (715 cp) than the one of the two other plantations (603 cp and 555 cp) Unite Cunti Poisie. The protein content of honey from the *C. siamea* plantation was significantly ($p \leq 0.05$) higher than the protein content of the honey obtained from the other plantations. It was concluded that the higher the yield the lower the quality of honey that was produced and vice versa.

Keywords: Colony, honey, tree plantation, quality, viscosity, yield

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Effects of Rangeland Management on Soil Properties in a Grassland and a Bush Savannah, South Africa

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The grassland biome and the bush savannah of South Africa are the major resources for livestock farming; yet, the soils of these rangelands are increasingly threatened by overgrazing. The aim of the present study was to investigate how soil properties respond to intensified rangeland management under different property right and management system. For this purpose we sampled different types of rangeland under communal (continuous grazing), commercial (rotational grazing) and landreform (mixture of grazing systems) farming, and within each of these systems we differentiated good, moderate and poor rangeland conditions along a gradient of increasing grazing pressure with decreasing distance to the water points. The analyses comprised the assessment of C, N and inorganic nutrient contents as well as physical fractionation (aggregates, particulate organic matter). The results showed differences between the bush savannah and the grassland in the response of the soils to different rangeland management. In the grassland, the commercial farms exhibited higher nutrient contents for especially C, N and Mg than the other farm types. The communal farms were generally depleted in the respective nutrient stocks. The nutrient depletion increased from good to poor rangeland conditions, *i.e.*, with increasing grazing pressure. Along that line there was an increased breakdown of macroaggregates with losses of the C and N stored therein. In the bush savannah heavy grazing removed more or less all vegetation at the poor sites nearby the water points in communal farms. As a consequence, C, N and most nutrients were depleted. But, and in contrast to the grassland biome, the moderate and partly also the good rangelands exhibited elevated nutrient stocks in the very surface soil (0–5 cm) under intensified grazing pressure, and bush encroachment in the communal and landreform farms, which exceeded those of the commercial ones and the nature reserve. We attribute these findings to increasing bush encroachment at the communal and landreform farms, which is negative for cattle feeding but apparently offers a chance for improving the soils under these management systems.

Keywords: Bush savannah, grassland, overgrazing, rangeland management, soil degradation, soil improvement

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NIRS Prediction of Neutral Detergent Fiber Digestibility (NDFD) of Tropical Forages

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Near infrared reflectance spectroscopy (NIRS) is a method to obtain rapidly information on plant compounds at low cost. It is environmentally friendly as it avoids the use of chemical reagents for analysis. Neutral detergent fiber digestibility (NDFD) is used to estimate energy content of feedstuffs and also as an important criterion in forage breeding. Thus the aim of this work was to develop a NIRS calibration equation for NDFD of tropical forages as a necessary step towards a quick tool for decision making in breeding and in diet formulation to increase productivity on farm. The study was conducted with 238 forage samples (154 grasses and 84 legumes, of which 42 were herbaceous and 42 shrubs). Different plant parts were collected with different cutting ages, vegetative stage and from varying localities forming a group with a high heterogeneity (CV of 36.63 %). They were then scanned and subject to standard laboratory analysis. The groups were analysed by the mathematical treatment 2,4,4,1, complete wavelength, and the mathematical model MPLS (Modified Partial Least Squares). The results of the equation shows an R^2 of 0.95, error of 2.1, 3.2 and 3.6, for standard error of the calibration (SEC), standard error of cross validation (SECV) and standard error for prediction (SEPcalibration) and the RPD (ratio of performance deviation) of 4.4 meaning a high predictive ability. This is associated with a correlation coefficient of 0.96 with a $P < .0001$ and confidence interval of $mbox95\%$. Validation of the equation was conducted with a total of 40 external forage samples (grasses and legumes) showing a SEPvalidation calibration of 4.3, R^2 of 0.93, a correlation of 0.96 ($P < .0001$) with a 95 % confidence interval. In conclusion, the study showed that is possible to obtain a calibration curve for NDFD to predict this trait with high accuracy and reliability for tropical forages, which facilitates decision making by breeders and farmers in suitable time frames.

Keywords: Calibration, neutral detergent fiber digestibility, NIRS, prediction, tropical forages

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Issues and Challenges of Current Agricultural Patterns in India: A Step Towards Sustainability

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The gains of the green revolution in India of the late sixties, which led to a phenomenal increase in crop yield, are slowly losing ground. Intensive agriculture under the green revolution led to depletion of soil productivity, water logging, salinity and ground water degradation. High-valued crop production and diversification with commercial value chains, particularly by large farmers, especially for export markets, may also undermine resource sustainability. With the recent spurt in food prices in the wake of other uncertainties arising out of declining growth in global food production, financial and economic slowdown, climatic variability besides massive land grabbing in parts of the developing world, the challenge is to provide for the food security of 75–105 million new poor globally without depleting land or water resources. In this context, this paper tries to analyse the negative externalities of intensive agriculture in the face of promoting food security to the ever growing population. The study will examine various approaches to meet these challenges. One such method would be integrated farming systems, which are pro-poor, pro-environment and believed to ensure economically beneficial and environmentally friendly agriculture. The study will examine organic farming as an approach to address these challenges. There are ample evidences in the literature to suggest that this would be adopted as an approach to promote economically profitable and environmental friendly agriculture. Using empirical studies already carried out by scholars in India, this paper aims to understand how far such an intervention would promote higher yield and ecologically sustainable agriculture. It also highlights the need for empowering agriculture extension services to promote scientific knowledge to farmers blended with their traditional wisdom.

Keywords: Integrated farming, organic farming, sustainable agriculture

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Rangelands Ecosystems of the Tibetan Plateau: Their Current Status and Sustainable Development Strategies

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Rangelands on the Tibetan plateau support a unique society and culture on the roof of world. Climate change is predicted to worsen the already harsh environmental conditions on the Tibetan plateau. Kobresia meadow is the dominant vegetation on Tibetan plateau, and yak is the key livestock species. Already today, degradation of rangelands and deterioration of livelihoods lead to herders out-migration. Livestock numbers have increased over the last 60 years, though stagnated during the last 10 years; especially yak numbers decreased due to warming and degradation effects. Rangeland degradation is expected to increase with global warming effects, especially in winter. Spots of barren land provoke heavy carbon losses from top-soil: the conversion of 1 ha alpine meadow to barren land result in a loss of 10 cm top soil and about 20–46 tons of soil organic carbon (SOC). It is estimated that close to 5 Mio hectares barren land exist in the headwater region of the Yangtze and Yellow river on the Tibetan plateau, which are estimated to have lost around 247 Mio tons SOC. In consequence of the above, ecological restoration is of first importance to improve Tibetan livelihood. Seed banks for rangeland species and active re-sowing of barren land is important to restore degraded areas. In addition, the pastoral value chain must be integrated, and large, privately managed areas should be dedicated to forage production. Supplying enough and nutritious feed and enhancing the value of livestock products is expected to enable a reduction of livestock numbers and increase herders' income. In addition, fostering the development of biological control of rangeland pests (*e.g.*, grasshoppers) and keeping the ecosystem in balance is needed as well. Overall, the philosophy of sustainable development needs to be incorporated into the regional policy and become as important as economic development. In particular, more 'bottom-up' programs and approaches need to be applied for the improvement of livestock and rangeland management, to ensure the effectiveness of government investments in maintaining the productivity of the Tibetan rangelands.

Keywords: Alpine meadow, degradation, restoration, sustainable development, tibetan plateau

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