Food and Agriculture Organization of the United Nations

South Sudan

Feed management and utilization

guidelines for pastoral and agropastoral areas of South Sudan

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Preface

The Food and Agriculture Organization of the United Nations (FAO) developed these guidelines with the overall objective to protect and improve the productivity of the ruminant livestock species of South Sudan. Focussing on the best use of local feed resources, the guidelines mainly target livestock extension workers promoting livestock feed development good practices to pastoral and agropastoral communities as well as the emerging market-oriented smallholder livestock producers. This document also serves as an important tool for advancing the policy and strategic priority actions of the East Africa Animal Feed Action Plan (FAO and IGAD, 2019) and the draft National Livestock Development Policy of South Sudan.

Equipping frontline extension workers with appropriate tools that help increase the production, management and access of quality and safe feed could ultimately protect livestock asset against climate change-induced crises, increases the availability of animal products, creates jobs and improves social wellbeing of livestock value chain actors.

This document comprises five independent chapters, each designed to convey different but complimentary messages. Users may make use of the chapter of their immediate interest. The implementation of the extension messages intend to help curve the widely observed inefficient management and utilization of the feed resources and the dry season feed shortage across South Sudan.

In order to make the extension messages simple and easy to follow, technical jargons and visual aids have been used sparingly wherever appropriate. Sketches, cartoons and photos compliment the descriptions to further strengthen the comprehension of the messages conveyed.

Acknowledgements

The preparation of these guidelines was preceded by a series of consultations with key stakeholders representing the South Sudan public extension system including the different departments of the national Ministry of Livestock and Fisheries (MoLF), Eastern Equatoria, Western Equatoria, Lakes and Jonglie States MoLF, non-governmental organizations (NGOs) such as the Norwegian Refugee Council and Star Trust Organization, community-based organizations and technical officers from FAO in South Sudan (Juba and field offices). The insights and thoughts of these stakeholders have greatly helped in customizing and fine-tuning the guidelines to the situations in South Sudan and all are thanked for their valuable inputs. FAO South Sudan's reporting unit staff supported the reviewing and formatting of this document. Their contributions are duly recognized.
Thomas Peter drew the sketches and cartoons used to ease the understanding and to help impart lasting impression of the messages communicated. His patience, interest and commitment in the task are much appreciated.

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Introduction

Target audience and objectives

These technical guidelines mainly target livestock extension agents working for government and non-governmental organization (NGOs) in South Sudan, and are meant to facilitate the promotion of livestock feed management and utilization good practices.

If implemented properly, these good practices will improve the management and utilization of locally available feed resources. By applying these good practices, livestock keepers should be able to protect their livestock asset against climate change-induced risks and get more from the livestock they keep. Furthermore, positive change in livestock performance improves food security and nutrition, and the income of vulnerable pastoral and agropastoral communities, as well as the contribution of livestock to the national economy.

The implementation of these guidelines will:

- Promote participatory rangeland management and rehabilitation measures that supports the restoration of rangelands' health and productivity.
- Enhance feed security and year-round supply of feed through proper application of conservation measures and use of roughage densification technologies.
- Improve the resilience of pastoral and agropastoral communities to climate change-induced feed insecurities.
- Support the development of market-oriented livestock production operations and enhance their economic viability.

The importance of good plane animal nutrition

The adequate supply of safe and quality feed is important for maintaining animal welfare and productivity. This is also important to increase the production and access of safe animal source protein to livestock producing households and consumers. The plane of livestock nutrition strongly affects animal health since the nourishment of an animal determines its immune system and ability to fight diseases. A malnourished animal is physically weak and morbid and readily succumbs to the effects of diseases and parasites. The right feed and feeding system are thus essential for sustaining the desired state of animal health, reproduction and production.

Practical evidences in many countries show that proper feeding contributes to over 60 percent of improvement in livestock productivity. In economic terms, nutritionally sound and efficient feeding systems could bring enormous economic benefits as the cost of feed in livestock produced for selling account for about 70 percent of the total livestock production expenses.

In South Sudan, livestock production is largely subsistence-oriented with heavy reliance on rangeland forages and crop residues as source of livestock diet. Rangelands, which contribute to the largest share of livestock feed, undergo marked seasonal fluctuation in forage production. When such seasonal forage availability coincides with prolonged periods of feed deficits, it causes hidden but glaring economic losses to subsistence pastoral and agropastoral systems; undernourished animals take longer to reach sexual maturity, milk production and reproduction plummet, and morbidity and mortality rise in extreme circumstances.

The negative consequences of the unstable supply of livestock feed on the production of livestock products, notably milk, is particularly critical as it compromises the health and productive capacity of livestock keeping communities and the country's population at large. Lack of access to animal source food causes stunting and wasting in children, and micronutrient deficiencies in pregnant and nursing women.

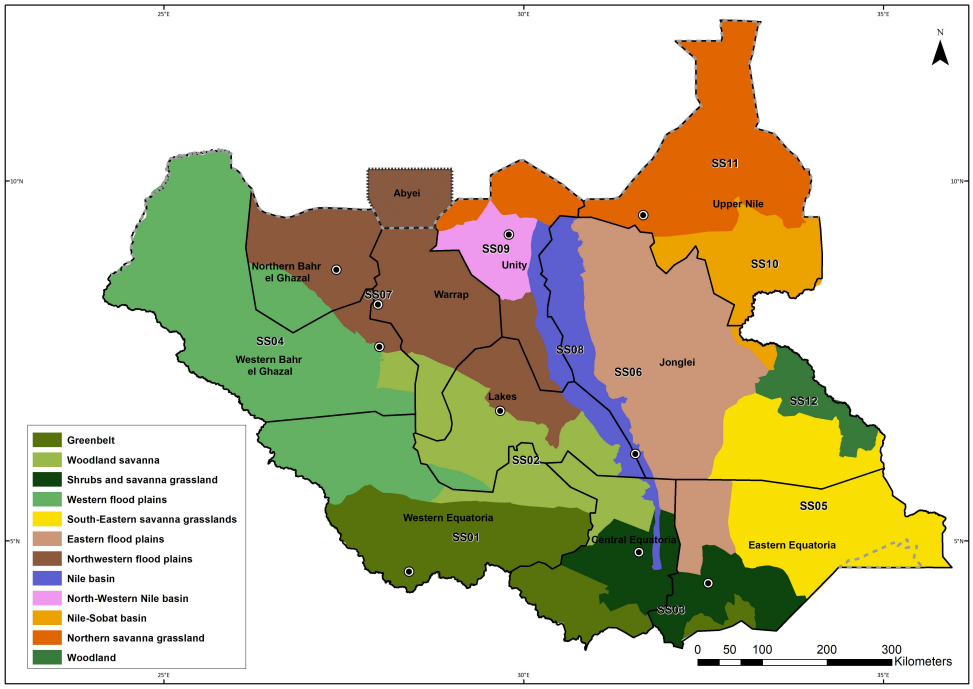
Main source of livestock feed

Grassland forages

In South Sudan, grasslands account for over 62 percent of the country's total land cover (Land Cover Atlas South Sudan, 2011). The grasslands harbour a wealth of diverse plant and animal biodiversity and encompass protected habitats. Forage from the open and woodland grasslands provides much of the feed consumed by the grazing animals in the pastoral and agropastoral production systems. The predominant vegetation structure that make up the grasslands include grasses, forbs and shrubs.

Based on the annual forage biomass production and vegetation structure, the grassland in different eco-zones bear different names. The major ones include savanna grassland, shrub savanna grassland, savanna woodland and flood plains, locally identified as Toiches (*Figure 1*).

Figure 1. Vegetation types of South Sudan



Source: Famine Early Warning Systems Network (FEWS NET), 2018

Each of these grasslands portray marked microhabitat diversity and bear the following unique features:

- Savanna grasslands exhibit wide variability in annual biomass production, mainly due to the spatial difference in the amount and duration of rainfall. Savanna grasslands in semi-arid lowlands, for instance, produce much lower biomass than the humid and sub-humid environments. These savanna grasslands make up the stretch of land covering the eastern and southeastern parts of the country. The grasslands in these eco-zones receive annual precipitation of 300–800 mm and have a plant growth period of 100–120 days. The dominant grass species include *Hyparrhenia, Andropogon, Cenchrus* and *Panicum*. Sparsely distributed *Combertum*, *Acacia* and *Balanite* species also make up the integral part of the savanna grasslands. The trailing and climbing *Neonotonia wightii* herb is also noticeably present as an understory vegetation in this grassland category. Areas under savanna grassland oftentimes experience extreme seasonal feed and water shortages.

- Shrub savanna grassland refers to the vegetation type with predominant grasslands with scattered shrubby trees. It is present in the semi-arid environment of the country inhabited by pastoral communities.

- Savanna woodlands account for the largest share of the grasslands and fall in between the shrub savanna grassland and the forestland that extends from the northwestern to the western international borders of the country. This grassland category lies along the previous Green Belt Region of Bahr El Gahzal, Western Equatoria and parts of Central Equatoria. It is a relatively wetter environment with 800–1 200 mm annual precipitation and growing period exceeding 180 days resulting in high primary forage production as well as a high *tse tse* fly threat to livestock production. The savanna woodlands share much the same grasses species with that of the savanna grasslands with favourable distribution of trailing legumes particularly *Neonotonia wightii*.

- The flood plains, where biomass production is high, include the Nile Basin and the Nile-Sobat Basin. The flood plains constitute important dry season grazing reserves for livestock coming from far and wide.

Grasslands make for the largest part of the country's land cover and the feed available to the ruminant livestock population is from grass. These grasslands vary with landforms, vegetation structure, biodiversity, biomass production and seasonal availability of forage.

Crop residues

In the agropastoral areas of South Sudan, crop residues briefly contribute to the feed budget of ruminant animals. With the return of peace to the country and the engagement of returnees into crop production, the contribution of crop residues and crop aftermath grazing to the annual livestock feed budget is expected to increase considerably. Presently, the agropastoral communities grow a variety of crop species. Among others, these crops include maize, sorghum, rice, groundnut, cowpeas, beans and horticultural crop species.

Crop residues.

State of livestock feed

Rangeland degradation

The shrubs and understory herbaceous forage, which provide the bulk of the ruminant animals' diets in South Sudan, are under constant threats of climate change and human activities. In the last decades, the country has experienced a series of extreme weather events such as high variability in precipitation and heat waves. These phenomena have disrupted the rangeland ecosystem and caused a wider fluctuation in forage and water supply, negatively impacting livelihoods, security and way of life.

Inappropriate human activities, such as prolonged heavy grazing pressure and unregulated wildfires, have triggered the degradation of the rangelands in South Sudan. The prolonged heavy use of the rangelands is, in part, associated with the growing incidences of cattle rustling that curtails seasonal livestock mobility and culminates in the loss of rangeland grass cover in relatively safer areas. Frequent and uncontrolled fires have had similar effect on the grass cover. Rangelands that have lost its grass cover are prone to all kinds of soil erosion including loss of top soil by wind and rainwater. It is common to note that the latter eventually develops into gullies.

Another form of rangeland degradation becoming evident in the savanna grasslands involves the shift in its vegetation structure, where invasive plants are seen to increase in abundance. These plant species could either be indigenous or alien in origin.

Prosopis juliflora, an alien invasive plant in South Sudan's rangelands.

The alien invasive plant species presently getting the foothold in the rangelands of South Sudan are *Prosopis juliflora* and *Calitropis procera.* These invasive plant species are known for their prolific seed production and unique adaptive traits to rapidly spread into rangelands once introduced.

Inefficient management of crop residues

The use of crop residues as an importance source of livestock feed is growing, although its management is inefficient and subject to huge wastage. Among the majority of agropastoral households, the commonest form of crop residues and crop aftermaths utilization is direct grazing. This direct use destroys the largest share of the biomass through trampling and soiling. It also shortens the period that ruminant animals feed on crop residues.

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Preparing crop residues for grazing.

Post-harvest management of crop residues is critical since proper management minimizes wastage and improves nutrients' bioavailability and the storage life. Proper post-harvest management involve:

- Timely harvest of crop residue biomass to minimize the risks of livestock and weather damage.
- Use of drying platforms to encourage rapid drying and reduce loss of leaves through shattering. This is particularly necessary for leguminous crops such as groundnut and cowpeas.
- Store cured crop residues under sheds as such structures provide protection against sunlight, rain, flood and termites damages. Chaffing and baling could save storage space and ease subsequent utilization.

The following good practices improve the efficient use of crop residues:

Harvest crop residues timely in order to minimize the risks of livestock and weather damage.

Use drying platforms to speed-up drying and reduce leaf loss through shattering. This is particularly necessary for leguminous crops such as groundnut and cowpea.

Protect crop residues from sunlight, rain, flood and termites damage by storing it under shed. Chaffing and baling could economize storage space and ease subsequent utilization.

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Improving rangeland health and productivity

Promoting participatory approaches

Mapping rangeland resource key actors

The challenges facing South Sudan's rangelands are complex and multi-dimensional. Insecurity, resource use conflicts, prolonged heavy grazing pressure, pervasive and indiscriminate use of wildfire, introduction of invasive plant species, the weakening of the traditional natural resource management system, limited use of rangeland restoration good practices and weak institutional support – all contribute to the continued decline in the condition of the rangelands. Addressing these challenges would require the involvement and active participation of resource users and various interest groups.

The identification of these stakeholders is necessary to understand the concerns and define the roles and responsibilities of each key actor. More importantly, the identification of key stakeholders is useful to reinforce customary institutions and community-based organizations who are responsible for leading the overall management and influence policy decisions necessary to ensure the sustainable management of rangeland resources.

Rangeland stakeholders' dialogues.

The first important step in participatory rangeland management is mapping the key actors, which among others involve the broad categories like rangeland users, policy makers, community-based organizations and the private sector. Essentially, the task requires carrying out a stakeholders' analysis that defines the rights, responsibilities, relationships and benefits. *Table 1* provides the framework for conducting such a stakeholders' analysis.

Table 1. Rangelands stakeholders' analysis matrix

Stakeholders	Rights	Responsibilities	Relationships	Benefits
Stakeholder 1				
Stakeholder 2				
Stakeholder 3				
Stakeholder 4				
Stakeholder 5				

Rangeland resources and mobility mapping

Demarcating the boundaries of the target area and getting adequate information on the rangeland and the related resources are crucial to properly plan and implement rangeland management interventions. The grazing resources and mobility maps are thus tools to conduct a rangeland situation analysis, prepare appropriate plans of action, share roles and responsibilities and negotiate over resource use. Specific tasks in the rangeland situation analysis involve identifying the biophysical, socio-economic and political conditions including the vegetation structures, key grazing resources and infrastructures, livestock mobility routes, and the grazing resources governance system.

Community drawn resources maps give a good insight on key rangeland resources and associated challenges, livestock mobility routes and boundaries. While drawing the rangeland resources and livestock mobility maps, it is important to ensure the participation of the key resource users.

Resources maps help stakeholders visualize the present state of the rangelands but do not show the direction of desired change. Once the present state map of the rangeland resources is completed, the same rangeland users groups are requested to draw the rangeland resources vision map to portray the desired state of the rangeland in three to five years or longer.

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Community drawning rangeland resource maps.

The community drawn 'present' and 'vision' maps are further reinforced and upgraded through transect and GIS maps. The transect map helps to conduct a detailed analysis of the key resources along the cross-section of the landscape. The key resources constitute soil types, water resources, cultivated crops, vegetation structure, kinds of forages and the livestock species raised. The GIS map, other than capturing the rangeland resources and livestock mobility routes, help facilitate decision-making, storage of information and the subsequent monitoring and evaluation of the action plans. Table 2 presents a template for developing a rangeland management action plan.

Table 2. **Participatory rangeland management action plan**

Location	Key intervention	Resources required	Timing of action	Responsible stakeholder

Participatory rangeland management promotes sustainable and equitable use of natural resources. It takes into account priorities and concerns of all relevant actors and engages them in policy dialogues and implementation of good practices.

Rangeland management and restoration measures

Rangeland management restoration refers to sound management practices that optimize the health and productivity of grasslands. It involves defining the objectives and preparing a detailed workplan for the implementation of rangeland management good practices. Among others, the core priority tasks constitute the rangeland stakeholders' analysis and resources appraisal. Effective implementation of these priority tasks helps impart the sense of ownership and facilitate the implementation of sound management measures to restore the health and productivity of the rangelands. A variety of rangeland restoration measures is available. The ones believed relevant to the rangelands of South Sudan are briefly presented below.

Stock exclusion

Stock exclusion is a rangeland management practice where we rest the grazing land for at least one growing season. Periodic resting of rangelands encourages the emergence of range plants from soil seed banks and the regrowth of shoots from dormant stalks. Depending on the state of the rangelands and the climatic conditions, the resting period could last for one or couple of growing seasons. With the release of the grazing pressure, grass and other forage plants from soil seed banks and weakened stands start to emerge and improve the vegetation cover. Periodic resting reduces the exposure of the soil surface to all kinds of erosion, increases the infiltration of rainwater and recharges the ground water.

Stock exclusion allows emergence of pasture from soil seed banks.

The ideal length of rest period and mode of forage use

Depending on the rainfall, soil seed banks and fertility of the soil, stock excluded rangelands are usually put back into use following one to two rainy seasons rest periods. The mode of the renovated rangeland use is conditional. It could either be directly grazed if the stock excluded area is less prone to erosion or used through cut-and-carry system (or haymaking) where it is situated in steep slopes.

Reinforce rangeland through reseeding

Rangeland reseeding is the manipulation of the forage species mix. The practice improves the feeding value and biomass production capacity of the rangelands. Such actions are particularly important in rangelands that have lost the vegetation cover and soil seed banks due to prolonged heavy grazing. Rangeland reseeding is simple and relatively less costly as it requires small amount of seed and less elaborate seedbed preparation.

Restored dry season grazing reserve.

How to encourage rapid establishment of introduced forage species?

Moderate level of soil surface disturbance and the proper timing of a rangeland reseeding programme improve the establishment of introduced forage species. To improve the seed soil contact and hence establishment of introduced forage species, it is necessary to remove existing above ground vegetation cover through heavy grazing, controlled burning, lightly cultivated narrow strips, kraaling or micro-catchment structures. Seed soil contact can be further improved by over-sowing of the desired forage species seeds and driving flocks of small stock, which through their hooves bring the seed in contact with the upper soil layer. For best effect, it is advisable to carry out the range reseeding exercise at the start of the rainy season.

Micro-water catchments encourages the establishment of reseeded forages.

What species to use for rangeland reseeding?

A wide variety of forage crop species suits rangelands reseeding programmes. The characteristics required from the forage species intended for reseeding is the ease of establishment, ability for self-reseeding and spread under heavy grazing and better feeding value. Both grass and legume species suit rangeland reseeding programmes, although the latter is preferred because of the high protein and mineral content and slow drop in digestibility with maturity. Among the leguminous forages, *Neonotonia wightii, Stylosanthes species (S. guianesis* and *S. hamata), Siratro (Macroptilium atropurpureum),* and Silver leaf *Desmodium (Desmodiumuncinatum)* are the most suitable species for range reseeding programmes.

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Neonotonia wightii competing well with the grass species.

Where to start rangeland reseeding?

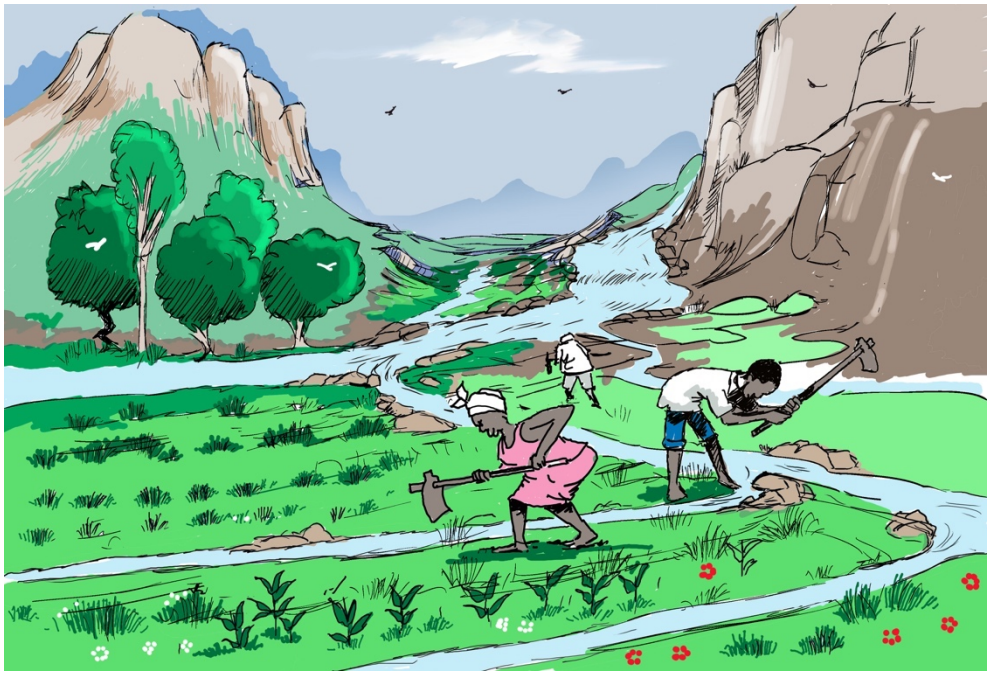
Rangeland reseeding is most suitable for reinforcing parcels of grazing land close to cattle camps around permanent settlement areas or erosion prone steep slopes. These grazing reserves provide forage to lactating, pregnant and weak animals during the long dry season. Fodder from grazing reserves, particularly those reinforced by herbaceous or woody forage legumes, could provide strategic supplement to lactating animals and help to put an end to seasonal migration of such productive animals to distant grazing areas.

Management of invasive plant species

Invasive plant species are plants that alter the health and productive state of rangelands, and the socio-economic welfare of livestock keepers. Invasive plant species can either be of native or foreign origin. Such plant species have characteristic adaptive features that help them proliferate and rapidly spread across the rangeland ecosystem. With a supportive policy environment and appropriate institutional setup, the implementation of technical measures can help minimize or avoid the threat of invasive plant species.

The management of invasive species involve four key steps – prevention, early detection and rapid response, control and management, and rehabilitation and restoration.

- Prevention: This refers to actions put in place to deny invasive plant species from getting foothold in the rangeland ecosystem. It involves the proactive monitoring of the rangeland to prevent the introduction and spread of new and undesired invasive plants into the ecosystem. Such preventive measures include establishing herders' scouts and natural resource management committees who regularly monitor the rangelands, and conducting wide-stakeholders' workshops to educate and raise awareness on the threats of invasive plant species and reduce the chance for unintentional introduction of new invasive plant species.
- Early detection and rapid response: Detect and irradiate invasive plant species to stop them from invading. When new invasive species are detected, a quick and coordinated containment and eradication response can reduce environmental impacts and prevent the long-term commitment of scarce resources. Rapid response to new infestations results in lower cost and lesser damage to rangeland resources. Early detection of new infestations requires vigilance and regular monitoring of the rangeland.
- Control and management: Eliminate or control invasive plant species of priority importance. The strategic approach to consider while planning the control of the priority invasive species is timing, understand site condition and species biology, and follow-up monitoring.
- Rehabilitation and restoration: This refers to measures implemented to heal, minimize or reverse the harmful effects of invasive plant species. It involves the rehabilitation of the invaded areas to their ecological functions after the removal of the invasive species. More importantly, this would require preventing the re-establishment and reducing long-term costs.



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Flood diversion encourages rangeland forage regrowth.

Spate irrigation in rangelands

Spate irrigation is a kind of flood water management commonly practiced in arid and semi-arid environments where mountain catchments border lowlands. The practice involves diverting flood water from ephemeral streams to crop fields or rangelands, or to refill drinking water ponds. Some countries of Africa, the Middle East, South and Central Asia and Latin America have used the practice for hundreds and thousands of years to grow food crops. Spate irrigation, when combined with improved forage production husbandry, could improve livestock productivity and the resilience of livestock keeping households.

The physical structures used in spate irrigation range from low-cost traditional diversion canals and the earthen gabion reinforced structures to the highly sophisticated physical structures with raised weirs. Floodwater diversion and distribution structures used in traditional and advanced spate irrigation schemes are guided by local knowledge and long-term hydrological/sediment transport data, respectively. In the rangeland settings, the preferred spate irrigation systems are the ones with simple and low-cost structures, i.e. diversion and distribution canals directing floodwater onto the grazing lands destined for dry season feed reserves.

What are the benefits of spate irrigation in the rangelands?

Improving the soil moisture regime through spate irrigation encourages the flush growth of both herbaceous and woody vegetation cover and hence enhances the resilience of the pastoral communities to periodic feed insecurity.

The improvement in soil moisture regime in spate-irrigated areas relates to the alluvial deposits, which has higher moisture holding capacity and fertility than the predominantly sandy textured rangeland soils. The increased availability of nutritious forage extends the duration of grazing well into the dry season. This will, at least support lactating cows producing the badly needed milk to the target pastoral community. By increasing the groundwater recharge, spate irrigation also improves the pastoral communities' access to water and fuel wood.

How best to use forage biomass developed through spate irrigation?

In order to make the best use of the forage developed through spate irrigation and minimize wastage, it is important to give adequate attention to the mode of utilization. As much as possible, the direct usage of fodder should be avoided. Direct grazing or browsing, other than being inefficient could risk damaging the canals.

In a spate irrigation scheme with a command area of 50 ha rangeland, it is possible to obtain 250 tonnes of forage dry matter (DM), at 5 tonnes DM yield per ha. At an average 3 kg per head of daily feeding of the grass-hay, the 250 tonnes DM will support 600 milking cows for five months. In doing so, pastoral and agropastoral communities can keep lactating cows within the permanent settlement areas for the entire part of the year.

Key steps in spate irrigation

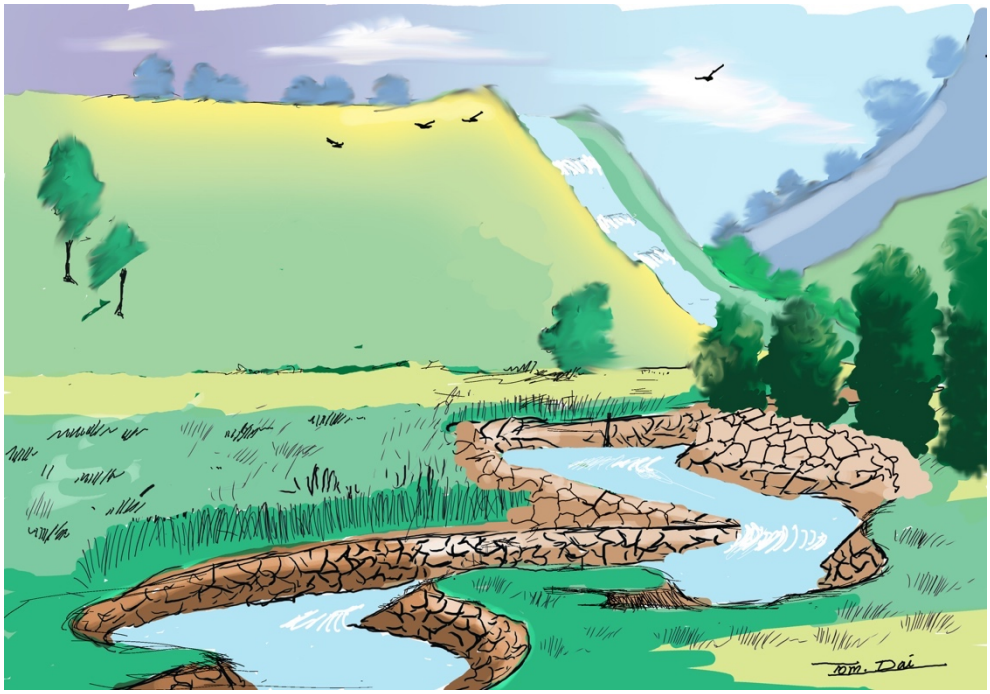
The restoration of rangelands using spate irrigation, as it demands building and maintaining structures and canals, is labour intensive. Hence, it requires the full engagement of the target communities and a sustained close follow-up. To realize this, all members of the target beneficiary communities have to be engaged in the entire process, i.e. from planning to the implementation of the spate irrigation scheme and in the utilization of the improved grazing resources. Reinvigorating the customary institutions, which traditionally entrusted with the authority of mobilizing communities and administering the grazing resources, is particularly important to ensure the sustainability of investment on spate irrigation.

There are unique and specific activities to follow while applying spate irrigation under rangeland conditions. The most important activities include:

- Select an ideal place for the diversion of the flash flood from normal watercourses. Preferred spot for diverting flash flood is where the likelihood of damage to diversion cannels is relatively low and the command area of the distribution canals is large. It is important to avoid diversion points from spots where flash water flow is large and most distractive.
- Construct diversion channels, where possible, with the retention walls reinforced with gabions or at least stone based physical structures and distribution canals reinforced with less invasive plant coverage. This minimizes the frequent demand for labour and the maintenance cost of diversion channels.
- Enclose the flooded grazing reserve with the use of earthen bunds reinforced with shrubs and trees of high feeding value, which increase the infiltration of flood water into soil and subsequent availability of moisture around the root zones of range plants.
- Adopt efficient conservation measures for the forage biomass produced via spate irrigation and preferentially use the conserved forage materials as dry season feed reserve and use it to sustain the production of milk for the households and/or for the market. The marketing of dairy products is particularly important since this could become an incentive for maintaining the diversion and the distribution canals.

Gully prevention and treatment

In rangelands or other forms of land uses, gully formation signifies an advanced stage of land degradation. Gully erosion considered to have occurred when run-offs erode soil to form channels deeper than 30 cm. Large and unregulated surface water run-offs when combined with soil disturbances, overgrazing, cutting of trees, and loss of vegetation cover would form deep gullies in a matter of a single rainy season. Gullies are signs of poor surface water and rangeland management that results in loss of soil, high surface run-off, low ground water recharge and low rangeland productivity.



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Gully treatment protects soil and rangeland vegetation.

How to prevent gully formation?

Preventive measures are much easier and less costly than treating gullies that often demand structural measures. Failure to take timely actions on sheet and rill erosions and incipient gullies may lead to the creation of big gullies. In rangelands that receive run-offs from heavy rain or flash flood, such big gullies sometimes engulf a chunk of grazing land or any nearby physical infrastructures. Preventive measures that halt the progression of incipient gullies or other forms of soil erosion into big gullies are the following:

- Build the capacity of local communities on sound rangeland management practices and soil and water conservation measures.
- Control unregulated bush fires. The indiscriminate use of bush fire is a serious threat to the rangelands, and the wildlife biodiversity and their habitat. Frequency, timing and intensity of bush fires have implication on the survival of plant species. Building the technical skills of extension workers and the community to straighten out the use of fire as rangeland management tool is crucial.
- Maintain adequate herbaceous and woody vegetation cover by adopting good grazing practice, herbaceous forage reseeding, and shrubs and trees planting schemes.
- Release the pressure on woody vegetation through the promotion of energy efficient stoves. This involves introducing innovative and affordable energy

saving cooking stoves. Solar stoves are the preferred options as it reduces dependence on ever-dwindling natural resources and foster the longer-term restoration of the biodiversity wealth.

- Incorporate soil and water conservation measures (e.g. trenches and terraces) that help retain and infiltrate surface water above the gully prone areas.
- Pastoral and agropastoral communities can be engaged in watershed management practices through efficient soil and water conservation activities, which help in reducing run-offs and encourage the recharge of the ground water.
- Construct diversion channels that direct run-offs away from gully heads to vegetated areas.

When to start reclaiming gully affected rangelands?

This is the process of reclaiming rangeland disturbed by excessive run-off to its original productive state and prevent further damage. In the implementation of gully treatment programmes, time is of the essence. Ideally, it is advisable to start the gully treatment as soon as it is observed. Any delay may worsen the damage and make the reclaiming exercise very difficult.

What are the common gully treatment measures in the rangelands?

Gully treatment measures involve the filliping, shaping and constructing of physical structures and the applying of complimentary biological measures that help restore the productive state of the rangelands. Gully treatment measures varies with the scale of the damage and slope gradients. The generic gully treatment measures of practical relevance to the rangeland conditions are the following:

- Filling and shaping of gullies involve plugging the gully with loose stones, logs, constructing check dams across the gully bed and building retention walls using gabions.
- Diverting peak flow of surface water from the gully heads and excluding livestock from the treated area, which delay or interfere with the gully healing process.
- Re-vegetating gullies artificially using hardy grasses and shrub trees.
- Stabilizing treated gullies through the construction of diversion channels that direct run-offs away from gully heads to vegetated areas.

Controlled fire


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Controlled fire helps properly manage rangelands.

Where properly used fire is an important rangeland management tool. It helps to manipulate the rangeland vegetation structure, increase forage availability and suppress invasive woody species by killing sapling and seedlings that grow to form impenetrable tickets. During the colonial era, in the then Sudan, chiefs used to effectively manage wildfires with no or limited negative impact on the grasslands' biodiversity. Such traditional practice was comparable with the present-day so called 'controlled fire'. Controlled fire is important to prevent the buildup of ticks transmitting parasites.

Pastoral and agropastoral communities in South Sudan use fire to stimulate the growth of lush grass, honey hunting and converting forestland for crop production. As the traditional use of fire is unregulated and indiscriminate, oftentimes it does much harm than good. During the latter part of the dry season, extensive bush fires are common scenes everywhere in the rangelands with devastating effect on the rangeland forage supply, biodiversity and the ecosystem.

For desirable impact while applying controlled fire it is necessary to observe the following:

- Conduct the controlled range fire when grasses are dormant. This is important to inflict less damage to herbaceous grass vegetation.
- To control the spread of fire, first burn or plough the perimeter (i.e. firebreak) of the target rangeland site when the weather is cool and the fuel load (grass and brush) is not bone-dry.
- Use backfire (burn the fuel-load opposite of the prevailing wind) to allow herbaceous forage to resume growth or recover with the start of the growing season. Head fire, on the contrary, has a higher fire intensity. It depresses the regrowth of grass sward and destroys soil fauna and flora.
- To achieve maximum level of kill on invasive woody plant species, complement the controlled fire with other bush control strategies (e.g. ring-barking, stumping and additional crown fire).
- Control the spread of invasive woody species by applying controlled fire on saplings and seedlings. Fire causes maximum mortality to young trees and bushes of less than two metres.

Grazing management systems

Forage from the rangelands can be put into use in a number of ways. In the pastoral and agropastoral production systems, direct grazing by herbivore animals is the commonest form of forage use. When grazing is the mode used, it is good to allow enough pasture regrowth to encourage root development and accumulation of food reserve. In no condition should animals be allowed to graze below the growing point.

Grazing is the main natural resource utilization strategy largely governed by social structure that mediate access to grazing resources. The grazing intensity (stocking rate) and duration have important bearing on the health and productivity of the rangelands, and the performance of animals. Extremes forms of animal use, i.e. underutilization and overutilization, as they both alter the vegetation cover and the species composition are not desirable. Heavy grazing pressure applied for an extended period removes the above ground vegetation cover beyond the point of recovery and cause irreversible damage to the rangeland. Very low grazing intensity leads to the inefficient use of the rangelands and encourages the botanical composition to shift in favour of pasture species of low feeding value. Any grazing system, when used inappropriately, could result in one or both of the above outcomes.

Commonly used grazing systems

Continuous grazing

Continuous grazing is an extensive form of rangeland use. In this grazing system, grazing animals freely harvest the pasture in a given locality for prolonged periods. Where the seasonal mobility between wet and dry grazing areas is functional, the duration of continuous grazing in the pastoral production system is demarcated by season. In such cases, continuous grazing poses little negative impact on the health and productivity of the rangelands. The deterioration of the rangelands condition become a problem when conditions force to alter the traditional mobile form of rangeland use. The currently observed high incidences of cattle rustling is forcing pastoralists to maintain grazing animals in the same pasture beyond one season.

Continuous grazing cannot compromise rangeland health and livestock performance as long as livestock keepers observe the following management practices:

- Maintain seasonal mobility to avoid underutilization of dry season grazing lands and the overutilization of the wet season grazing areas.
- Minimize buildup of tick and nematode infestation through the introduction of controlled fire.

Deferred grazing

Deferred grazing is a practice where pastoral and agropastoral communities set aside standing hay around homestead for use during the lean season. This kind of grazing reserve provides forage for young stock, lactating, pregnant and weak animals. These grazing reserves could belong to a community group but in some circumstances, individual households may also maintain their own dry season grazing reserve. The deferred grazing system encourages range regeneration since soil seed banks replenish from seeds falling from the standing hay. Deferring the use of forage from the grazing reserve up until the advanced stage of physiological maturity, however, compromise the pasture feeding value.

Measures to improve the usefulness of deferred grazing include:

- Reinforce the grazing reserve with leguminous forages (herbaceous and woody legumes), which normally have much slower drop in forage nutritive value with advance in physiological maturity.
- Compliment the standing hay grazing with strategic supplementation using conserved forage preferably leguminous forage leaf meals, processed browse tree pods or concentrates.

Standing hay provides maintenance diet to grazing animals.

Rotational grazing

This grazing system is applicable to productive pastureland. It is an intensive system that requires investment to partition the grazing land into small parcels or grazing units. Livestock keepers could use live shrub hedges or wooden fences to sub-divide the grazing lands. Depending on the size of the herd and area of the parcel, animals graze each parcel for a week or less before it moves to the next. This system allows animals to utilize the pasture at the proper stage of physiological growth and provides enough time for the grazed unit to recover.

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Rotational grazing demand partitioning grazing land into small units.

Zero grazing

This system is applicable in areas where direct grazing is prohibited due to the fragility of the grazing land. Oftentimes, this grazing system is put into use either for soil-water conservation in steep slopes or the efficient use of introduced high value cultivated forages. The biggest challenge in zero grazing systems is the high labour and transport cost needed for harvesting and transporting of the forage biomass. In the absence of simultaneous soil fertility restorative measures, either through manuring or application of mineral fertilizers, the pasture deteriorates due to the continuous mining of soil nutrients.

Adequate understanding of the rangeland landscape, forage species mix, and local grazing resource management help make rational decisions on the most suitable grazing system of a given pastureland.

The selected grazing system should always strive to strike favourable balance between nutrient yield and the health and productivity of the grasslands.

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Assessing rangeland condition.

Monitoring rangeland conditions

Change in rangeland conditions refers to the alteration or shift in vegetation structure, species (floristic) composition, basal cover and biomass production. These changes occur due to anthropogenic (human) activities and natural factors including grazing practices, manipulation in species mix, soil erosion, uncontrolled bush fire, drought, heat waves, pests and diseases.

What does rangeland condition monitoring entails?

The monitoring of the rangeland condition is the process of describing, evaluating and recording the state of the rangeland management unit. The complexity and sophistication of the rangeland monitoring programme is subject to the availability of technical skills, time and cost. These circumstances also affect the rangeland monitoring design and the rangeland attributes measured. As much as possible, rangeland condition monitoring techniques have to be simple and easy to apply.

Practical rangeland condition monitoring techniques

Systematic and simple monitoring techniques help rangeland users to appraise the rangeland condition and make an informed decision on follow-up actions. For practical purpose, the rangeland condition monitoring exercise centres around few key species and the states of the soil condition.

Easy to apply rangeland monitoring techniques include basal cover of key forage plant species, frequency of key species, biomass yield of key forage species and browse or tree identity.

Basal cover of key forage plant species

The key forage species are the palatable forage plants whose proportion declines with duration and intensity of grazing and replaced by the less palatable herbaceous grasses or shrubs.

Steps followed in determining the basal cover of key forage species include:

Step I. Identify the site in terms of landform, period of use and GIS coordinate.

Step II. Fix a 50 m long line transect on an easily identified spot of the grazing unit (use GPS coordinate reading or physical reference point, e.g. an outcrop of rock or big tree).

Step III. Carry out the basal cover measurement along the 50 m long line transect:

- Lower a metal rod (stick) to the tip of the sampler's toe in each step perpendicular to the ground surface and record strikes that touch the crown or base of the key forage species.
- If no strike, take the nearest key plant species 15 cm from the point of strike.
- In the absence of nearest key plant species or any other plant species, the strike is considered to have touched bare soil.

The key species basal cover can be determined by dividing the number of key plant strikes by the total number of times the rod is lowered.

Frequency of key species

Frequency is the vegetation attribute that describes the probability of finding a species within a particular area. Frequency is expressed as a value between 0 and 100 percent, representing the proportion of quadrats where the particular species was found during sampling. The occurrence of the species is determined as follows:

Step I. Fix a 50 m long line transect using pegs in the target rangeland site.

Step II. Determine the presence or absence of species within the quadrat placed in fixed distance along the transect.

Step III. Determine the proportion or frequency of the key species by dividing number of quadrats the species occurred by total number of quadrats placed along the transect.

Biomass yield of key forage species

Optimizing the level of key forage plants' use by grazing animals is important to maintain the health and productivity of the rangelands. The advocates of sound rangeland use recommend that the forage biomass removal from key species not exceed the 50 percent mark by the end of the grazing season.

Step I. Fix a 50 m long line transect using pegs.

Step II. Determine the dry matter (DM) yield of key pasture species:

- Take record of biomass at an interval of 20 steps using 0.5 m * 1 m quadrat harvests, i.e. two quadrat sample points per site (20th and 40th steps).
- Harvest biomass to ground level using sickle or scissors.
- Sort plant constituents in sample quadrat by species and record fresh weight.
- Take small sub-sample and oven/air dry to determine DM percentage.
- Determine the key forage species including the other pasture species constituents DM yield by multiplying fresh yield with DM percentage.

Browse or tree identity

Step I. Fix the four points of the belt transect (4 m * 50 m) using pegs.

Step II. Take GPS reading of the four corners of the belt transect for future reference.

Step III. Count each browse species and enter the number into the data sheet (if possible, species could be identified by its English and/or local name).

The practical benefits of periodic monitoring of rangeland conditions include:

Describes and understands the ecosystem including soil, vegetation structure and habitat.

Tracks grasslands condition changes and makes appropriate management decisions.

Determines the type of rangeland use and livestock carrying capacity.

Feed conservation, processing, packaging and feeding

Feed conservation

Feed conservation is useful to stabilize the year-round supply of livestock feed. It eases storage, minimizes wastage, maintains feed quality and diversifies the sources of supplemental feed. The stable supply of feed, particularly during the peak dry season, prevents loss of livestock body weight and sharp drop in milk production and increased vulnerability to diseases and parasites.

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Assessing rangeland condition.

There are several methods, which producers could use to efficiently store and preserve forages for lean periods. It is also important to recognize the fact that conserved materials do not match the nutritive value of fresh forage. This is so because conserved feed looses part of its digestible nutrients (proteins, sugar and fat) in the course of storage and conservation. Proper feed conservation and storage, however, can minimize such nutrient losses.

The palatability, intake and digestibility of forage drops with advance in the developmental stage of pasture. Conserve forage at growth stage where forage quality and quantity are optimized.

Timing forage harvesting for hay or silage

Appropriate decisions on the forage harvesting time help conserve forage DM biomass with reasonable quality. Harvesting forage at vegetative stage of growth produces biomass with high crude protein, intake and digestibility values but severely compromise DM yield. As a thumb rule, it is good to harvest grass and leguminous forage as soon as the floral parts start to emerge. This is a period where one notices visible signs of change in plant growth from vegetative to reproductive stage.

Suitability of conservation techniques

The suitability of conservation techniques is dependent on a number of conditions. Among others, these include forage morphological characteristics, storage facilities, weather condition and the intended use of the conserved forage material. Irrespective of the weather condition, rangeland forages, improved fodder crops and crop residues with thick stocks and high moisture content suit the silage-based feed conservation. Cactus (*Opuntia ficus indica*), elephant grass, and any succulent freshly harvested fibrous feed fall under this category. On the contrary, fine-stalked forages can ideally be conserved as hay. Forage sources that suit haymaking are native and improved grasses, legume leaf meals and shrub/tree pods.

Hay preparation

In contrast to silage production, haymaking requires aerobic and dry conditions. It is a practice where moisture is removed quickly from the forage material to less than 15 percent. Such low moisture content prevents plant respiration and helps conserve forage for a long period. The process of haymaking or curing normally takes place during dry weather. Dry air temperature and low relative humidity, wind speed and soil moisture are conditions that allow the rapid removal of moisture from the cured material. In light of this fact, it is recommended to set the timing of haymaking based on local weather forecast.

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Sunny and dry weather suits haymaking.

The other important condition for haymaking is the morphological difference of the various forage species. Forage physical characteristic of the plant such as stem thickness affects the speed of the process. In thick stemmed forages, the speed of the drying process is slow since the removal of moisture from the stem core to the epidermis takes a long time. Similarly, forage species whose leaf epidermis are covered with waxy substances require an extended curing time. As a group, grasses dry much faster than legumes, although the variation among grass species is considerably high. Within a group (grass or legumes), forage species with high leaf to stem ratio would be cured faster since leaves dry faster than stems.

What are the processes strictly observed while haymaking?

Adequate awareness and understanding of the basics of haymaking are useful for producing good quality hay. The key haymaking processes are:

- Start harvesting the forage during the week when the weather is conducive (sunny days, low relative humidity and dry soil surface). Where feasible it is recommended to set the conducive time based on local weather forecast.
- Harvest forage at the stage of maturity where the DM yield and nutritive value are optimized, i.e. at pre-flowering stage (boot to early heading stage for grasses) and late bud to early bloom (10 percent flowering) for leguminous forages.
- Reduce nutrient loss due to plant respiration and microbial degradation through spreading and frequent turning of the harvested forage, which help rapidly decrease the moisture content.
- Rake or turn legumes in the morning to avoid shattering.

- Speed up the drying of thick stem forages by chaffing and conditioning.
- Complete the field curing process within three to five days to prevent bleaching (loss of carotene), leaf shattering and decline in hay nutritional value.
- Check the adequate drying of the hay by twisting (well-dried swaths tend to be brittle or inelastic) and stem pilling techniques. Final product moisture content of less than 15 percent is necessary to avoid spontaneous hay combustion and the risks of mycotoxin production.
- Use baler or manual hay box to make bales.
- Store bales under shades. Beds raised from the ground could become necessary when the floor of the shades is not concrete.

Bruising thick-stemmed forages speeds up the drying process.

How to speed-up drying of succulent forages?

Conditioning of forage conserved as hay: The speed and the evenness of the drying process affects the quality and safety of forage material conserved in the form of hay. Leguminous forages (including freshly harvested groundnut and cowpea biomass) and relatively thick and succulent stemmed grasses will take longer time to dry. Crushing or bruising the stems of such forages using hammer, machete or any other suitable tool would facilitate rapid moisture removal and even drying.

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Tripods and raised platform help speed-up forage drying in wet season.

Use of tripods, drying racks or platforms: A dry and sunny weather condition is ideal for haymaking. Oftentimes, this weather condition may not correspond with the desired developmental stage of the harvested forage. In such situations, tripods, drying racks or platforms offer the opportunity to harvest and cure forage at the optimum stage of growth.

Characteristics of good quality hay

- Where laboratory analysis is possible, reasonably high crude protein and total digestible nutrients (values considered good varies with species).
- Leafiness: leaves contain three times more nutrients than stems, and much higher digestibility.
- Less proportion of coarse stems.
- Green colour: green coloured hay is rich in protein, vitamins (especially vitamin A) and imply proper curing.
- Agreeable smell: fresh or sweet smell indicate fast and proper curing.
- Absence of foreign materials (weeds).
- Absence of mould and dust.

Good quality hay production is subject to the following conditions:

Use of forages with fine stems.

Harvest forage while young and the leaf–stem ratio is high.

Rapid and proper drying.

Control of risks compromising safety and quality, i.e. shattering of leaves, exposure to rain and excessive sunlight exposure.

Silage preparation

Silage is the final product achieved following the anaerobic conservation of high moisture forage material. In the silage making process, the anaerobic condition encourages the fermentation of sugar into organic acids (e.g. lactic acid) that give the ensiled material the desired smell and prevents the development of spoilage microorganisms.

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Well-preserved silage bears yellowish-green color and agreeable smell.

Silage making processes

There are a number of critical issues to be considered while making silage and utilizing the ensiled material. These include:

- Harvest the forage to be ensiled at the stage of maturity where DM yield and nutrient content are optimized (milk stage for maize, 25–50 percent heading for grasses and 10 percent flowering for leguminous forage crops).
- Wilt forage materials with excess moisture in order to minimize seepage loss of nutrients and undesirable secondary fermentation (i.e. butyric acid production resulting in foul smell). For leguminous forage wilt until the material DM reaches 40–45 percent but for grasses at biomass DM content of 30 percent.
- Use fermentation accelerating additives where it is available. Ensure the forage material to be ensiled has adequate water-soluble carbohydrate to be fermented into lactic acid. Where possible, add additives (5 percent molasses or 5 percent maize or sorghum flour or 10 percent chopped sweet sorghum) in forages low in water-soluble carbohydrate.
- Reduce particle size using manual or power operated choppers, preferable at 30 cm or less particle size. This is useful for all kinds of forage materials ensiled but particularly so for forages with thicker stems. Chopping (chaffing) eases compaction and air removal.
- Rapid removal air (create an oxygen free condition) through adequate packing and sealing. The silo filling and packing should last from a few hours to about half a day (large-scale operation).
- Fill silo layer by layer (not more than 50 cm at a time) and packing to avoid the trapping of air.
- Finish filling with the top appearing dome shaped.
- Facilitate the fermentation process, which encourages lactic acid producing bacteria, eventually lowering the pH (3.8–5.0) of the ensiled material.
- Depending on the weather condition and the nature of the forage material, the fermentation process completes in two to four weeks' time.
- Use of ensiled materials once the silos or bags are opened. Longer exposure to air (oxygen) will lead to the deterioration and spoilage of the ensiled materials.
- Maintain silos or bags airtight. As long as the anaerobic conditions are maintained, the ensiled material can stay safe for a year or more. In big silos, plastic sheets and concrete barriers provide the required level of sealing. In the small-scale pastoral or agropastoral condition, earth-pits lined with heavy duty plastic sheets (5 mm thick and UV resistant) and covered on top with soil mass serve the same purpose.

- Where the silage is intended for milking animals, feed them after milking to avoid the milk from taking the smell of the silage.

Characteristics of good silage

- Smell: pleasant acid smell
- Colour: yellowish green
- Wholesomeness: absence of mould

Types of silos or ensiling containers

Concrete silos

This is a silo whose floors and sidewalls are concrete. Its initial investment cost is high, but it can last for many years. The sidewalls of the silo and the top of the ensiled material could be wrapped with plastic sheets to maintain airtight conditions. Gravel or sand filled bags are put on top of the silo to hold down and avoid damage to the plastic sheets.

Once constructed, concrete silos lasts for many years.

Earthen silos

One big or a couple of medium-sized rectangular pit silos can be dug with varying sizes to match the available ensiled materials or to ease utilization. Maintaining a smooth floors and sidewalls in pit silos is necessary to minimize damage to the plastic sheets used for lining. Once the fresh material is filled into the silo, water drums are rolled over it several times manually or using trained traction animals to achieve the desired compaction. On top of the upper plastic sheet, smooth stones, wooden logs or old tyres are put in place to hold it down.

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Earthen pit silos can be prepared for any size of ensiled material.

Stone reinforced upright silos

This type of silo works in stony areas, where digging a pit may be difficult. The same features and precautionary measures of the pit silo apply, except that it is an above ground silo.

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Stone-reinforced silos are as good as other types of silos.

Polyethylene bags

Any size of polyethylene bag (500–750 gauge) can be used to ensile forage material provided it is intact. In fact, such small size containers are easy to feed-out and the spoilage risk commonly encountered in big silos reduced. The most important thing to consider is to compress the material inside the bag in order to let air out and then tie the bag with twine close to the material as tightly as possible. Hay baling twines are suitable to ensure the complete sealing of the bags.

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Most polyethylene containers can serve as forage ensiling structures.

Critical issues to consider in the production of good quality silage:

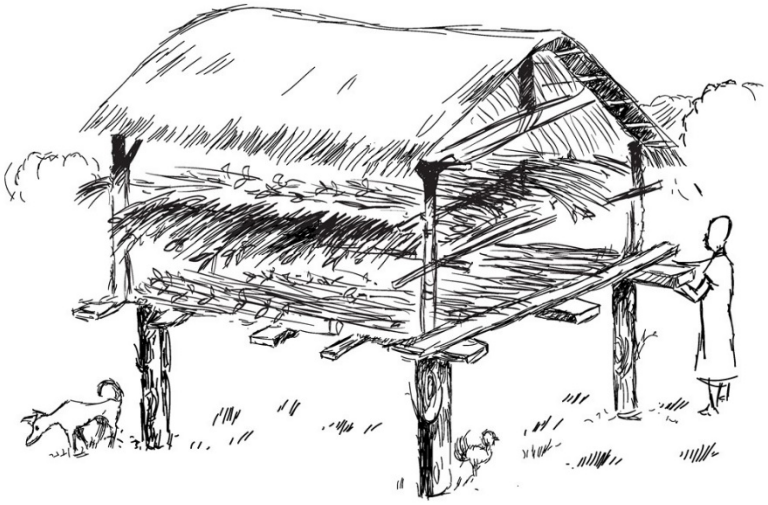
Harvest pasture as soon as floral part starts to emerge and then wilt it.

Use additives where ensiled materials are low in soluble sugar to assist with fermentation.

Chop (if coarse stemmed), compact, and seal ensiled material to ensure anaerobic conditions.

Forage and packaging

Introducing forage harvesters and processors (choppers, hydraulic presses and mixers) help reduce wastage and improve the utilization efficiency of the locally available feed resources. The fully mechanized forage harvesters and processors allow conserving large amount of feed in a short span of time but demand a huge investment and appropriate skills. Technological options that cater for the subsistent-oriented systems are also available. These constitute semi-mechanized and manually operated equipment. Fibrous feed harvested at the right stage of development, and processed and packaged in the form of bales or pellets are convenient to store and transport.



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Hayshed protect conserved feed from rain and excessive exposure to sunlight.

Why process and package fibrous feed?

The challenges of seasonal fluctuation in the supply of livestock feed in South Sudan seriously affects the performance and the very survival of livestock. The fluctuation in feed supply causes grazing animals to undergo cyclic change in body weight and growth over the seasons – a condition that delays the age to sexual maturity or extend the marketable age. Milk production from lactating animals drops or ceases altogether during the long dry season with direct negative consequence on food security and nutrition, particularly those of pregnant and lactating women, children and the elderly.

It is unfortunate that the dry season feed shortage in South Sudan occurs in the midst of plenty, i.e. because of the inability of livestock keepers to conserve and process the abundant forage from the rangelands. Across the country, huge forage biomass from the rangelands and crop farming is wasted or misused. The grass species, which make up the bulk of the rangeland forage, grow fast and become coarse and wiry. Even when not burned down, as it commonly happens in most parts of the country, in the advanced stage of maturity this forage biomass becomes nutritionally less worthy and unpalatable to grazing animals. Supporting subsistent or market-oriented livestock producers through capacity development programmes including the transfer of skill and the promotion of feed processing and packaging technologies could help save storage space, overcome wastage, stabilize year-round supply of fibrous feed, and promote quality and DM weight-based forage trade.

What technologies are available to process or densify bulky fibrous feed?

The kinds of fibrous feed processing and densifying technologies put into use are subject to the livestock producers' skills and capacity to invest in such technologies. For private entrepreneurs and organized groups who want to take feed conservation and processing as a business and source of livelihood, there is room for the application of more sophisticated machineries. Given the huge potential of the country in forage biomass production, the importance of using medium- to large-scale feed conservation and processing technologies cannot be over-emphasized. However, the promotion and application of simple technologies can go a long way in stabilizing the seasonal supply of feed among subsistence livestock producers.

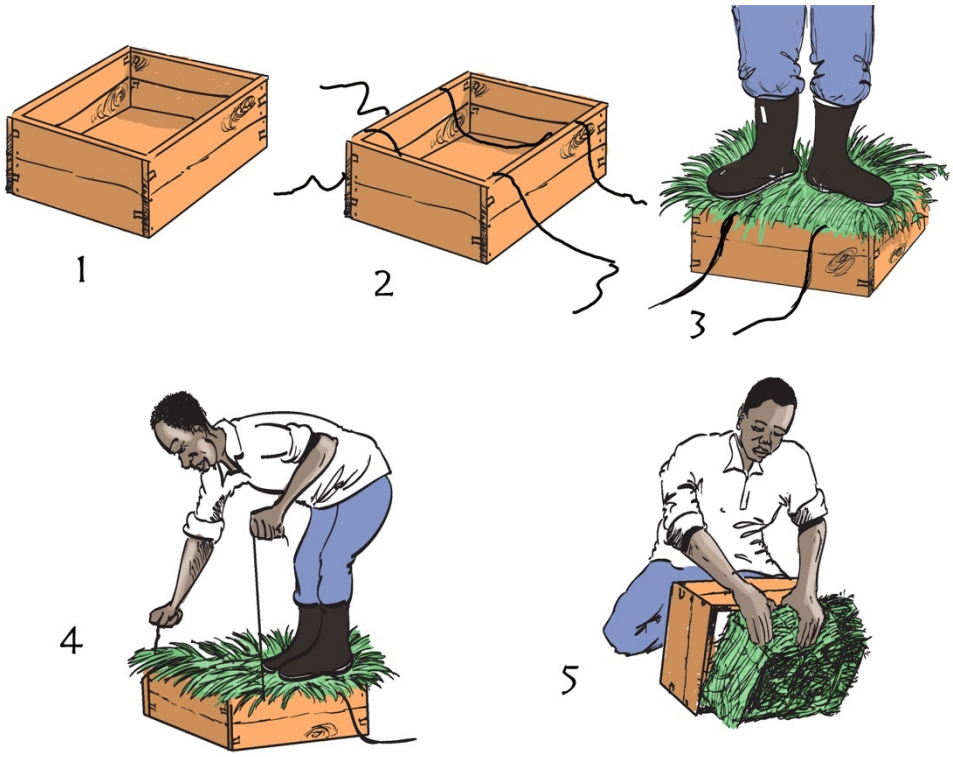
Feed conservation and processing technologies with practical relevance to South Sudan include mechanized forage mower and harvesters, machine-based baling, hydraulic feed pressing equipment and pellet making machines and manual hay baling (baling box). Each technology is described below:

- Mechanized forage mower and harvesters: This equipment suits private and organized groups having interest in running commercial operations. If applied successfully, it takes the feed industry to a higher level.

- Machine-based baling: Power operated baler are suitable for compressing grass hay or cereal straws for efficient storage and transport. The machine-operated haymaking equipment commonly produces rectangular or circular types of bales. Oftentimes, the rectangular bales measure 45 cm x 90 cm and weigh 14–18 kg. Such size suits manual handling at times of storage or feeding. On the other hand, the circular type of hay bales measure as high as 500 kg and are designed for machine-based handling.

- Hydraulic feed pressing equipment and pellet making machines: This technology converts bulky roughages into blocks and pellets. These machines have parts that chop, grind, mix and turn the final product into either a block or pellet. Depending on the need, one can incorporate other feed ingredients (e.g. concentrates) into roughage-based blocks or pellets to produce total mixed ration (TMR), which is particularly relevant in emergency feeding programmes. Overall, the use of densifying technologies would help overcome the logistical, transport and cost related challenges commonly encountered in fibrous feed. Dense and pelleted forages are easy to transport to places facing feed crises or to intensive livestock production centres that demand the steady supply of roughages.

- **Manual hay baling (baling box):** In the pastoral and agropastoral settings, there exists little incentive or capacity to incur cost on power operated balers. With this technology, livestock keepers can use simple baling boxes to produce custom-made bales. Livestock keepers can easily construct baling boxes locally from timber. A baling box of 75 cm length, 50 cm width and 40 cm depth can produce bale-weighing 10–14 kg. Although bales made using locally improvised baling boxes are less dense and might not look tidy, its use offers a number of advantages. It saves storage space and eases transport, handling and feeding.



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Baling box reduces bulk and improve hay handling in smalholder condition. The recommended dimension of hay making box is 75 cm x 50 cm x 40 cm.

Processing and packaging of conserved forage is important.
It helps to:

Reduce bulk, save storage space, ease feed handling and transport.

Introduce livestock feed need planning and budgeting.

Introduce standardized conserved forage trade.

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Feed supplementation

Benefits and timing of strategic feed supplementation

Why supplement grazing animals?

Feed supplementation is an integral part of good animal husbandry practices. Feed supplements are put into use to achieve the following objectives:

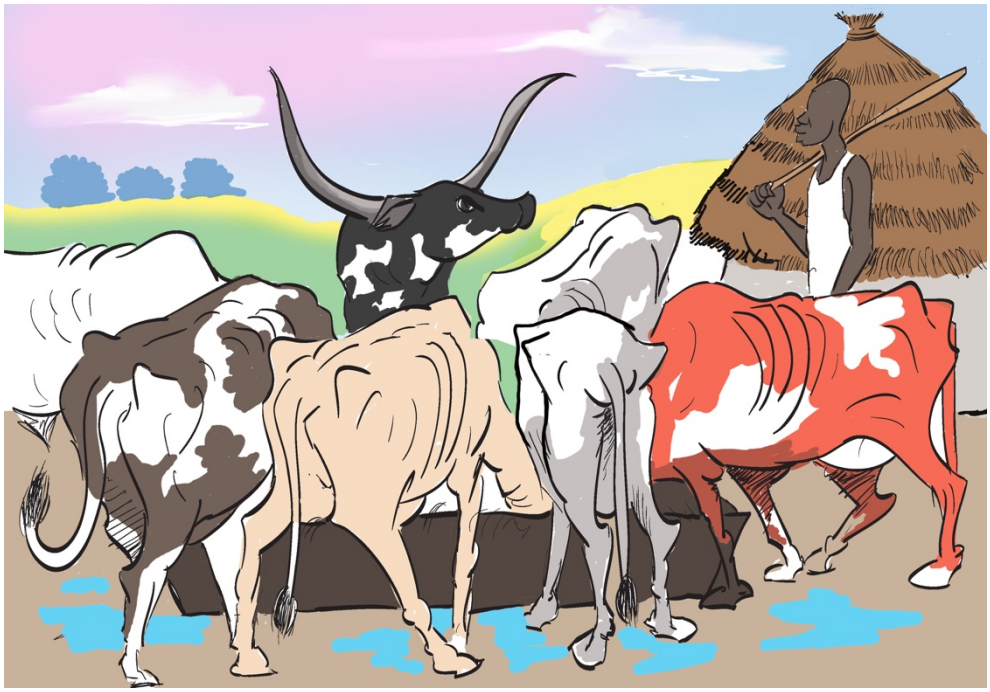
- **Bridge or meet deficient nutrient(s)**
  Feed that constitute the bulk of grazing animals' diet, namely range forages and crop residues, oftentimes are deficient in one or more essential nutrients. Failure to supplement deficient nutrient(s) severely suppresses rumen functions, DM digestibility and hence animal performance. Deficient nutrient(s) are administered in a variety of way, for minerals and vitamins through a drench, rumen bolus or injection, and as part of the ration for protein and energy related deficiencies.
- **Improve the utilization of feed in relative abundance**
  Here, the objective is to create a rumen environment that enhances microbial degradation of the abundantly available fibrous feed. In this circumstance, feed supplements help maintain optimum rumen environment for increased utilization of the poor quality fibrous feed.
- **Prevent scouring**
  Using dry roughage as a supplement could become necessary when animals graze on lush grass commonly high in moisture. Feeding dry forage reduces scouring and slows the passage of forage through the rumen thereby increasing nutrient uptake and pasture utilization. Feeding animals with dry roughage also reduces the risks of bloating in places and times such incidences are high.
- **Speed recovery from nutritional stress**
  During drought or periods of extended dry spell, the quality and quantity of feed decreases thereby limiting animal nutrient intake and causing substantial loss of tissues or body condition. The body tissues reduced during these periods are deposited when adequate animal feed intake is restored. Rapid recovery of the undernourished livestock and resumption of production and reproduction would require a feed supplement with sufficient digestible nutrients. Legume-based forage are ideal supplements.

- **Increase production and reproduction**

  Growing, breeding, pregnant, lactating or working animals require the consumption of feed over and above the maintenance requirement. When animals in such physiological states are not given supplementary feed, production and reproduction drops, and in the extreme cases vulnerability to diseases increases. In lactating cows, for instance, the *ad-lib* supply of good quality forage could support 2 to 5 litres of milk production (*Table 3*). For higher production, it is advisable to provide concentrate-based feed supplements. As a thumb rule, it is required to provide 1 kg of good quality concentrate feed for every 2 litres of milk produced.

Table 3. **Good quality forage supports high milk production**

Forage type	Crude protein (%)	Digestibility (%)	DM intake (kg DM/day)	Milk yield (l/head/day)
Grass + legume	12	60	9.5	5
Sole grass	8	50	7.5	1



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Feed supplementation is provided during normal and feed crisis periods.

When to provide animals with feed supplements?

The timing of feed supplements depends on the objective. Otherwise, it occurs both in normal and periods of livestock feed crises. In normal times, feed supplements are used to increase livestock production and ensure the economic viability of livestock operations. The main purpose of providing supplement feed in periods of feed crises and during post-stress periods is to save the lives of animals and encourage rapid recovery of body condition.

Providing grazing animals with supplemental feed is part of improved livestock management practice. Feed supplements are necessary to:

Ensure animals get enough amount of nutrients required to maintain desirable level of production and reproduction.

Enhance intake and rumen degradability of fibrous feed.

Avoid loss of condition and mortality of livestock during extreme feed crises.

Encourage post-feed-stress period recovery of grazing animals

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Characteristics of supplemental feed

Desired characteristics of feed supplements

In ruminant animals' diets, feed supplements require to fulfil three conditions. These include:

- **Feed supplements should supply nutrients that further improve the rumen fermentation process.** Under smallholder conditions, the ideal feed supplements constitute good quality forage, preferably forage legumes. For best effect, it is necessary to maintain the inclusion level of good quality forage between 10 and 30 percent of the total ration. Higher levels reduce the utilization of the poor quality basal diet.
- **Supplemental feed should supply by-pass protein.** This is a protein source, which is required to pass the rumen intact and reach the small intestine in order to support high livestock production performance. A wide array of feed

supplements serves this purpose. These include whole cottonseeds, oil seed cakes, fishmeal and leaf meals of browse shrubs and trees high in polyphenolics (tannins). In order to avoid the depression effect of the by-pass protein sources on the low quality basal diet and for economic reasons, these forms of feed supplements should not exceed a 30 percent level of inclusion.

- **Supplements should provide most deficient nutrient(s).** An ideal rumen function requires an adequate supply of rumen soluble protein or more specifically a protein source with fermentable Nitrogen (N). This is particularly vital for a basal diet (cereal residue/mature grass) whose crude protein content is less than 7 percent. Fertilizer grade urea or poultry manure are good sources of rumen soluble N. Treating cereal residues with rumen fermentable N (e.g. fertilizer grade urea) increase DM intake, digestibility and animal growth rate or milk production (*Table 4*).

Table 4. **Urea treated maize stover on DM intake, digestibility and gain of weaned lambs**

Basal diet	Intake (g DM/day)	Digestibility (% DM)	Gain (g/day)
Untreated maize stover	338	56	60
Treated maize stover	434	59	90

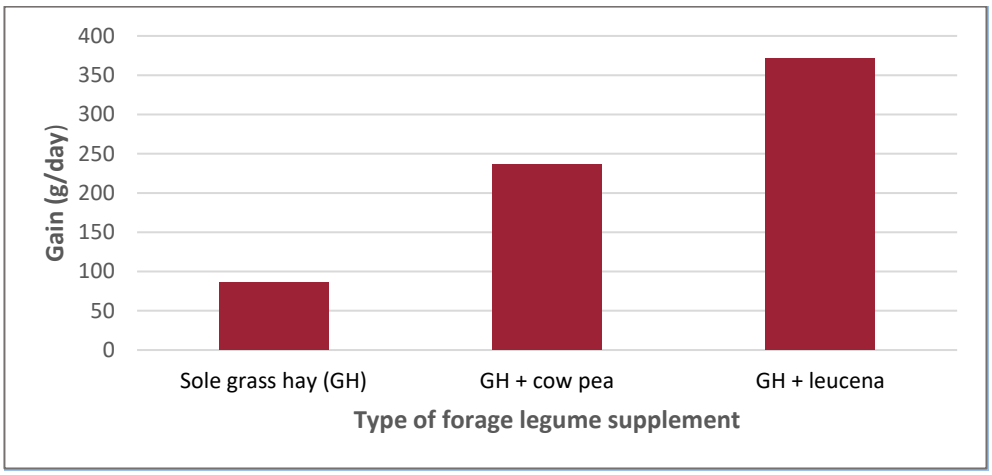
Types of supplemental feed

A number of conditions are taken into account when selecting feed supplements. Among others, these include local availability, cost and/or the nature of the production system. Local availability is particularly crucial as such conditions eases accessibility and minimizes transport costs. In South Sudan, the experience on the use of supplemental feed either to maintain production or protect livestock asset at times of critical feed shortage is limited. Subsistence livestock producers neither have the experience in the use of supplemental feed nor the economic incentive to incur cost in the preservation of such feed. With adequate awareness and the integration with mainstream markets, subsistent livestock keepers will likely start producing and/or buying, and using supplemental feed. The climate change-induced severe feed crises will increase the necessity to use supplemental feed. The supplemental feed with practical relevance to the pastoral and agropastoral areas of South Sudan are forage legumes and concentrate feed.

Forage legumes

Forage legumes are rich in essential nutrients such as protein, vitamins and minerals. Nutrients are often deficient in matured pastures and cereal crop residues. It is possible to introduce forage legumes in a variety of ways including through reseeding of grazing reserves, backyard forages production and as commercial crops. The leaf meals either from herbaceous or woody forage legumes constitute valuable supplement to low quality basal diets. With the supplementation of modest amounts of good quality forage, livestock on poor quality basal diets could maintain a reasonable level of growth rate (*Figure 2*). For lactating cows, 3 kg of good quality leguminous forage supplement would support as much milk yield as the supplement of 1 kg commercial concentrate feed. Curing or wilting of leguminous foliage particularly those originating from browse shrubs or trees high in condensed tannins increases the proportion of by-pass protein reaching the small intestine of ruminant animals.

Figure 2. Forage legume supplements on crossbred steers daily gain



Concentrate feed

Oilseed cake and cereal by-products rich in readily fermentable carbohydrates, crude protein and by-pass protein are ingredients used commonly in the formulation of concentrate-based supplements. Availability and cost are the major limitations in the use of concentrate-based feed supplements. For market-oriented systems close to urban centres, concentrates would support the sustained production and supply of livestock and livestock products. In order to guard against prohibitive concentrate feed prices and encourage wider use, it is necessary to produce ingredients locally.

Cost, nutrient density, local availability, potential to supply rumen degradable and bypass nutrients, and risks of anti-nutritional factors are key conditions considered while identifying potential feed supplements.

Homegrown leguminous forage constitutes an important supplement as it supplies extra protein, minerals and vitamins.

Emergency time feed supplementation

At times of severe feed crises, be it during rapid-onset (flood, earthquake or insecurity) or slow-onset (drought) crises, providing feed supplement is necessary to protect the lives of livestock. In the last decades, drought- and flood-induced severe feed crises in South Sudan and elsewhere in eastern Africa have resulted in starvation of livestock and caused massive livestock mortalities – driving many pastoralists and agropastoralists into destitution.

Does emergency feeding make economic sense?

The provision of emergency feed supplement is more cost effective as compared to post drought restocking. Studies in East Africa have shown that post drought restocking is three or more times expensive than maintaining the core breeding stock through survival feeding programmes.

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Climate change-induced feed scarcity threatens livelihoods.

Common approaches to avail emergency feed

Depending on the local situation, livestock targeted through an emergency feeding programme could receive survival feed in one of the following ways:

- Home-based feeding where beneficiaries get the survival feed via vouchers or in-kind and manage the feeding of the targeted animals as per the recommendation (3.5 kg roughage and 1 kg of concentrate per head per day for cattle, and 250 g roughage and 100 g concentrate for small ruminants).
- Camp-based emergency feeding programme where the affected animals are fed in centrally managed shades. This mode of feeding ensures strict adherence to the recommended practices but the aggregation of animals in one place may increase the risks of cattle rustling and the spread of infectious livestock diseases.

These feeding programmes have their own advantages and disadvantages. Each programme should be weighed against its specific merits.

How to improve the cost-effectiveness of emergency feed supplementation?

It is necessary to have prepositioned emergency feed supplements ahead of time from locally available feed or bought-in feed. In either case, it is good to consider complimentary measures to reduce the number of targeted animals and increase the effectiveness of emergency feeding programmes. Feeding all affected livestock is impractical and extremely costly. This is particularly difficult in pastoral

communities where individual households own large number of animals and road infrastructures are virtually non-existent. Some of these complimentary measures include:

- Commercial destocking: Accelerated commercial destocking helps reduce the competition for scarce feed and pressure on the natural resources. In times of drought, it is important to implement commercial destocking during the alert phase of the drought cycle when the body condition of the animals is still good, and the markets are not flooded by large influx of animals.

- Slaughter destocking: In pastoral areas, getting a timely early warning information on the severity and duration of drought is always a challenge. Even when the early warning information is communicated to the affected communities in good time, pastoralists and agropastoralists may be reluctant to sell a significant number of their herd. In such situations, livestock body conditions deteriorate to a worst state. In such circumstances, administering slaughter destocking is the only way to salvage animals of very poor body condition before nature harvests them. Slaughter destocking, implemented as part of the humanitarian assistance, provides modest monetary compensation to the households supplying the animals and animal protein to households in dire need of food support.

- Encourage keeping ruminant animals with different feeding behaviours: Livestock keepers who keep livestock species with different feeding habits notably grazers and browsers are less prone to feed crises. Such mixed herds would also allow the efficient utilization of the locally available feed resources and hence increase the carrying capacity of rangelands.

- Forced weaning and herd splitting: In order to halt further deterioration of lactating animals under nutritional stress, it is necessary to wean and dispose young stocks (calves, lambs and kids) as soon as drought strikes. This approach is part of a drought coping strategy among pastoral communities in East Africa. Herd splitting where the dry females and strong replacement stocks are taken to distant grazing areas is also exercised by most pastoralists to help spare the scarce feed for core breeding stock staying behind for the entire duration of the drought. Furthermore, herd splitting could play a key role in enhancing the resilience of pastoralists and agropastoralists to the increasing climate change challenges.

Emergency livestock feeding saves livelihoods
and avoids costly post crisis re-stocking.
Its cost-effectiveness is enhanced when integrated with
destocking (commercial/slaughter),
prepositioning of feed reserves,
and other traditional feed scarcity copping strategies.

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Minimizing feed waste

In semi-intensive and intensive systems, animals are offered feed while they are in confinement. Where properly managed, such mode of feeding encourages the efficient and proper use of feed. The effectiveness of the practices demands the following:

Sanitation of feeding platforms

This involves keeping the feeding platforms including feeders and floors dry and clean at all times. This sanitation process avoids the contamination of feed with animal faeces and urine. Clean feeders and floors allow the collection and the re-use of spilled feed by animals under confinement.

Forage material chopping

Chopping fibrous feed reduces the chances of feed spillover and facilitates the mixing of different feed sources.

The practice also encourages the uniform consumption of thick-stemmed and coarse forages, which is oftentimes poorly utilized.

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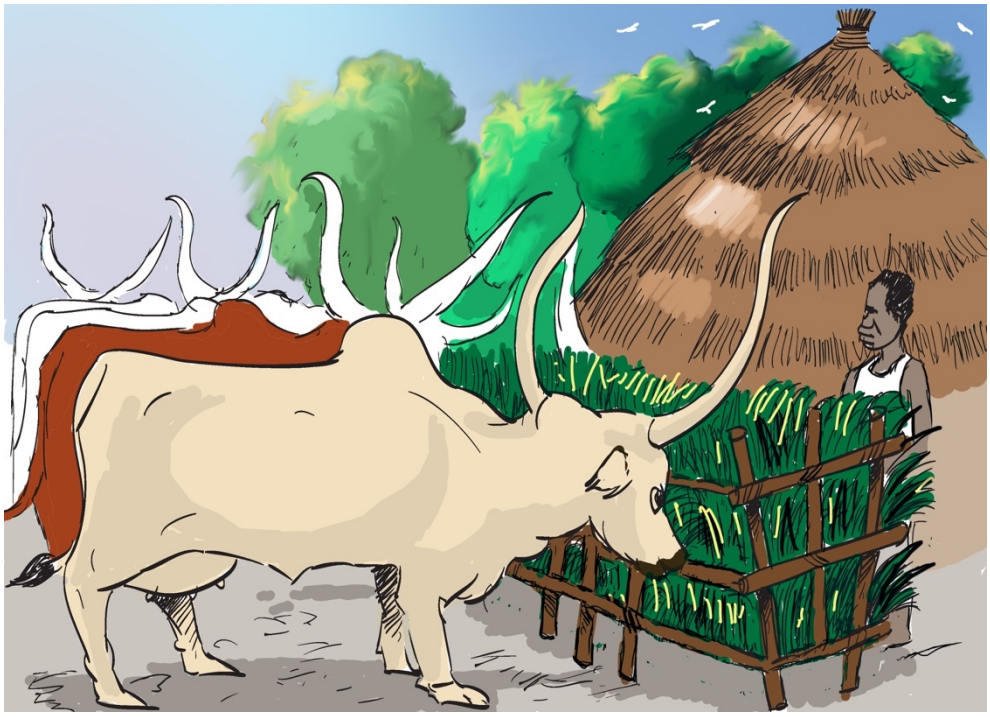
Chopping saves storage place and encourages uniform consumption of forage parts.

Use of troughs and hayracks

The use of troughs is important to avoid the contamination of feed materials by faeces, urine or mud, and to discourage disease and parasite build-up. More importantly, troughs suiting the specific species, body size and age of animals reduces feed trampling, competition and wastage. As a general guide it is important to place troughs off the ground and provide them with barriers preventing animals from jumping into it. Likewise, hayracks, by allowing slow and orderly consumption of long dry and fresh forages, reduces feed wastage. It is necessary to construct hayracks in such a way that racks are set at head height and all animals access the forage materials at the same time.



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Stall feeding of milking cows.

Feed troughs and hayracks that cater for
different body size and age groups
avoid feed competition,
reduce feed wastage, and
prevent parasite and disease spread.

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Glossary

Agropastoral system: Farming systems that combine the growing of cops and the raising of livestock.

Biomass: Organic materials coming from plants or animals.

Dry matter (DM): Forage biomass following the removal of much of the moisture.

Grasses: Member of the Poaceae plant family. Grasses are tuft forming or creeping long narrow-leaf blade, a leaf sheath and a ligule.

Fodder: Refers to feed given to animals (including plants cut and taken to them) rather than which animals forage for themselves. It includes fresh cut forages, hay, silage, straw compressed and pelleted feed, oil seedcakes, and mixed rations.

Forage: Plant materials (mainly plant leaves and stems) eaten by grazing livestock.

Geographic information system (GIS): A computer-based tool used for mapping and analysing featured events on earth.

Grassland: Land on which the indigenous vegetation is predominantly grasses, grass-like plants, forbs or shrubs and managed as a natural ecosystem.

Grassland condition: State and health of the grassland (rangeland) assessed in terms of vegetation structure, species composition, cover and the status of the soil.

Grazing land management: Manipulation of soil-plant-animal complex of the grazing land in pursuit of a desired result.

Plane of nutrition: Term used to express the nutritional composition or the nourishing value of livestock feed.

Species composition: Proportion of different plant species found in association in a given area.

Savanna grasslands: Grasslands with predominant grass vegetation.

Spate irrigation: An irrigation practice that uses the floodwaters of ephemeral streams and channels guided through short, deep canal to bunded basins.

Toiches: Open grassland in low-lying areas, which constitute important grazing resource during the dry season but inundated by rainwater or flood and become inaccessible to grazing animals during the wet season.

Vegetation cover: The proportion of the soil surface covered by vegetation.

Vegetation structure: The arrangement, spacing and size of plants within a given area. Measured structural features are height, volume, stem size, crown size and spacing.

Woodland grasslands: Stretches of native grass vegetation with scattered trees and shrubs.

Zero grazing: A grazing system where cut forage is brought to animals rather than putting them to pasture.

Saving livelihoods saves lives

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