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REPUBLIC OF KENYA

Pastoral and Agropastoral Production Systems
in the Arid and Semi-arid Areas

FIELD PRACTITIONERS GUIDE NO. 3

WFP Rural Resilience Programme

August 2018

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This Field Guide was compiled by Mathew K. Kigomo

Cover Page Photo: Cattle in Northern Kenya (source: ILRI)

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Foreword

Kenya's agricultural sector is evolving each day, driven by among others; the gathering momentum of the devolved system of Government, the need to transform agriculture from subsistence to agri-business, a growing population with increasingly complex consumer demands, as well as innovations emerging from farmer trials, the information superhighway, innovations, research and technology.

At the same time, Kenya's agriculture responds to and is affected by international protocols, among these, the Sustainable Development Goals (SDG) whose clarion call is *"Leaving no-one behind".* This motto, when applied in the Kenyan context literally calls for special attention to be accorded to the arid and semi-arid lands (ASALs), which constitute 83 percent of Kenya's land area. It is in the ASALs where agriculture faces special challenges associated with aridity, erratic weather, lack of water, and rudimentary technologies in how water is managed. In essence, the *ASALs should not be left behind!*

The Government of Kenya (GoK) is committed to implementing development initiatives that lead to food and nutrition security, national wealth creation and wellbeing, while also contributing to the achievement of the SDGs. In particular, the Ministry of Agriculture, Livestock, Fisheries and Irrigation (MoALF&I) is implementing programmes, projects and activities at national and county levels, which ultimately contribute to achieving the SDG-2: End Hunger, achieve food security and improved nutrition, and promote sustainable agriculture, whilst simultaneously contributing to a number of other SDGs (especially SDGs 1, 5, 6, 12, 13 and15). This will be achieved by infusing science, innovation and technology in smallholder agriculture, especially in the ASALs, where the knowledge gaps are greatest.

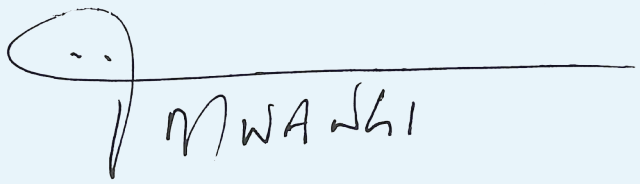
Aware of the complex nature and challenges that face agricultural development in the ASALs, the Ministry has been working with various development partners, among them the World Food Programme (WFP) towards supporting livelihoods in the ASALs. In particular, the WFP has in the past contributed to food relief efforts. However, as we implement the Agriculture Sector Transformation and Growth Strategy (ASTGS) and the BIG 4 on food and nutrition security, focus is now changing to support the most food-insecure communities (Flagship 6 of ASTGS) in the arid and semi-arid lands to become resilient and

adapt to shocks such as drought and climate change, by becoming food producers rather than recipients of food aid.

This focus sees ASALs as having resources which include the human, natural, social and financial capitals. Resilience building therefore takes cognizance of the inherent potential and through complementary efforts with partners, implements activities on the ground. This relies heavily on support and collaboration with County Governments, the private sector, development partners, non-state actors and all stakeholders. These partnerships are necessary to facilitate infrastructure development, community mobilization, implementation of income generating activities; skills development among land users and decision makers and to enhance best practice in resource management and agricultural production.

In our continued efforts to build knowledge, reach the decision makers, extension workers and farmers on solutions and interventions that upgrade agriculture in the ASALs, these set of Technical Manuals and Field Guides developed by WFP in collaboration with MoALF&I brings on board innovations, technologies and best practices that will help upscale agricultural productivity and improve rural livelihoods. I expect the materials to be shared widely and utilized so that the knowledge in them is turned into action, thereby benefitting farmers, communities and the country.

Lastly, I wish to reaffirm the commitment of the Ministry in supporting good practices and innovations that improve rural resilience and upgrade agricultural production in the ASALs, and indeed in all parts of the country where sustainable agriculture is practiced, as we continue the journey of making Kenya food and nutrition secure.



Hon. Mwangi Kiunjuiri, MGH, EGH

Cabinet Secretary, Ministry of

Agriculture, Livestock, Fisheries

and Irrigation

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1 Introduction

1.1 Background

Rangelands consist of natural grasslands, pasturelands, shrublands, open to closed woodland, meadows, tundras, coastal marshes, and savannas These are complex and diverse ecosystems dominated by native grasses, grass-like vegetation, forbs, and shrubs growing in either natural or recreated lands under different scenarios of grazing and management. Pasturelands consist predominantly of single- or native multi-grass species and grass-legume mixtures. Pasturelands that consist mostly of grasses are known as “grasslands” (Blanco & Rattan, 2010).

In Kenya, rangelands are mainly comprised of natural grasslands, pasturelands, shrublands and open to closed woodland. Rangelands have multi-purpose uses including animal grazing, firewood production, recreation, landscape scenery, wildlife habitat, and ecotourism. Traditionally, rangelands have been primarily used for livestock production, but there is now an increasing recognition about their importance to wildlife habitat, tourism, and contemporary ecosystem services.

Although the extent of rangelands is still large, their capacity to provide all the essential services is declining due to rapid degradation and fragmentation. Rangeland degradation is understood as a significant change in plant species composition from the desirable perennial-dominated to annual-dominated species as well as an increase in woody plants on range previously dominated by perennial grasslands (Blanco & Rattan, 2010). There are numerous reasons behind the degradation of range land (table 1-1)

Table 1-1: Causes and effects of rangeland degradation

	Cause of degradation	Effects of degradation
1	Drought and other environmental disasters such as extreme weather	Deterioration in rangeland condition such as soil stability and integrity of biotic composition
1.	Poorly managed tree and bush cutting	Reduced vegetation cover; decreased seasonal availability of forage; deterioration in herbaceous pasture
2.	Excessive stocking rate	Excessive intake; reduction of vegetation cover; diffusion of unpalatable and toxic poisonous species; reduction of seed bank in the soil
3	Poorly managed grazing	Continuous removal of tissue and nutrients from plants; management difficulties of weed and manure
4	Lack of improvement to sustain productivity and biodiversity (sowing, fertilization and weed control)	Vegetation productivity lower than optimal; reduced soil fertility; invasion of alien species
5	Proliferation of invasive species	Plant succession; alter plant community composition; result in less desirable species.

1.2 Objectives of the guide

The objective of this guide is to assist, by imparting knowledge to field practitioners and extension workers and through them to famers and herders, in achieving increased level of awareness in pastoral and agro-pastoral production systems' management issues and solutions. The strategies presented are designed around three ways to build resilience:

A. Reduce exposure to shock
B. Reduce the sensitivity of systems to shocks
C. Increase adaptive capacity

1.3 Definition of terms

Agro-pastoral production system denotes land use systems in which livestock husbandry and cropping are practiced in association.

Extensive system

In the extensive system, the cattle are reared on pasture. It is practiced where grazing land is available.

Intensive system

In the intensive agro-pastoral production system, animals are enclosed in zero-grazing units, where they are provided with all their requirements for feed and water.

Nomadic pastoralism is pastoralism base on random / erratic and long-range movement with herder's family.

Pastoral production system denotes land use systems based on use of natural or semi natural vegetation for livestock husbandry, with the main function of livestock rearing being subsistence.

Rangeland is defined as land carrying natural or semi-natural vegetation which provides a habitat suitable for herds of wild or domestic grazers and browsers.

Semi-intensive system

In the semi-intensive system, the cattle graze for some time during the day and in the afternoon or evening they are supplemented with other forages. This method is a compromise between intensive and extensive systems, whereby land is not limiting as in the intensive system but on the other hand is not enough to allow free grazing throughout the day.

Stocking rate refers to how many animals are allowed into a given area of pasture and at any given time.

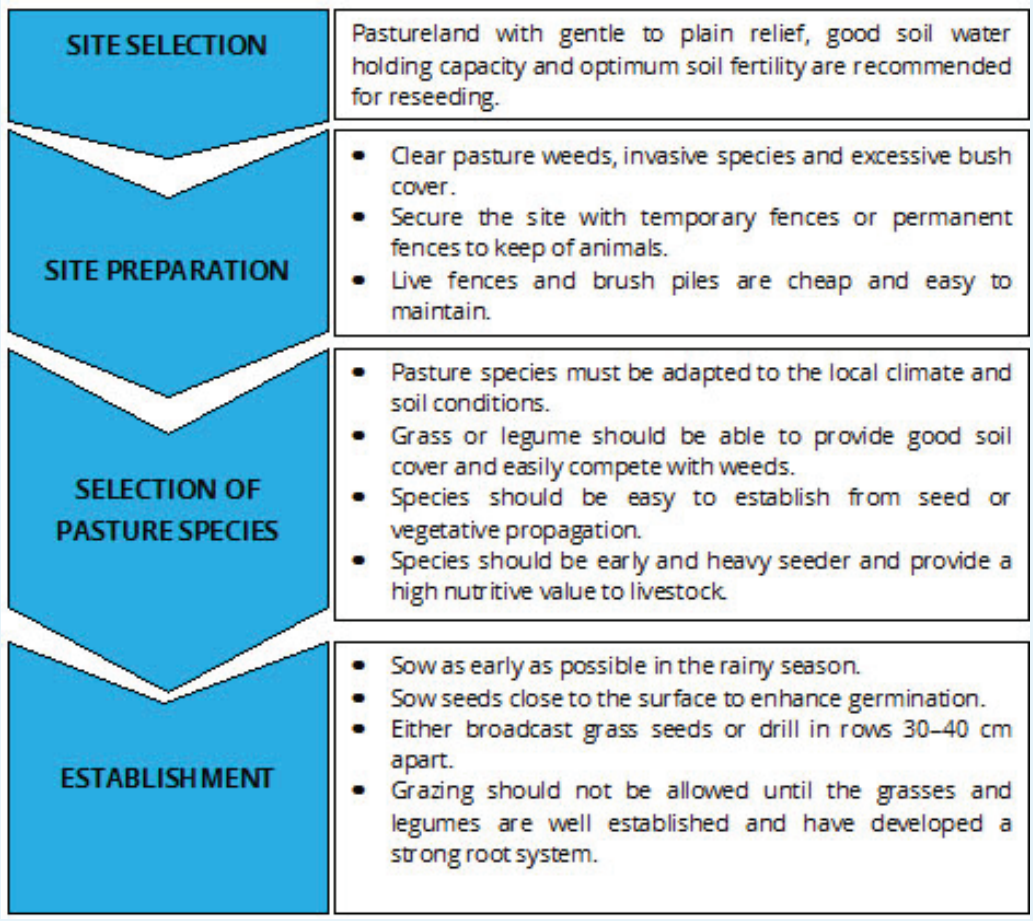
Transhumant pastoralism is pastoralism based on more or less regular seasonal migration from a permanent homestead.

2 Pasture, Rangeland and Grazing Management

Pasture, rangeland and grazing management involve the practice of manipulating the grazing animal-forage plant-soil complex. The goal of the practice is to improve rangeland health and function thus increasing forage production for livestock production and resilient livelihoods. The main strategies for improving pasture rangeland and grazing management are:

2.1 Pastureland Reseeding

Reseeding pastureland involves deliberate efforts to increase nutritive value of pasture, eradication of pasture weeds, rehabilitation of overgrazed land and improvement of pasture species. The following are the major steps in reseeding pasturelands:



Common grasses suitable for pastureland reseeding in arid and semi arids lands in Kenya

1. *Bothrochloa insculpta* (Sweet pitted grass)
2. *Cenchrus ciliaris* (African foxtail grass)
3. *Chloris roxburghiana* (Horsetail grass)
4. *Cynodon dactylon* (Star grass)
5. *Dactyloctenium aegyptium* (Crowfoot grass)
6. *Enteropogon macrostachyus* (Bush ryegrass)
7. *Eragrostis superb* (Masai love grass)
8. *Heteropogon contortus* (Black or bunch soear grass)
9. *Hyparrhenia rufa* (Amakale grass)
10. *Panicum maximum* (True guinea grass)
11. *Themeda triandra* (Red oat grass)

Enteropogon macrostachyus

Chloris roxburghiana

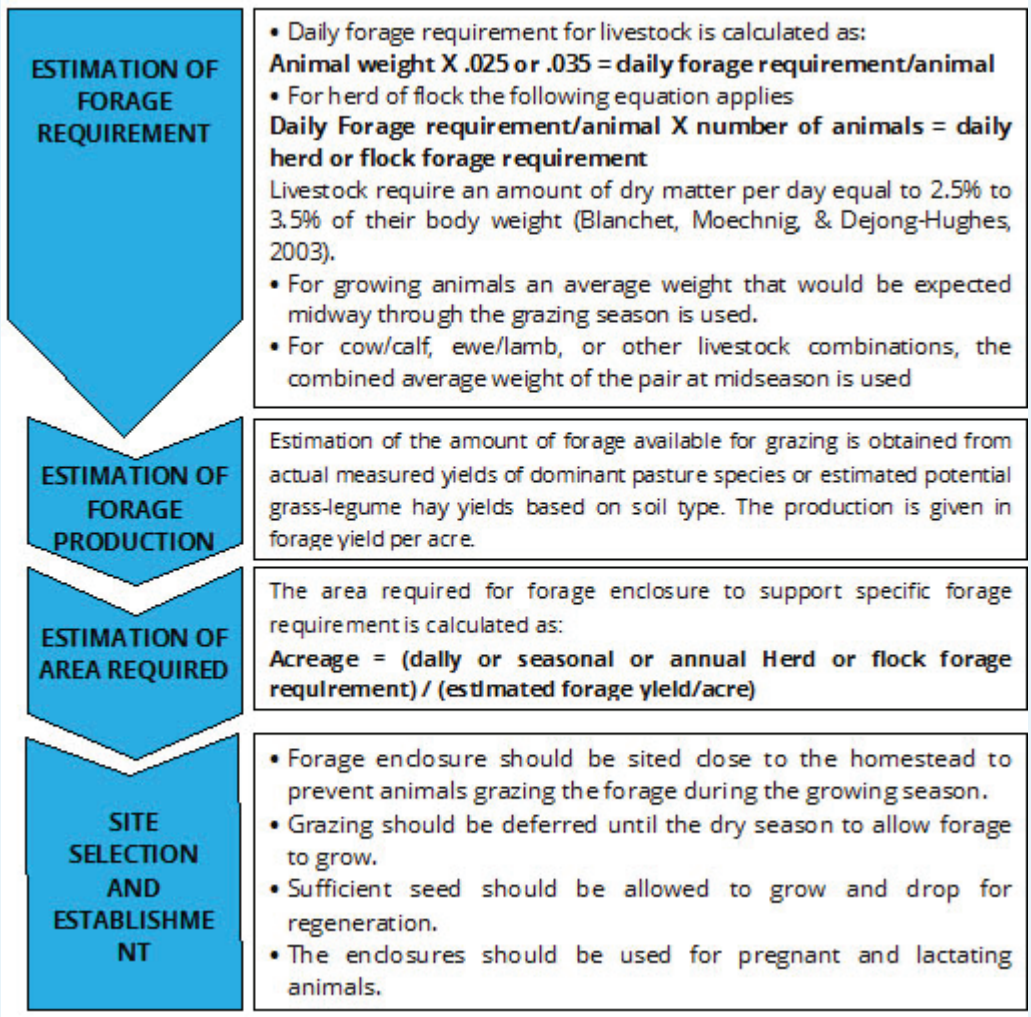
Bothriochloa insculpta

(Source Muyekho 2004, Mnene 2009)

Figure 2-1: Examples of common grasses in ASALs of Kenya

2.2 Establishment of forage enclosure

Establishment of forage enclosure involves encouraging vegetation regeneration particularly for browse and fodder to alleviate feed shortage during dry season. To develop a forage enclosure the following procedure can be applied (Blanchet, Moechnig, & Dejong-Hughes, 2003):



2.3 Establishment of fodder banks

Fodder banks are small densely sown stand of fodder crop (table 2-1) providing high quality fodder for dry season feeding with natural forage of crop residues. Two major activities are involved in establishing fodder banks.

- Select an area restricted of any livestock and crop production considering proximity to homesteads, production potentials and ease of protection.
- Suitable fodder species are then established through direct sowing of oversowing.

Table 2-1: Common fodder crops suitable for arid and semi-arid lands

Fodder crop	Establishment	Management	Feeding management
Elephant grass *(Pennisetum purpureum)*	• Planting is by using cane cuttings or rooted shoots. • Row planting is recommended with widths of 1 to 2 m between rows and 0.5 to 1 m between plants.	• Cutting is best done when plants are 1 to 1.5m tall. • The cutting height should be 2 to 5cm above the ground.	• It is best used as a cut-and-carry feed. • Grazing leads to early death
Giant setaria *(Setaria splendida)*	• It can be established through rooted cuttings or divided rootstocks. • The spacing used on soil bunds is 50 cm between plants and 50 cm between rows.	• It should be cut at a height of 15 cm from the ground at a cutting interval of 6 weeks.	• It is used as a cut-and-carry feed.
Lablab *(Lablab purpureus)*	• It is sown at a spacing of 1x1 m at a sowing depth of 2.5 cm and a seed rate of 10 to 30kg/ha. • Two to three seeds are sown per hole.	• Cutting should be done at the beginning of flowering to harness its optimum feeding value. • The best cutting height is 30 cm above the ground and should be above the branches to allow a re-growth.	• Wilting or drying before feeding is important to avoid off-flavours in milk
Lucerne (Medicago sativa)	• Planting should be with seed in continuous rows 30 cm apart at a seed rate of 5 to 7 kg/ha.	• Cutting should be done when it begins to flower at 15 cm above the ground.	• It is used as a cut-and-carry feed.
Rhodes grass	• Planting depth should be at 0.5-1cm. • Seed rate should be 3-7kg/ha	• The cutting height should be 2 to 5cm above the ground. • Harvesting should be done at flowering stage	• Suitable for hay making

Fodder crop	Establishment	Management	Feeding management
Velvet beans	• Planting depth should be at 2-3cm. • Seed rate should be 40-50kg/ha	• Harvesting should be done at flowering stage	• Wilting or drying before feeding is important
Cowpeas	• Planting depth should be at 1-2cm. • Seed rate should be 15-20kg/ha	• Harvesting should be done at flowering stage	• Wilting or drying before feeding is important
Pigeon peas	• Planting depth should be at 1-2cm. • Seed rate should be 35kg/ha	• Harvesting should be done at flowering stage	• Wilting or drying before feeding is important
Sunn hemp	• Planting depth should be at 1cm. • Seed rate should be 10-15kg/ha	• Harvesting should be done at flowering stage	• Wilting or drying before feeding is important
Forage Sorghum	• Planting depth should be at 1cm. • Seed rate should be 10kg/ha	• Harvesting should be done at tasseling	• Harvesting Suitable for silage making

2.4 Establishment and management of fodder trees

Fodder trees provide high quality forage for livestock during the dry season. Their leaves and pods are a source of protein for livestock. Establish of fodder tree requires that:

- Fodder trees are best propagated from seed.
- Fodder trees can be established through alley cropping (Figure 2-2) where trees are grown in rows of 4-8m apart on croplands and food crop cultivation is done between the alleys. They can also be established as fence or hedge lines.

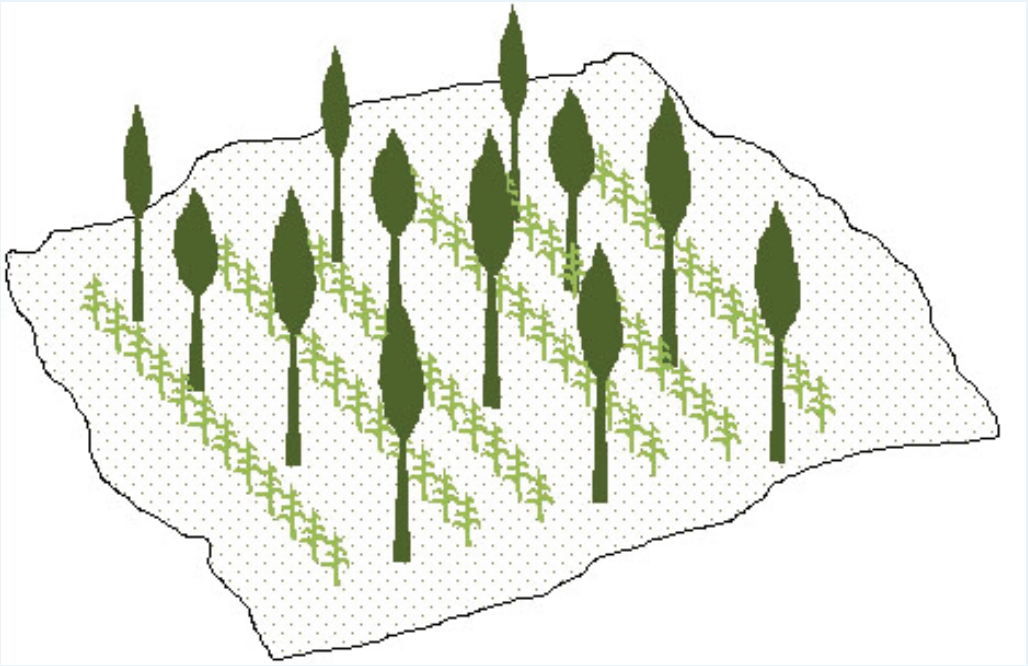


Figure 2-2: Alley farming

Table 2-2: Fodder trees suitable for arid and semi-arid lands

Common indigenous fodder trees	Common exotic fodder trees
Acacia mellifera (Blackthorn) *Acacia nilotica* (Scented thorn) *Acacia senegal* (Gum Arabic acacia) *Acacia tortilis* (Umbrella thorn) *Balanites agyptiacum* (Desert date) *Boscia Salicifolia* (Willow-leaved boscia) *Comiphora Africana* (African myrrh) *Teclea nobilis* (Small-fruited teclea) *Terminalia spinosa* (Country almond) *Zizyphus mauritiana* (Jujube) (FAO species list; Nyariki, Kitalyi, Wasonga, Isae, Kyagaba, & Lugenja, 2005).	Calliandra Leucaena Sesbania Gliricidia Mulberry Moringa (USAID, 2004; Otsyina, Norton, & Djinde, n.d; Angina, 2009).

Fodder trees feed management

- Fodder trees should be utilized for cut-and-carry to maximize and prolong fodder production.

- Their fodder can be either fed fresh cut or dried for later feeding.
- Cutting height of 30cm at an interval of 3 to 4 months is recommended for exotic species.
- For indigenous species pruning is recommended. Allow a few trees to grow tall for seed production.

2.5 Pasture soil fertility management

Proper manure distribution on pastureland allows for good stand establishment, promotes early growth, increases yield and quality and improves dry spell hardiness and persistence. Three major approaches towards pasture soil fertility management include:

A. Manual spreading

- Collect manure every 1 to 3 days from the animal yards, and pastures
- Cover the manure to keep nutrients from leaching away.
- Apply or spread the manure as a fertilizer on growing plants during the growing season using manual labour, draft animals or motorized carriage

B. Strategic herding

Split the herd into small grazing units and distribute them evenly across the land (Figure 2-3) to enhance manure distribution and reduce soil compaction (Eldridge, 2004).

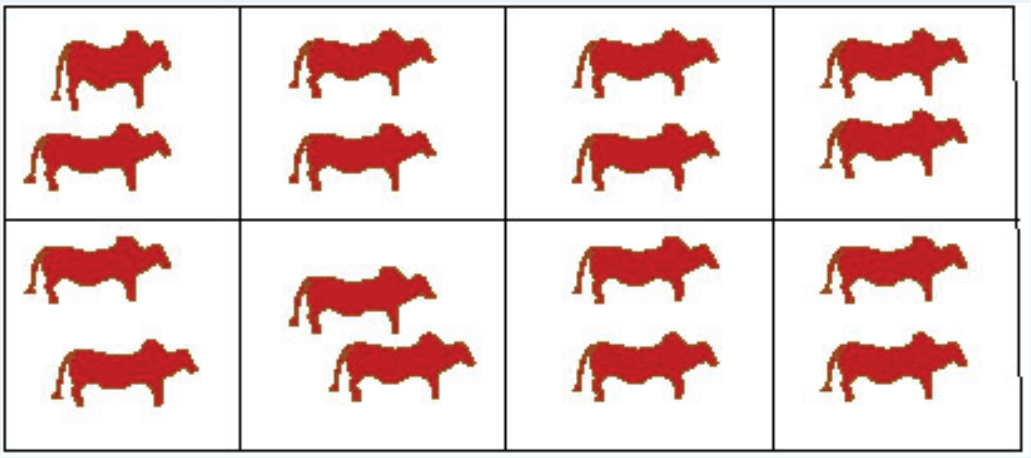


Figure 2-3: Herd splitting

C. Strip grazing

Distribute livestock across the landscape by grazing them along strips with the help of temporary fences (Figure 2-4) to enhance manure distribution. Applicable in pastoral range production system.

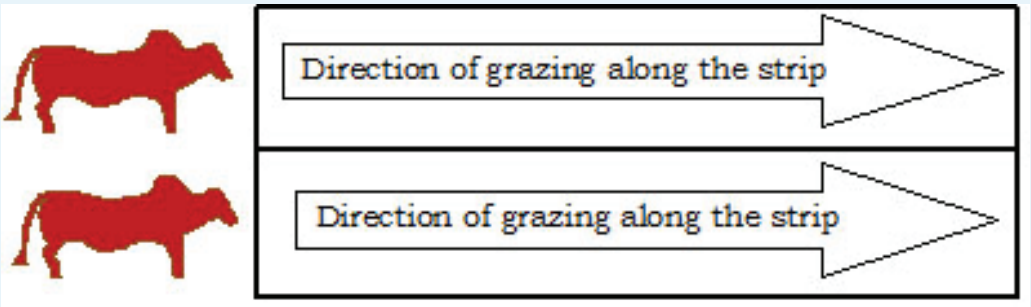


Figure 2-4: Strip grazing

2.6 Pasture weeds and invasive species management

To manage pasture weeds and invasive species the following techniques can be implemented:

- **Good grazing management**. A conservative stocking rate and effective grazing management system ensure a stable, perennial grass stand that prevent establishment of weeds.
- **Mechanical.** Woody pasture weeds and invasive species can be removed by use of machines such as power saws, brush cutters and bulldozers among others.
- **Hand chopping.** This technique is effective if the correct chopping is adhered to. The chopped wood can be bundled and sold as firewood. It is labour intensive and aftercare is important.
- **Stem burning.** In times of drought or during the rainy season, smouldering fires of branches or dung can be lighted around the stem of woody pasture weeds and invasive species. The technique is effective if the bark is burnt to such a degree that it peels off. It is labour intensive and more suited for larger bushes.

Weeds and invasive species common to ASALs in Kenya

1. *Acacia polycantha* (White thorn tree)
2. *Acacia reficiens* (thorn mimosa, thorny acacia)
3. *Acacia hockii*
4. *Acacia mearnsii* (Black wattle)
5. *Cymbopogon afronardus*
6. Capparis sp
7. Caesalpinia decapetala (Mauritius thorn)
8. Lantana camara
9. Opuntia ficus indica (Prickly pear cactus)
10. Prosopis juliflora (Mesquite)
11. Senna spectabilis (cassia)
12. Vernonia campanea.

The weeds and invasive species have local names which range from one place to another. The facilitators together with the rangeland resources user can identify these names.

(Source: Cactusplaza)
Opuntia ficus

(Source: garden.org)
Lantana camara

(Source: B. Kigomo)

Prosopis juliflora

(Source: Wawra & Peyr)

Acacia reficiens

Figure 2-5: Examples of invasive species common to ASALs in Kenya

2.7 Bush management

Bush is the main competitor for soil moisture and nutrients needed by livestock forage. The goal of bush clearance is to enhance re-establishment of pasture (Parrill & Blacksheep, 1981; Rothauge, 2007). The following should be considered in bush management:

- Bush eradication should be aimed at those species that are of little value and in excess
- Bush control should be combined with restorative measures aimed at rehabilitating grass stands.
- Bush control should be spread around the rangeland by systematically treating progressively larger areas year after year.
- The general rule is that the amount of long term rainfall per year (in mm) x 2= optimum number of bush units per hectare - one bush of 1.5m height = one bush unit (Figure 2-6) and a bush of 4.5 m height = three bush unit (Figure 2-7) (Helmut, 2008).

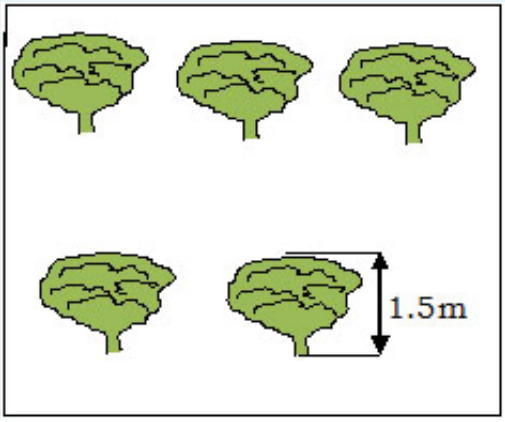


Figure 2-6: Five (5) bush units

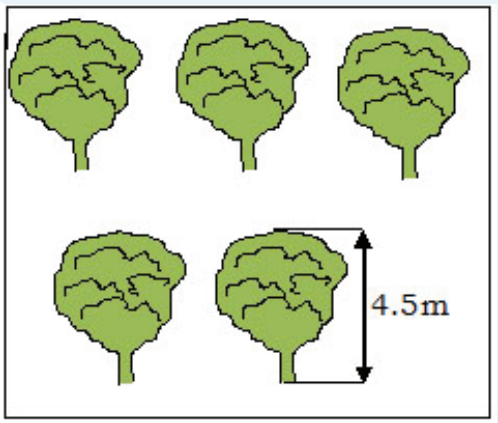


Figure 2-7: Fifteen (15) bush units

2.8 Grazing systems

Proper grazing management can minimize range degradation and increase vegetation production by manipulating frequency and intensity of grazing. The following the major practicable grazing systems for pastoral and agro-pastoral production systems.

A. Multispecies grazing

This involves grazing different animal kind and classes together on a diverse pasture to achieve even grazing and maximize grazing intensity (Taha & Khidr, 2011; Coffey, 2001). Different animals have different grazing preferences (Table 2-3). It applicable in pastoral range livestock production system.

Table 2-3: Livestock species dietary and topographical site preferences

Species	Diet preferences	Topographic position preferences
 Cattle (ILRI)	Grazer: grasses, and seasonal forbs and browse	Prefer level to rolling land
 Sheep (Bridget *etal*)	Intermediate feeder: high use of forbs, but also use large volumes of grass and browse	Better adopted to steep lands and rough terrain
 Goats (Hardin county)	Browser to intermediate feeder: high forbs and browse use, can utilize large amounts of grass; highly versatile	Adapted to a wide variety of terrain and vegetation types.
 Camel (Flickr)	Predominantly a browser, although it also grazes on tall succulent young grass. Forage plants include thorny bushes and aromatic species avoided by other animals	Adapted to a wide variety of terrain and vegetation types.

B. Rotational grazing system

System with more than one pasture in which livestock is moved to allow for period of grazing and rest of forage. The following activities are followed under the system:

- Land is subdivided into grazing divisions (pastures, paddocks) to gain control over livestock movements.
- The divisions are demarcated by fences, natural barriers, or for herders by blazed trees or natural features.
- Animals are then grazed on the pastures on a flexible, rotating basis (Figure 2-8).

It is applicable in pastoral range livestock production system.

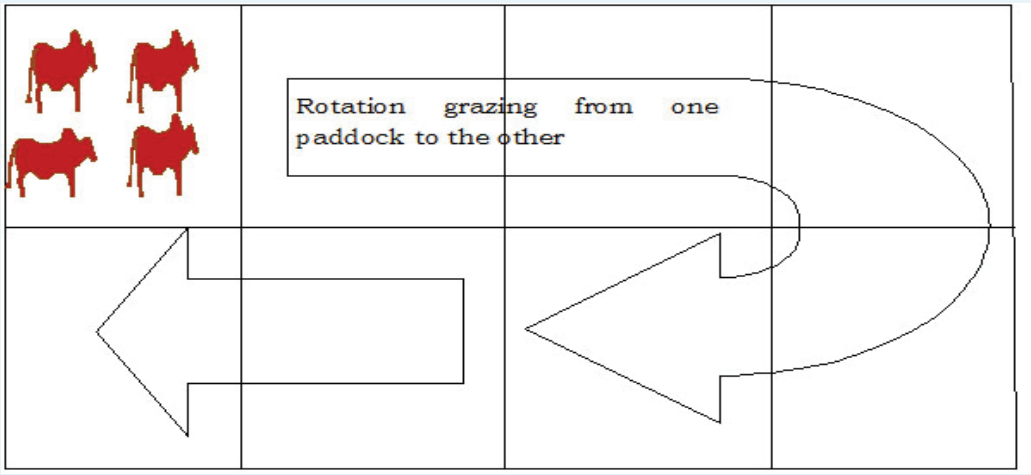


Figure 2-8: Rotational grazing

C. Deferred grazing

This system involves discontinuance or deferment of grazing of a specific pasture or unit during the rainy or growing season (Table 2-4) to promote plant reproduction, establishment of new plants or restoration of plant vigor (Rothauge, 2007). The following measures should be adhered to while planning for deferred grazing:

- Only part of grazing land should be utilized during the rainy season, allowing the remaining part to rest for a complete growing season.
- Allow the rested area to recover from previous grazing and to accumulate adequate herbaceous matter for utilization during

the dormant season.

- Rotated the system of resting areas during the growing season around the rangeland in a cycle of three to four years to enhance recovery and improvement of rangeland condition.
- The size of the area on which grazing should be deferred during the growing season depends on the aridity of the area the more arid, the larger the proportion of deferred grazing

Deferred grazing is applicable in pastoral range livestock production system.

Table 2-4: Simple deferred grazing calender

RAINY SEASON		DRY SEASON	
Grazing unit 1	**Grazing unit 2**	**Grazing unit 1**	**Grazing unit 2**
Graze 	Rest	Rest	Graze 

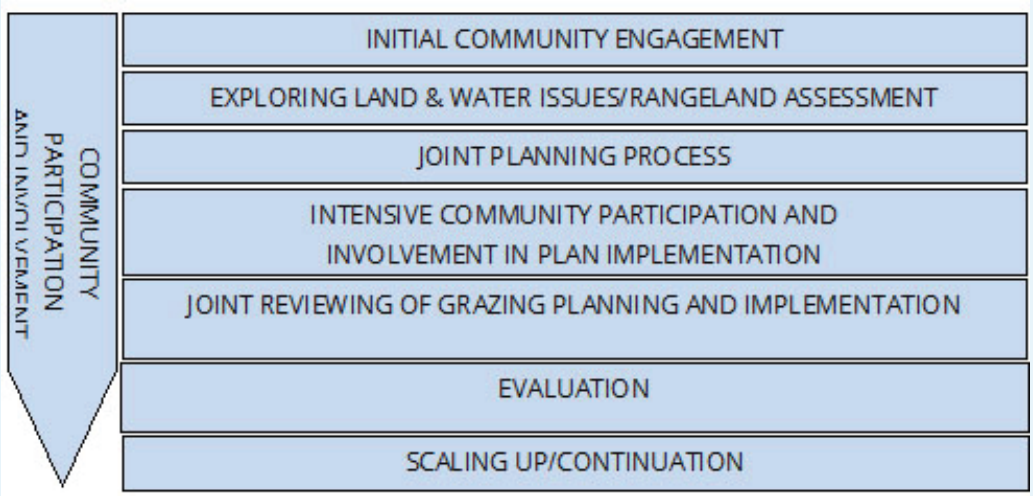
D. Holistic planned grazing

This system involves integrating livestock production with rangeland production in a way that ensures continued land regeneration, animal health and profitability (Savory, 2015).

- Land is subdivided into grazing divisions (pastures, paddocks) to gain control over livestock movements.
- The divisions are first planned on a map and then demarcated on the ground by fences, natural barriers, or for herders by blazed trees or natural features.

Livestock managers decide how long the animals will stay in one place, where they will move next and when they will come back. Its success is based on the strength of community based participatory planning (CBPP).

Steps involved in holistic planned grazing



E. Zero grazing

Animals are enclosed in zero-grazing units, where they are provided with all their requirements for feed and water. This method is mainly practiced where grazing land is scarce. The forage can be grown on farm or purchased. This is applicable in agro-pastoral production system.

F. Tethered grazing

Animals are tethered on areas of good quality fodder and are moved two or three time per day so they can have sufficient vegetation to select and eat. This is applicable in agro-pastoral production system.

Grazing guidelines

- A compromise is necessary to balance dry matter yield and an acceptable nutritive value.
- Enough forage residues must remain to ensure the plant's ability to carry out basic metabolic processes and persist at the site. Grazing height of not less than 20 to 30 cm is recommended.
- In grass/legume pastures, the grass and legume components should be kept in balance.
- Occasionally, the grasses and legumes in the pasture should be allowed to flower and produce seed as much as possible.
- Stocking rate should be flexible such that the number of animals kept are increased or lowered to match pasture availability.
- Grazing should be distributed evenly across the pastureland to minimize overuse and underuse of grazing land and to achieve healthier and productive pastures.
- Kind and classes of livestock should be matched with vegetation, topography and climate to optimize potential for vegetation and forage production.

2.9 Forage conservation and supplementary feeding

The aim of forage conservation and supplementary feeding is to overcome the problem of feed scarcity, conserve what is in excess and to improve animal performance (Tripathi, et al., 1995; Hans, 1982; Lukuyu, Gachuiri, Likuyu, Lusweti, & Mwendia, 2012; Taha & Khidr, 2011). Strategies for forage conservation and supplementary feed include:

2.9.1 Hay making

Hay is forage conserved by drying to reduce the water content so that it can be stored without rotting or becoming mouldy. Hay making is the most practicable method of forage conservation in arid land (Tripathi, et al., 1995). The following measures should be adhered to in hay making:

- Harvest the fodder for haymaking when the crop has attained 50% flowering.
- The fodder should be harvested after 2 to 3 days of dry weather so that drying will be possible. The moisture content should be reduced to about 15%. Check the dryness by trying to break the stem. If it bends too much without breaking, there is still too much water.
- Drying should be done under shade so that the dried fodder retains its green colour, which is an indicator of quality.
- Baling can be mechanized (Figure 2-9) or manual depending on livestock production system.

(Source: Weiku)

Figure 2-9: Mechanized bailing of hay

- Manual hay baling (Figure 2-10) is done using a baling box with dimensions 85 cm long x 55 cm wide x 45 cm deep, open on both ends. If the hay is well pressed, the box will produce an average bale of 20 kg. Where a wooden box is not available, a pit with the same measurements as the box can be used.
- Hay should always be stored in a sheltered enclosure away from direct sunlight and rainfall

- Good-quality hay should
  - Be leafy and greenish in colour
  - Have no foreign material mixed with it
  - Have no smell

(Source: Gachuiri 2013)

Figure 2-10: Manual bailing of hay

- Alternatively, a pit of the same dimension as the bailing box can be used or hay can be tied in small bundles of 5-8kg each (Figure 2-11). Hay can also be stored without baling by heaping it into a dome-shaped stack and covering it with a polythene sheet

Modified from: jmmcdowell.com

Pit bailing

Source: coam.org

Hay bundle

Figure 2-11: Alternative hay bailing methods

If hay is the only feed available, depending on its quality and excluding any wastage, the requirements will be as shown in Table 2-6.

Table 2-5: Hay requirements for different ages of animals

Animal	Grass hay (kg/cow/day)	Legume hay (kg/cow/day)
Cow	7–13	3–5
Heifer	5–9	1–3
Young dairy stock	2–3	1

2.9.2 Silage making

Ensiling process should be done as follows (Figure 2-12):

- Harvest the pasture or crop (material) for ensiling
  - Grasses are harvested when flowering.
  - Legumes are harvested during pod filling.
  - Maize/sorghum are harvested during milk-stage.
- An ideal crop for silage making should:
  - Contain an adequate level of fermentable sugars in the form of water-soluble carbohydrates

- Have a dry matter content in the fresh crop of above 20%
- Possess a physical structure that will allow it to compact readily in the silo after

- Chop up the material to 2 to 5 cm pieces that will ensure firm packing to exclude oxygen (air).
- Addition of molasses, maize bran or cassava flour will improve the quality of the silage by increasing the energy content and act as preservative. Table 2-6 shows the quantities of additive to add for every 1,000 kg of green material to be ensiled. The quantities can be adjusted to match the amount of fodder. Two parts of water should be added to one part of molasses to ease application.

Table 2-6: Types and quantities of additives for silage making

Forage	Molasses (kg)	Maize bran (kg)
Legumes	35–40	15
Grasses	15–20	40
Grass/legume mixture	25–30	55–70

- Rapidly fill the silo to be used and make it air tight. The bag silo is recommended. Circular pit silos can also be used.
- The silage made should be ready for use in 14-20 days. Under proper storage conditions, it could be kept for a several months.

(Source: Farmers trend)

Chopping the plant materials

(Source: ILRI)

Addition of molasses and maize bran

(Source: ILRI)

Mixing to ensure even distribution of additives

(Source: Hillfarming blog)

Storage in air tight bag silos

Figure 2-12: Silage making process

Different types of stock can be fed silage in quantities as shown in Table 2-7.

Table 2-7: Utilization of silage for different types of stock

Stock type	Quantity of silage (kg)
Milking cow	10–20
Dry cow	10–15
Dairy heifer	5–8
Beef breeding cows	12–20
Fattening calves	4–8

2.9.3 Improving the quality of crop residues

Common crop residues include straw and chaff from cereal grains, maize or sorghum Stover, maize cobs and bean haulms. Chemical treatment is the most common method (Figure 2-13).

1. The chopped material is soaked in urea solution mixed at the rate of 4 kg urea (fertilizer grade) in 100 litres of water (4%).
2. The urea-water solution is sprinkled on batches of the chopped material as it is added to the pit silo or bag silo.
3. After each addition, the mixing should be thorough. The mixing can be done in the pit/bag silo or on a plastic sheet on the ground before packing the pit.

4. It is commonly recommended that the pit or bag silo remains closed for at least 3 weeks and preferably 1 month, but treatment times longer than necessary do not have adverse effects.

(Source: Gachuiri 2013)

Figure 2-13: Crop residue improvement using urea

2.9.4 Urea–molasses blocks

The ingredients and relevant formulae used in making feed blocks are presented in table 2-8 (ESGPIP, 2007; Abebe, Amane, G, & Molla, 2015).

Table 2-8: Formulae for making Urea molasses blocks (composition in %)

Ingredients	ALTERNATIVE FORMULAE												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Wheat bran	25	25	27	35	40	40	23	25	23	25	25	35	22
Molasses	40	50	10	20	10	5	50	45	50	31	34	39	50
Urea	10	10	8	8	10	10	5	15	10	10	10	10	9
Salt	4	5	5	8	5	5	5	5	5	3	3	5	5

Ingredients	ALTERNATIVE FORMULAE												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Quicklime		5	5	5	7	7	5	0	10			6	
Agricultural lime/ Cement	10	5	10	5	5	10	10	10	10	15	15	5	14
Triple phosphate							2	0	2				
Dicalcium phosphate	1		5		3	3				3			
Poultry litter			15										
Oilseed			15							13	13		
Clay				20	20	20							
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Source (ESGPIP, 2007; Abebe, Amane, G, & Molla, 2015)

To prepare urea-molasses block the following process should be followed:

- Weigh the amount of ingredients based on the formula of the block;
- Thoroughly mix the ingredients, and place the mixture in molds.
- Remove the blocks from the molds after 24 hours and place on racks to dry for at least 5 days depending upon the weather condition (Figure 2-14)

Source (Abebe, Amane, G, & Molla, 2015)

a. Mixing the ingredients b. Drying the molded block

Figure 2-14: Preparation of urea molasses block

It is essential to note the following while supplementing using urea

Molasses blocks.

- Feed to ruminants only (sheep, goats, cattle, camels). Do not feed to young ruminants less than six months of age.
- Blocks should be used as a supplement and not as the basic ration.
- The amount of blocks fed to sheep and goats should be limited to 100 grams/day;
- The blocks should never be supplied in ground form or dissolved in water as this can result in over consumption and cause urea toxicity
- Supply sufficient amount of water

2.9.5 Browse meal

Browse meal (Figure 2-15) is conserved leaf and pod material from the protein-rich fodder legumes. In preparing browse meal, the following steps should be followed:

- Harvest the leaves and ponds and dry them on a clean floor (under shade).
- Collect the dry leaves and ponds and put them in a gunny bag.
- Store the leaf meal in a dry place and away from the sun.
- Feed as a supplement. The meal should not form more than 30% of a daily ration.
- Wet the browse meal with water before feeding to reduce wastage through spillage.

Leguminous trees suitable for extraction of leaf meal are presented in table 2-2.

(Source: Trees for livestock)

Figure 2-15: Browse meal made from dried calliandra leaves and pods

3 Livestock Health and Marketing

3.1 Reportable Livestock Diseases

These are the priority livestock diseases that have significance in terms of food security, public health and livestock trade. There are many reportable diseases but the pertinent one to livestock production in pastoral and agro-pastoral production systems include:

Foot and mouth disease

Lesions on the foot and mouth (DEFRA)

Affects cattle, sheep, goats, camels and pigs. FMD should be suspected and reported to the veterinary office when the following occur:

- Lameness in a number of animals
- Salivation (drooling)
- Smacking of the lips, grinding of teeth
- Vesicles in the mouth (on the tongue, gum, cheeks, lips)
- Unwillingness to move or stand
- In lactating animals, significant drop in milk production

Anthrax

Un-clotted blood-stained discharges (Ugandameat.ug)

Affects cattle, sheep, goats and camels

Anthrax should be suspected and reported to the veterinary office when the following occur:

- Sudden death of an animal occurs
- Un-clotted blood-stained discharges through the mouth, nose and anus

Peste des Petits Ruminants (PRR)

Purulent eye and nose discharges in a goat (FAO)

Early mouth lesion showing areas of dead cells (FAO)

Affects sheep and goats. PRR should be suspected and reported to the veterinary office when the following occur:

- Acute diarrhea
- Coughing
- High morbidity (can be low in endemic areas)
- High mortality (can be low in endemic areas)

Sheep Pox and Goat Pox (SGP)

Papules in the mouth of sheep (DEFRA)

Affects sheep and goats. SGP should be suspected and reported to the veterinary office when the following occur:

- Hard swellings (papules) may cover the body, or may be restricted to the groin, axilla and perineum
- Nasal discharge
- Enlargement of superficial lymph nodes
- Lesions develop on mucous membranes of the eyes, mouth and nose

Necrotic lesions in the skin of a goat (DEFRA)

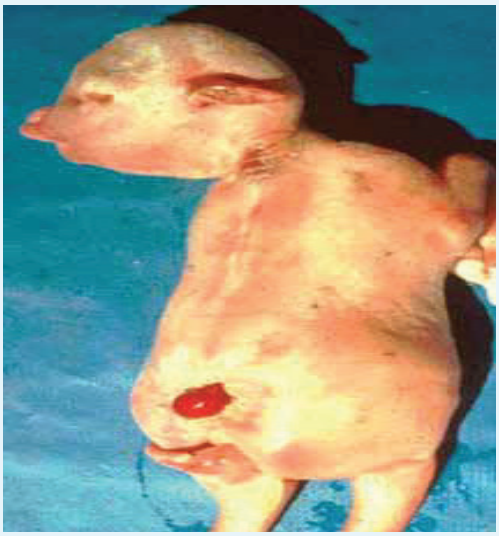
Contagious Caprine Pleuro-Pneumonia (CCPP)

A distended neck of goat due to difficulty of breathing (Solomon Nega/FAO)

A disease of goats. CCPP should be suspected and reported to the veterinary office when the following occur:

- Labored breathing (dyspnoea)
- Nasal discharge
- In terminal stage animal are unable to move
- Saliva continuously drips from the mouth

Rift Valley Fever



Aborted fetus (FAO)

Affects humans and ruminants. RVF in cattle sheep, goats and camels should be suspected and reported to the veterinary office when the following occur:

- Abortion in pregnant animals
- Bloody diarrhea and vomiting
- High mortality (particularly young animals)

Camel Pox

Papules on head, eyelids, nostrils ad neck (alchetron.com)

Affects camels. Camel pox should be suspected and reported to the veterinary office when the following occur:

- Enlarged lymph nodes
- Papules/vesicles/pustules with crusts develop on head, eyelids, nostrils, neck, limbs, genitalia, mammary glands and perineum
- Animals show lacrimation, muco-purulent nasal discharge
- Abortion may occur in pregnant camels
- Diarrhea may be observed in sick animals

Lumpy Skin Disease (LSD)

LSD nodules (FAO)

Affects cattle. LSD should be suspected and reported to the veterinary office when the following occur:

- Appearance of painful cutaneous nodule in the body especially head, neck, perineum, genitalia, udder and limbs
- Lesions appear on muzzle, nostrils and mouth
- Superficial lymph nodes are enlarged
- Mucopurulent nasal discharges
- Persistent dribbling of saliva
- Coughing and distressed respiration
- Reduced milk production in lactating animals

Brucellosis

Affects cattle, wildlife and human.

Brucellosis should be suspected and reported to the veterinary office when the following occur:

- Abortion and infertility

3.2 Internal and External parasites

Common external parasites include lice, mites, ticks and flies. Affected animals show irritation, itchiness and hair loss. Cattle infested with external parasites may lose grazing time and thus reduced productivity. External parasites can be controlled through dipping, rubbing or spraying. Internal parasites include roundworms, tapeworms and flukes. Signs are variable and can range from reduced weight, decreased milk production, low pregnancy rates, scouring

and or depression and even death is possible in young animals. It is recommended that animals are dewormed regularly to control internal parasites.

3.3 Marketing strategies

Alternative marketing strategies include:

a. Livestock Auction yards
b. Private treaty transactions
c. Order buyers and country dealers
d. Pooling **-** Grouping cattle from several producers to sell them in larger lots is more attractive to buyers. It requires setting up of grading methods and pooling specifications
e. Video auctions **-** This system takes advantage of the continued information technology. It is conducted by posting animals for sale on media through videos and photos.

3.3.1 Processing to add value and preserve products

Farmers can process their milk within their households into products such as ghee and yoghurt, which can be consumed at home or sold or bartered in the village to rural consumers.

3.3.2 Investing in Information technology

The geographical position, the availability of forage and water resources, the conditions of the animals, the occurrence of events can be conveyed through mobile phones this medium. Mobile phones can support more informed market engagement by livestock keepers, pastoralists and livestock traders (WISP, March 2010).

4 Livelihood Diversification and Resilience Buidling

Practicable livelihood diversification and resilience building strategies include:

4.1 Rearing locally adapted livestock species

The approach is to make use of locally adapted breeds, which are not only tolerant to heat and poor nutrition, but also to parasites and diseases (WISP, March 2010). Examples of locally adapted livestock species include dorper sheep, galla goat, toggenburg goat, boran cattle among other.

4.2 Intensification of small stock production.

Small stocks reproduce faster even during droughts, hence offtake is achieved faster and the loss of one small stock unit on total herd size is less dramatic than in the case of large stock (Louwrens, 2001). Goats in particular are more tolerant to drought and reproduce faster (Figure 4-1).

(Source: ILRI)

Figure 4-1: Goats as a means of restocking in Turkana

4.3 Purpose rearing and use of emerging livestock

This involves keeping of livestock to meet specific purpose such as egg production, milk production, draft animal and or bull for leasing. It is considered cheaper to feed and maintain animal kept for specific purpose.

Emerging livestock are animals outside traditional pastoral agro-pastoral livestock herd composition that have not received adequate attention in terms of development yet they have immense performance and productivity potential. Practicable emerging livestock practices for incorporation into pastoral and agro-pastoral production systems include guinea fowl farming, ostrich and rabbits farming (Pratt & Gwynne, 1977; URT, 2014; Watson & Binsbergen, 2008;Watete, Makau, Njoka, AderoMacOpiyo, & Muriithi, 2016).

4.4 Backyard poultry rearing

This involves rearing any flock of chicken that are kept under free range management and on which no selection of breeds or improvement by crossbreeding has been done (Ondwasy, Wesonga, & Okitoi, 2006). Pastoral and agro-pastoral families can improve their meat and egg production by adhering to the following recommendation:

- Feed birds with energy, protein, minerals and vitamin rich feeds in addition to scavenging. This could be from premix or pastured feeds (figure 4-2).
- Provide clean and adequate drinking water.
- Provide secure and clean housing to control predators, pests and diseases.
- Avoid inbreeding by introducing one cock for every ten hens every two years.

(Source: Peril of Africa)

Figure 4-2: Supplementary feeding of free ranging chicken

4.5 Beekeeping

Beekeeping is suitable for areas which have a rich vegetal diversity necessary for nectar collection (GoK, 2015). Beekeeping involves construction of beehives in sites with high nectar yielding vegetation (Figure 4-3). Common beehive types include the langstroth and top bar hives. It is advisable to avoid locations with direct agricultural activities or settlement. The location must also take into consideration weather conditions such wind, shade and sunlight exposure.

Figure 4-3: Beekeeping as a livelihood diversification strategy

4.6 Ecotourism

Rangelands present opportunities for investing in ecotourism ventures where communities can devote part of their land for conservation and in return get income. In addition controlled grazing and ecotourism ventures are considered to be compactible land uses.

4.7 Grazing contracts

Contract grazing involves managing pastureland to generate economic returns from cattle grazers by renting pasture during the growing season. It is a possible enterprise for youth who do not own land but can rent and manage pasture for grazing on contract.

4.8 Aquaculture

Aquaculture can be implemented in dams, water pans and farm ponds depending on kind of species to be farmed. Fingerling or mature reproductive catfish or mudfish are introduced in the water source and harvested at maturity or when the water source nears drying up. The method of farming waterweeds is the peg and line. In this method, nylon ropes with waterweed are tied between two wooden

pegs. The waterweed branches, usually about 100gm, are tied to the lines and allowed to grow for six weeks before they are harvested. When harvesting, farmers remove the lines and the seaweed and then tied in new seaweed branches.

4.9 Grass seed production

Seed production includes effort ranging from growing, harvesting and drying, pre-treatment and storage. Seed harvesting is manual or mechanized. The approaches are harvesting the entire plant, the seed head and its stalk or the seed head only. While under storage, regular checks should be made to ensure that pests and mold do not infest seed. In addition, it is advisable to test seed samples for viability from time to time.

5 Decision Tree Matrix

The choice of strategies and or technologies for building resilient livelihoods in pastoral and agro-pastoral production systems is dependent on land capacity, land use and ownership pattern, production systems and socio-cultural practices (Figure 5-1).

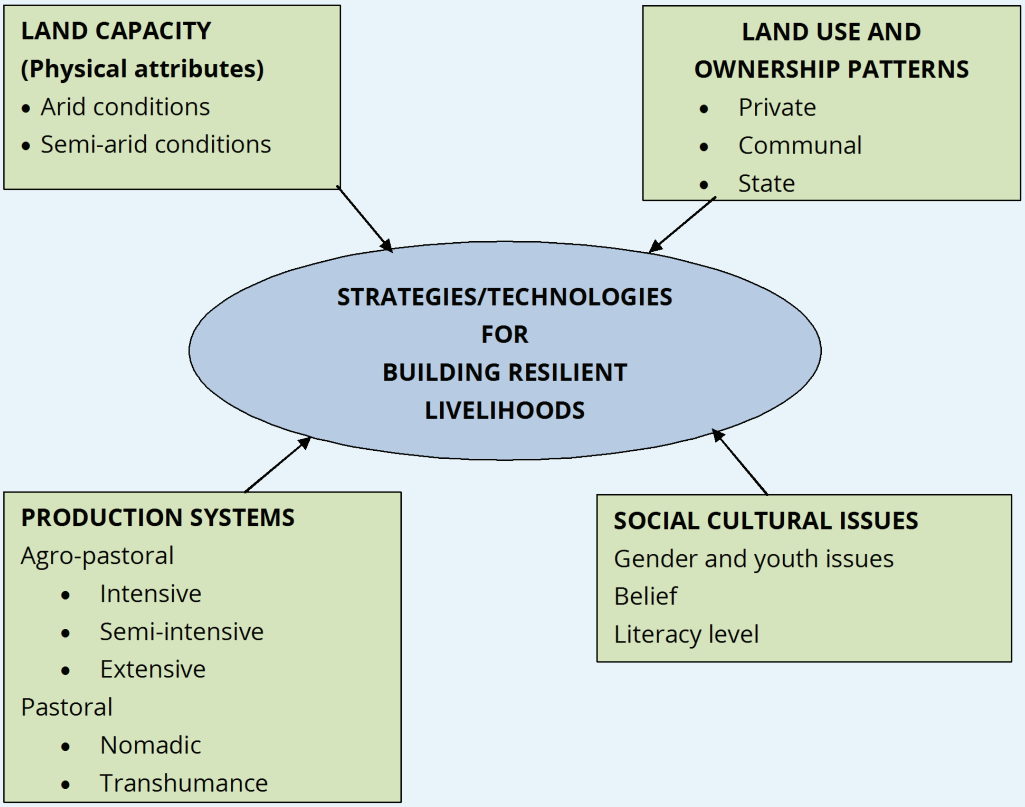


Figure 5-1: Factors influencing choice of strategies and technologies for building resilient livelihoods in pastoral and agro-pastoral production systems

Based on the assessment of the limitations of these factors figure 5-2 presents the decision tree for various strategies and or technologies for building resilient livelihoods in pastoral and agro-pastoral production systems

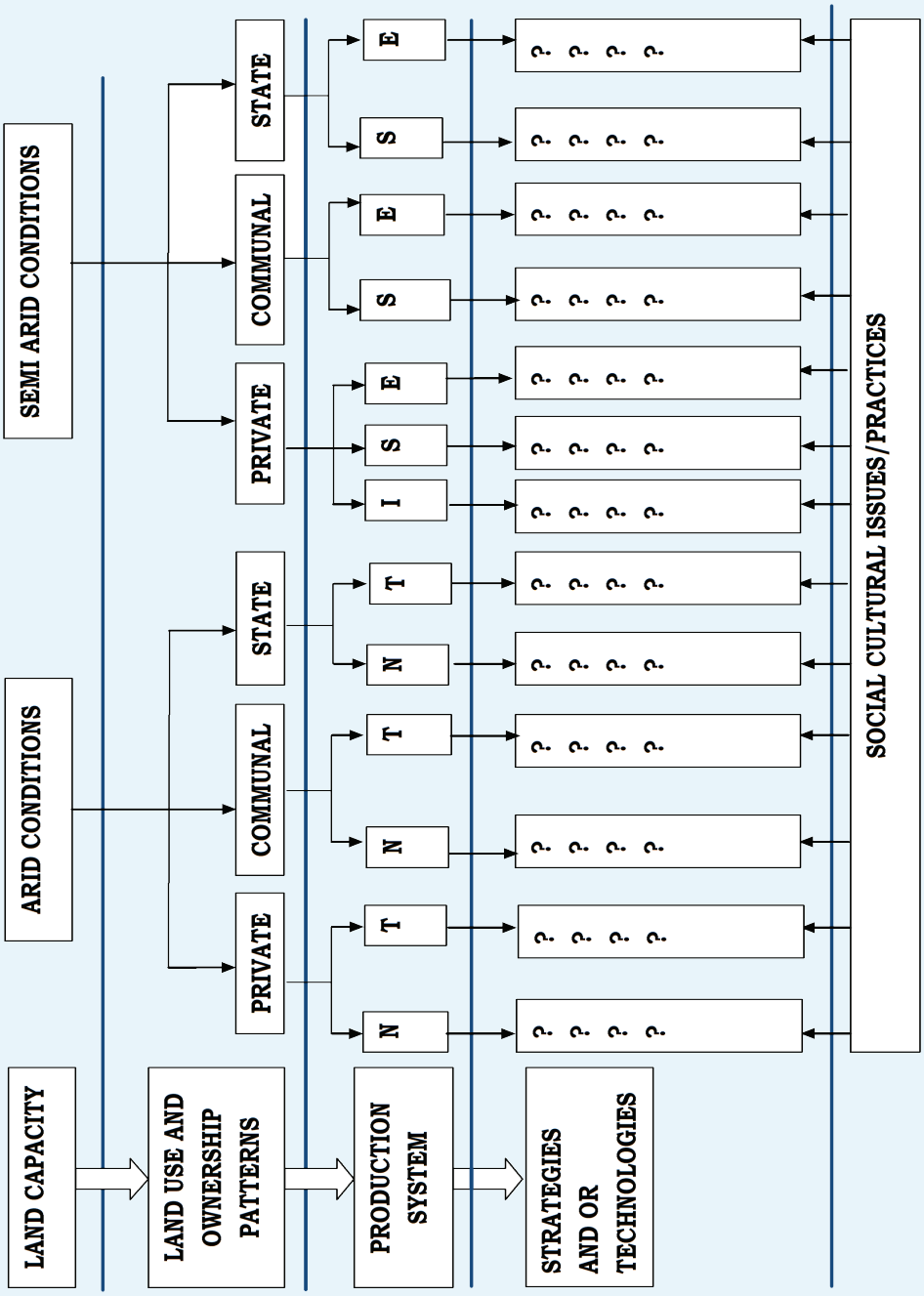


Figure 5-2: Decision tree for choosing appropriate strategies and technologies for building resilient livelihoods in pastoral and agro-pastoral production systems

N denotes Nomadic pastoral production, **T** denotes Transhumance Pastoral production, **I** denote Intensive livestock production, **S** denotes Semi-intensive livestock production, and **E** denotes Extensive livestock production system

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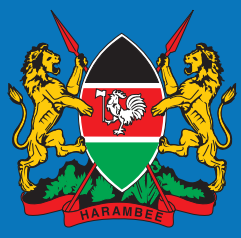
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