1.6 Pasture Sowing (For Specific Varieties)

Step	*Process*	*Description*	*Remarks*
1	 **Rhodes Grass** Seed to be sown in $1m^2$ of land	**Rhodes Grass, Buffel Grass and Native Grass Available in Borena** ➢ Buffel Grass is more drought resistant than Rhodes Grass. However, Rhodes Grass is more productive. ➢ Seeding rate of grass forage is 1-4kg/ha. ➢ Manure application (dried cattle dung) is important for early establishment. ➢ 1 to 2 times ploughing (minimum tillage) is required depending on the land hardness.	They are well-adopted varieties in lowland. They tolerate heavy grazing and cutting. It can also control soil erosion.
2	 **Buffel Grass** Seed to be sown in $1m^2$ of land	**Rhodes Grass, Buffel Grass and Native Grass Available in Borena** ➢ The seed should be sown as soon as rain starts in both g*ana* and *hagaya* season. *Gana* season is more preferable for sowing the seed. ➢ Method of the sowing is broadcasting. Maximum soil depth should be 2cm and not be more than that.	

Step	*Process*	*Description*	*Remarks*
3		**<u>Rhodes Grass, Buffel Grass and Native Grass Available in Borena</u>** ➢ Communities should close the areas where people sowed grass seed from 2 to 5 years for the purpose of establishment of new *kalo*. They should ban entering of animals in the areas. ➢ Yield is 3.5 to 4ton/ha at one harvesting time if sown at degraded rangeland in Borena zone. Compare the pictures taken at the same day. Left; since it is too much seed density, the grass becomes dying. Right; Low seed density encourages the grass to expand its body. The grass has grown from one seed.	They can start collection of forage seed from first season. If there is a deficiency of animal feed at community before 2 to 5 years and people agrees, they can use pasture by cut and carry system.
4		**<u>Rhodes Grass, Buffel Grass and Native Grass Available in Borena</u>** ➢ During three years after sowing pasture, cut and carry system is highly recommended. Since they are perennial grass species, they can re-grow after rainy season starts. ➢ If the closed areas are well stabilized, communities can start using as *kalo*. ➢ For harvesting, 15cm above the ground of grass should be cut.	The left picture shows Rhodes Grass.

Step	*Process*	*Description*	*Remarks*
5	 **Alfalfa** Seed to be sown in 1m^2 of land	**Alfalfa** ➢ Land should be ploughed very well like land preparation of Haricot Beans. It requires a well-prepared seedbed. ➢ Seeding rate is 8-10 kg/ha for pure stand, and 5-6 kg/ha for mixed forage plot. ➢ The seed is sown by broadcasting or line planting. ➢ To be sown as soon as rain comes in both *gana* and *hagaya* season.	It adapts to arid environmental condition. On degraded land, water conservation practice such as micro basin is necessary. It requires 600mm rainfall per year. Thanks to its deep root system, it can grow in drought areas. It grows over a wide range of altitude.
6		**Alfalfa** ➢ Sow the seed at less than 1 cm depth in heavy soils and 1 to 2 cm depth in light soils. ➢ It can be harvested every 30 to 45 days during the growing season. ➢ Feeding should be mixture of 30% of alfalfa and 70% of other roughages in order to avoid bloat. Animals gradually get accustomed to taking alfalfa. ➢ Since it is perennial grass, it can re-grow after rainy season starts.	Bloat is abnormal fermentation of the stomach and occurred if ruminant animals take excess legume such as alfalfa, clover, cow pea and ect. Highland forages like alfalfa and vetch are more productive if good management is in place. High yield and good nutrition value are expected (has much CP, Ca, P). Resistance to overgrazing

Step	*Process*	*Description*	*Remarks*
7	 **Vetch** Seed to be sown in 1m^2 of land	**Vetch** ➢ It requires rough seedbeds. ➢ Sowing rates is 20 kg/ha for pure stand, 5-12 kg/ha for mixed forage plot. ➢ Depth of seeding should be less than 6mm in clay soil. ➢ Weeding needs at the early stage.	It requires above 400mm rainfall per year. Tolerant to most diseases and pest. It grows in the wide range of soil types.
8		**Vetch** ➢ Vetch can be sown by intercropping with maize and sorghum. ➢ Vetch can be sown with other types of grass. It can be planted in the backyard plots. ➢ Since it is a perennial grass, it can re-grow after rainy season starts.	Bloat has occurred by taking too much alfalfa, white clover, and red clover. It rarely happens by vetch.

Step	*Process*	*Description*	*Remarks*
9	 **Cow Pea** Seed to be sown in 1m^2 of land	**Cow Pea** ➢ It is **annual** and dual purpose legume (for human food and animal feed), and drought tolerant. ➢ It can be established in the rough seedbed ➢ It can be sown at 15 kg/ha for pure stands and about 12 kg/ha for mixing with the other forages.	Highland to Lowland. It requires more than 300mm annual rainfall. It is adapted to well-drained and frost free area.
10		**Cow Pea** ➢ At the begging, feeding should be mixture of 30% of cowpea and 70% of other roughages in order to avoid bloat. Animals gradually get accustomed to taking cow pea. ➢ It is **annual crop**. Therefore, the seed must be harvested and stored for next rainy seasons.	

Step	*Process*	*Description*	*Remarks*
11	 **Lablab Grass** Seed to be sown in $1m^2$ of land	**Lablab** ➢ Lablab is **an annual** or a short-lived legume with very vigorous seedlings. ➢ It is a dual purpose legume (for human food and animal feed) and drought tolerant. ➢ It should be sown at 18-20 kg/ha for pure stands, 15 kg/ha for intercropping (maize etc.) and 2 kg/ha for forage strip sowings. ➢ It can be easily planted in a the rough seedbed.	Highland to Lowland. It requires more than 400mm annual rainfall. Lablab is suited to a wide range of soil types but will not tolerate salinity or water-logging. It has moderate palatability and cattle may require several days to get accustomed to it. Lablab leaf should be supplied with other grasses.
12		**Lablab** ➢ It should be cut regularly at the height of 25-30 m. Avoid cut at the height of 25cm below. It can kill plant. ➢ At the begging, feeding should be with mixture of 30% of vetch and 70% of other roughages in order to avoid the bloat. Animals gradually get accustomed to taking vetch.	

Step	*Process*	*Description*	*Remarks*
13	 Only 8 pieces of pea/ m^2!! **Pigeon Pea** Seed to be sown in $1m^2$ of land	**Pigeon Pea** ➢ It is a perennial and dual purpose legume shrub providing forage and grain for human consumption. ➢ The seed should be sown at the rate of 10–20 kg/ha by broadcast or about 1 kg/km of contour forage strips. ➢ Spacing: about 1m apart between rows. It should be sown in the well-proughed land and covered with no more than 2.5 to 10 cm of soil. ➢ It can be intercropped very well with maize and sorghum.	It lives up to 4 years and is an excellent crop to improve food security and integrate forage and cropping systems. Because of its use for human food, Pigeon pea is a useful plant to introduce the concept of contour forage strips and alley cropping to lowland agro pastoralists. It is drought tolerant and adapted to wide range of soil types.
14		**Pigeon Pea** ➢ Growth in the early stage is slow. Once the crop established the plants, it requires little attention. ➢ For feeding, cut the plant at 80 cm height when the first pods begin to ripen. ➢ Since it is a perennial grass, it can regrow after cutting if rain is available or after rainy season comes.	It is palatable forage and keeps high productivity of seed. 400mm annual rainfall is needed. It cannot persist if it is heavily grazed by animals. It can also be damaged by water logging.

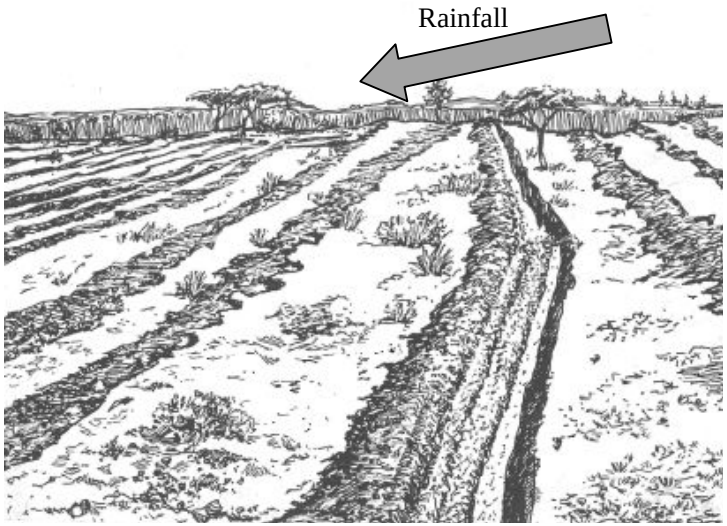
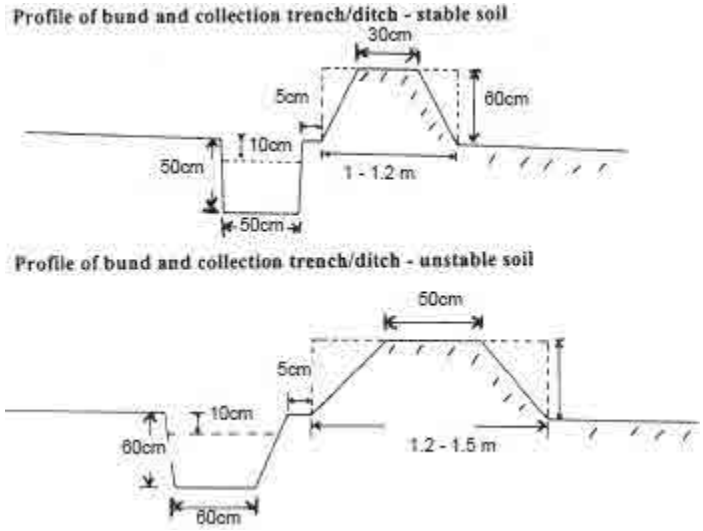
Step	*Process*	*Description*	*Remarks*
15		**<u>Elephant Grass</u>** ➢ The cutting (30cm length) of Elephant grass can be planted in the site. It should be transported and planted after actual rain comes. ➢ Angle of cutting should be 45^{o} as the left picture shows. ➢ If the cutting has three nodes, two nodes should be buried in the soil and one should be outside. Always only one node should be outside. ➢ Two planted cuttings need 0.5m spacing between them.	Requires more than 700 mm annual rainfall. Elephant grass is a robust perennial with a vigorous root system. It becomes 180 to 360 cm in height. It is valued for its high dry matter yield. It responds manure and can be planted at backyard. Frost susceptible.
16		**<u>Elephant Grass</u>** ➢ Once Elephant grass establishes its body, it is easy to manage them. ➢ It is well suited to contour around the other forages.	It has high fiber content at maturity stage. Productivity of seed is low (usually use cutting for planting).

Step	*Process*	*Description*	*Remarks*
17		**<u>Elephant Grass</u>** ➢ Elephant Grass should be used for cut and carry system. For feeding livestock, cut at 10cm from the ground before the grass exceeds 1m in height since the grass will be very hard.	
18		**<u>Leucaena (fodder tree)</u>** ➢ It can be planted by both direct seeding and transplanting of seedlings. ➢ Cultivation; Light cultivation for direct seeding and dug holes for transplanting (see *2.7*). ➢ Suitable mixing species include *Sesbania sesban, Cajanus cajan* and local leguminous browse species such as *Acacia sp*.	Well-adapted for highland. Leucaena is a long-lived tree and grows up to 20 m in high. It is suited to warm-hot regions below 2000m altitude and requires more than 400 mm rainfall. It prefers well-drained, fertile soils and will not tolerate high acid and waterlogged soils.

Step	*Process*	*Description*	*Remarks*
19		**<u>Leucaena (fodder tree)</u>** ➢ The seed should be sown at 4–7kg/ha, but different rates or spacing can be used depending on the utilization. ➢ Sowing is done by both direct seeding and planting seedlings. Sowing depth by direct seeding is 2–3cm. ➢ Spacing between alleys is 2–2.5m to 4.0m. It should be spaced at about 50 cm between plants in the row. ➢ Seed treatment is necessary. Soak the seed in hot water for 10 minutes. https://toptropicals.com/catalog/uid/Leucaena_leucocephala.htm	It is a vigorous plant with high yield and high-quality protein contents. Leaves and thin twigs are eaten by livestock very well. Its secondary uses include fuel wood production, nitrogen supply for companion crops, erosion control, and shelter.
20		**<u>Leucaena</u>** ➢ It should be used by the cut and carry system. It is also well adapted to browsing. ➢ Cut at 80–100cm in height every 6–8 weeks. ➢ Use as a supplement feed for animals and feed with grass forage. Ration of feeding needs attention to prevent toxic effects on the grazing animals.	

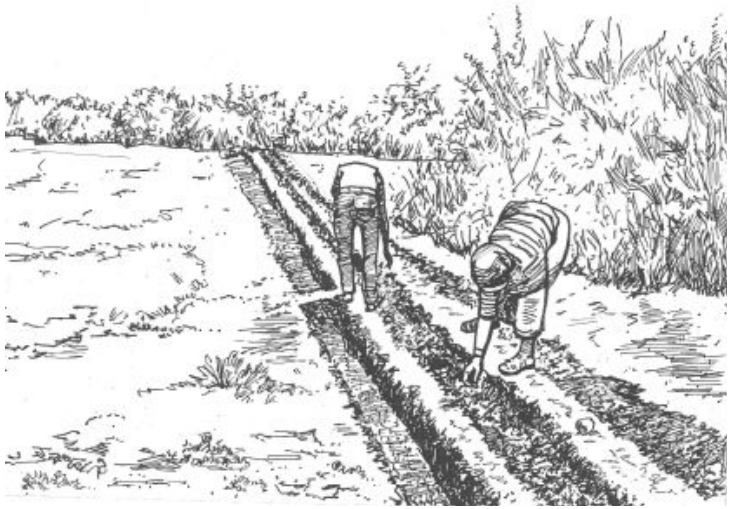
Step	*Process*	*Description*	*Remarks*
21		**<u>Sesbania</u>** ➢ It can grow rapidly from direct seeding. ➢ It should be sown in the well-prepared seedbed at the beginning of main rainy season. In addition, keep weed free. ➢ Plant the seedlings at the beginning of rainy season too (see *2.7*).	Highland to lowland Sesbania is highly suited to contour banks, backyards and alleys of farming areas. It grows in wide range of soil types including very poor acid sandy soil and waterlogged soil, but responds well to good fertility soil. It requires more than 600mm annual rainfall for survival
22	 Seedlings of Sesbania	**<u>Sesbania</u>** ➢ Spacing varies according to uses; ➢ Continuous hedge; 50seeds/m or 2–3seeds/hole at 50cm spacing. ➢ Alley cropping; 4m or more spacing needs between alleys. ➢ Utilization; Cut at 0.5–1.0m in height every 6–8 weeks; use as supplement food (20–30%) with grass forage. There is toxicity if too much Sesbania is given too animals.	

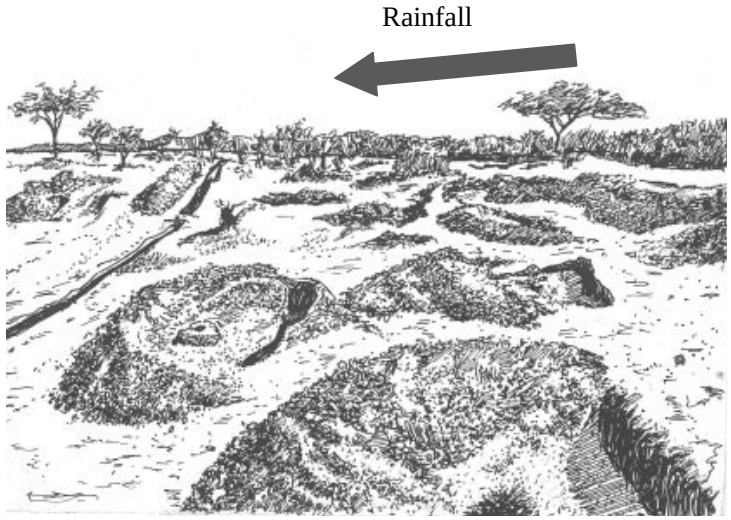
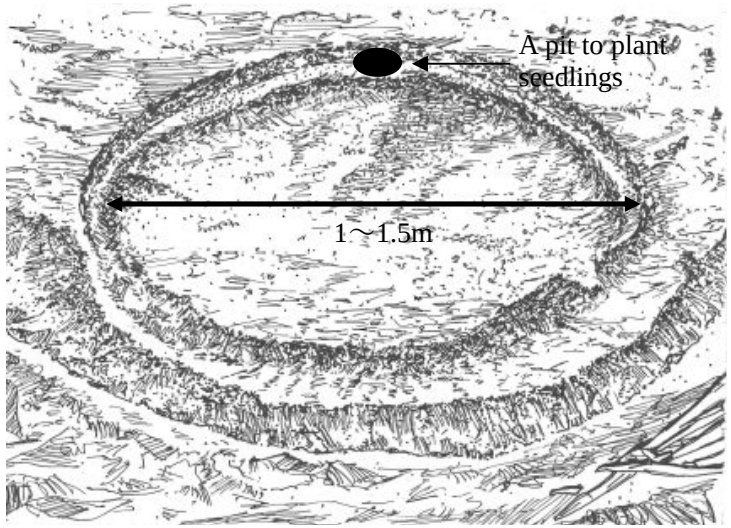
1.7 Pasture Sowing on Soil Band & Micro Basin

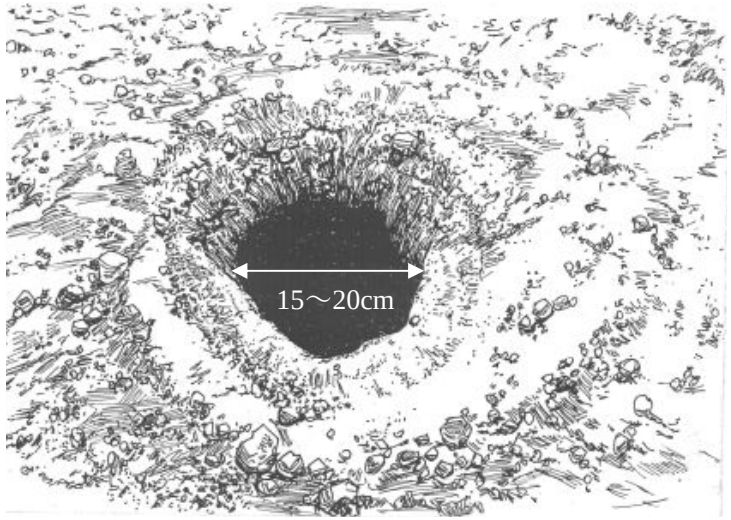
Step	*Process*	*Description*	*Remarks*
1		**Sowing Forage Seed on Soil Band** ➢ As the left picture shows, soil band should be allocated along the contours. ➢ Embankment should be downside of the soil band.	
2		**Sowing Forage Seed on Soil Band** ➢ The left picture shows recommended structure of Soil Band. Source: Community Based Participatory Watershed Development, A Guideline, MOA	

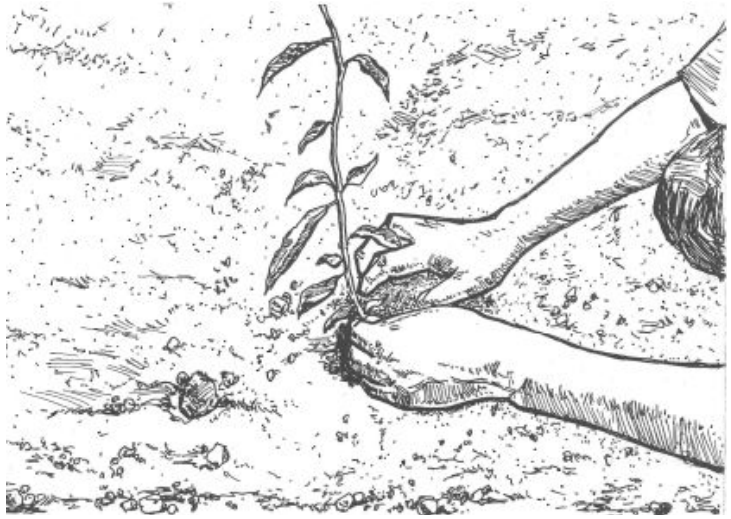
Step	*Process*	*Description*	*Remarks*
3		**Sowing Legume Forage Seed in Soil Band** ➢ Make lines on the embankment.	
4		**Sowing Legume Forage Seed in Soil Band** ➢ Drop one legume seed in regular intervals of spacing. ➢ Pigeon pea needs more spacing.	

Step	*Process*	*Description*	*Remarks*
5		**<u>Sowing Legume Forage Seed in Soil Band</u>** ➢ Cover the seed by soil.	
6		**<u>Sowing Grass forage Seed in Soil Band</u>** ➢ Roughly plough the embankment.	

Step	*Process*	*Description*	*Remarks*
7		**<u>Sowing Grass Forage Seed in Soil Band</u>** ➢ Broadcast the grass seed in the embankment.	
8		**<u>Sowing Grass Forage Seed in Soil Band</u>** ➢ Cover the seed by soil.	

Step	*Process*	*Description*	*Remarks*
9		**<u>Planting the Seedling of Fodder Tree or Elephant Grass in Micro Basin</u>** ➢ As the left picture shows, Micro Basin should be allocated along the contours. ➢ Embankment should be downside of Micro Basin.	
10		**<u>Planting the Seedling of Fodder Tree or Elephant Grass in Micro Basin</u>** ➢ Size of Micro Basin depends on the level of land degradation. If a target site is highly degraded, the size should be big. The left picture shows an example of Micro Basin.	The structure of micro basin should avoid waterlogging of seedlings (particularly for fodder trees). Elephant grass is somewhat resistant to waterlogging.

Step	*Process*	*Description*	*Remarks*
11		**Planting the Seedling of Fodder Tree or Elephant Grass on Micro Basin** ➢ Dig a pit to plant a seedling. ➢ The depth is about 20cm.	
12		**Planting the Seedling of Fodder Tree or Elephant Grass in Micro Basin** ➢ Remove the polyethylene tube from the grown seedling.	

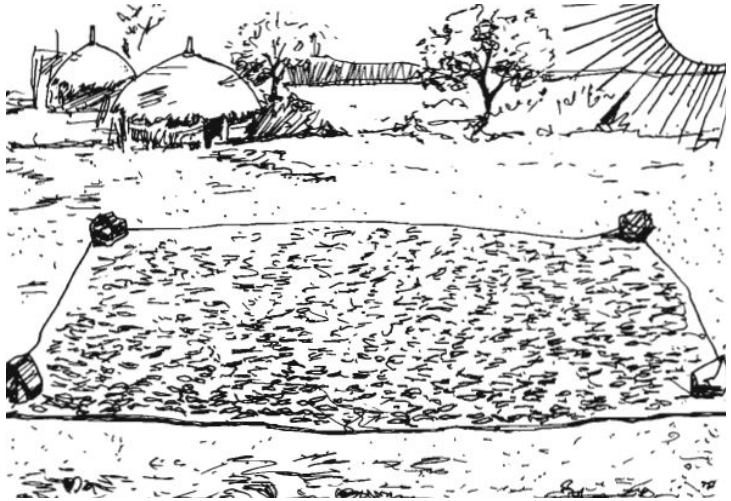
Step	*Process*	*Description*	*Remarks*
13		**<u>Planting the Seedling of Fodder Tree or Elephant Grass in Micro Basin</u>** ➢ Put the seedling into a pit.	
14		**<u>Planting the Seedling of Fodder Tree or Elephant Grass in Micro Basin</u>** ➢ Cover the pit with soil.	

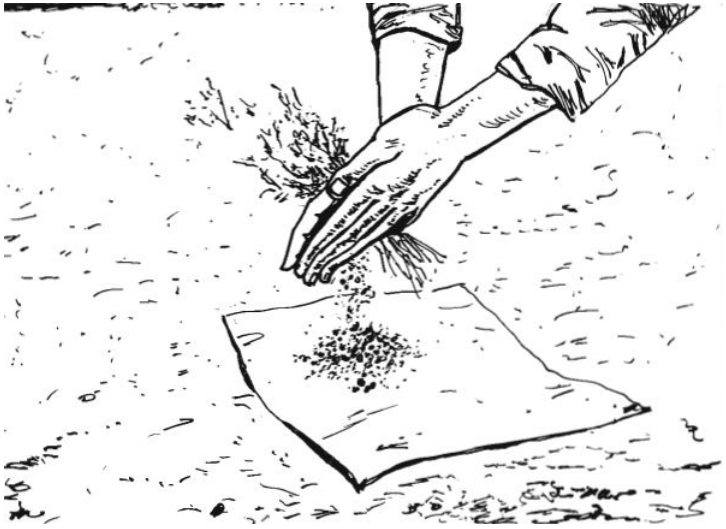
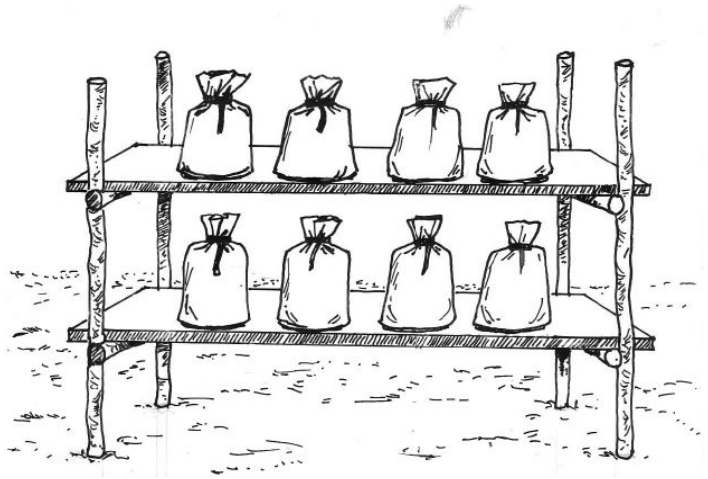
1.8 Seed Collection

Step	*Materials to be Collected*	*Remarks*
0	➢ Sickle ➢ Seed collection sack ➢ Machete ➢ Stick for threshing	
		

Step	*Process*	*Description*	*Remarks*
1		**<u>Checking Maturity of Seed (Grass Seed)</u>** Maturity of grass forage should be checked through scratching by finger. When the seeds are easily released, it is an indicator of ripe seed. Seed should be collected when easily removed by gentle rubbing or shaking. ➢ Grass seed should be fully ripened. ➢ Optimum harvest time usually occurs before maximum flower density.	Through discussion with communities, potential sites for seed collection should be identified in advance. Native (Natural) grass can be also collected by communities to expand rangeland and it is highly adaptable to the local environment.
2		**<u>Checking Maturity of Seed (Legume Seed)</u>** ➢ Pod becomes matured and brown, the seed should be harvested.	The left picture shows ripened pigeon pea.

Step	*Process*	*Description*	*Remarks*
3		**<u>Seed collection (Grass Seed)</u>** Cut the head of grass	
4		**<u>Seed collection (Legume Seed)</u>** Hand picking	

Step	*Process*	*Description*	*Remarks*
3		**<u>Drying</u>** ➢ Dried as soon as possible after harvesting ➢ Grass seed should be dried under the shade, because grass seeds are very light and exposed to wind. ➢ Dry forage seeds on the plastic sheet by turning the seed twice a day. ➢ Drying from 3 to 5 days is enough under normal condition of dry season in Borena.	Grass seed dried slowly than legume seed to maintain its viability.
4		**<u>Threshing (Legume Seed)</u>** By beating with sticks on the plastic sheet	

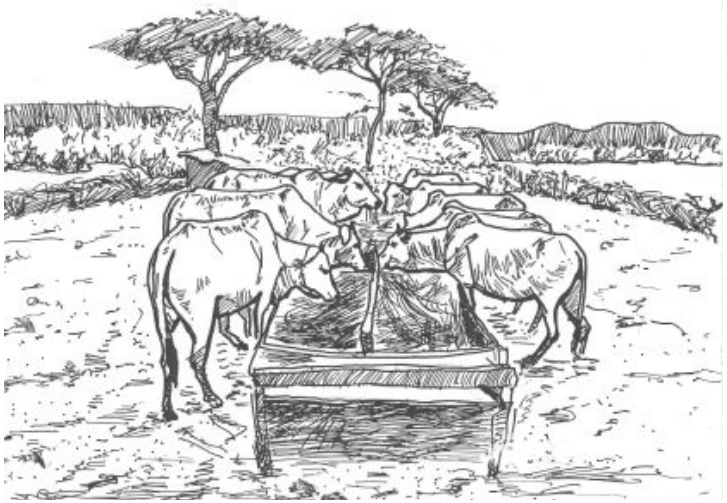
Step	*Process*	*Description*	*Remarks*
5		**Threshing (Grass Seed)** ➢ Shaking on the plastic sheet ➢ Or kindly rubbing on the plastic sheet	
6		**Storing seed** ➢ Harvested seed must be stored in a cool and dry place. Length of seed life depends on the environment of storage. Generally speaking, seed can be stored for 5 years in good environment. ➢ On prepared drying bed/shelf that is 1.5m from the ground and the space between the shelves 50cm	Grass seeds should be heaped immediately after harvest so that they will "sweat" to assist final maturation of the seed. Grass seed is more sensitive than legume seed and should be dried slowly to maintain its viability.

Step	*Process*	*Description*	*Remarks*
5		**Storing seed** ➢ In the storage ➢ In the bag ➢ Cool and dry place	
6		**Collecting Cutting of Elephant grass** ➢ As the left picture shows, a stem between nodes should be cut. ➢ Cutting should be about 30 cm ➢ Cutting should be prepared when people transplant it. It should be delivered to the target site to be planted as soon as possible after being cut.	

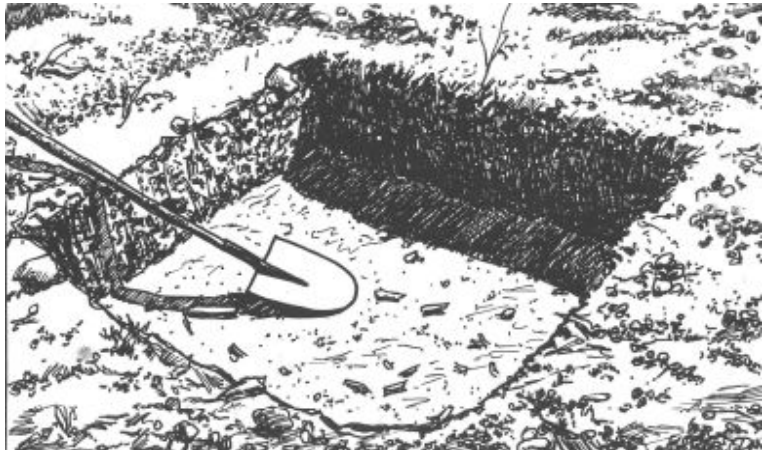
1.9 Hay Making

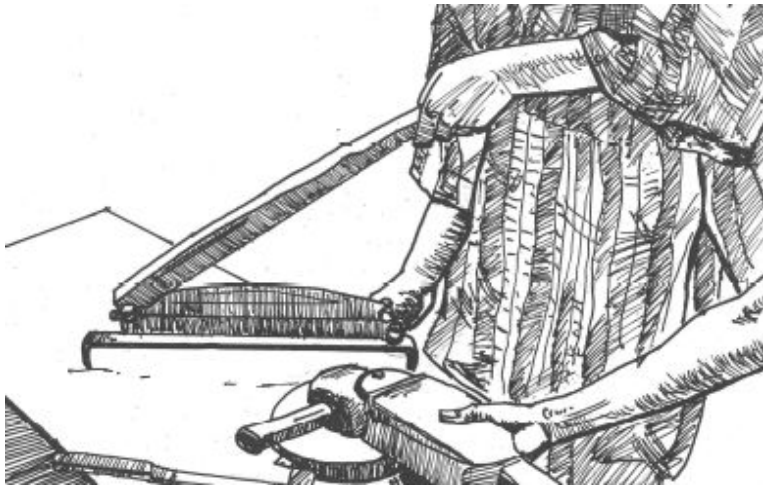
Step	*Process*	*Description*	*Remarks*
1		**<u>Species of Grasses for Hay Making</u>** ➢ In Borena, Buffel grass, Rhodes grass and the other native grasses are good for hay making. ➢ Grasses should be harvested when they start flowering.	The aim of hay making is to minimize respiration and decay of plant materials by desiccation. Generally, forage is cut, dried under the sun, compressed into bales and stored under low moisture environment.
2		**<u>Harvesting</u>** ➢ Grasses should be harvested/cut at 15cm to 20cm above the ground.	

Step	*Process*	*Description*	*Remarks*
3		**<u>Drying</u>** ➢ Dry harvested grasses as quickly as possible (1 to 3 days) under the sun. ➢ Keep the grasses free from mould by regular turning	If harvested grasses are exposed to rain water, they may be damaged and cannot be used as hay. Therefore, harvesting should be done during dry season.
4		**<u>Hay stack (for storage)</u>** ➢ After drying, stack the hay by heaping up as a picture on the left shows. ➢ Pile under the shed like circular or rectangular pile. ➢ Keep the hay under roof	

Step	*Process*	*Description*	*Remarks*
5		**Feeding hay to animals** ➢ During shortage of feed and breeding season, people particularly can feed hay to animals. ➢ As supplement feed, they can serve it at morning and night time.	
6		**Utilization of crop residues** ➢ Crop residues such as wheat straw, teff straw and barley straw should also be stored under the shade. ➢ Large cereals such as maize stalk and sorghum need to be chopped down into 10cm pieces. It is also good idea that dissolved salt (locally available salt) is added (0.5kg salt per 100kg dry matter). ➢ Legume residues such as haricot beans should be fed by mixing with the other grasses or cereal straws.	

1.10 Silage Making

Step	*Process*	*Description*	*Remarks*
1		**Digging a pit** ➢ Dig a box hole on the ground ➢ Size of a pit depends on the amount of silage to be made.	$1m^3$ size of the silage pit can retain 260 to 325kg Dry Matters of forages. This can enable 1.23 to 1.52 cattle to survive one month extended drought. (one cattle requires 7kg of dry matters per day.)
2		**Harvesting Crops/ Grasses** ➢ As materials of silage, residue of maize, sorghum and millet, and Elephant grass could be used in Borena. ➢ Crop residues should be harvested when 1/3 of leaves are dried up (are brown) and 2/3 are still green. ➢ After harvesting, expose silage materials to the sun for a day in order to discharge water from the surface of plants	In Borena zone, sometime people cannot harvest any grains of maize due to shortage rainfall. In that case, they may be able to use such maize leaves and stems for silage making. In addition, since Elephant grass has high dry matter, it is suitable for silage making.

Step	*Process*	*Description*	*Remarks*
3		**<u>Manual Handy Chopper</u>** ➢ The left picture shows a manual grass chopper. This instrument is really convenient to chop grasses short. ➢ However, if communities do not have it, they can use a sickle and machete for chopping silage materials.	Mixing of legumes (50%) into silage materials improve nutritive value. However, using sole legume grass is not good for silage making. Therefore, mixture is recommended.
4		**<u>Chopping</u>** ➢ Chop grasses/crops at the length of 5 to 7cm	Weed should be removed from materials of silage.

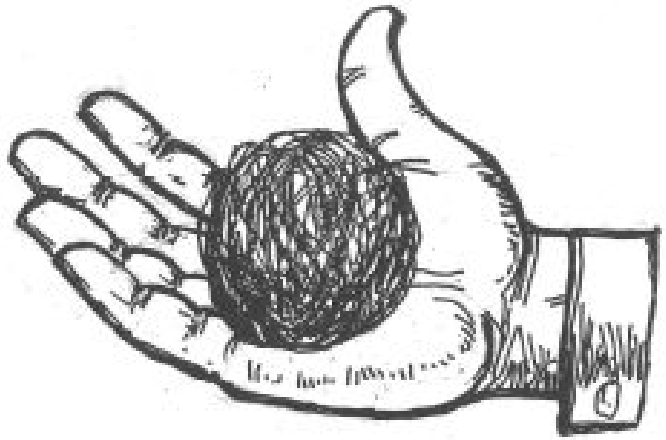
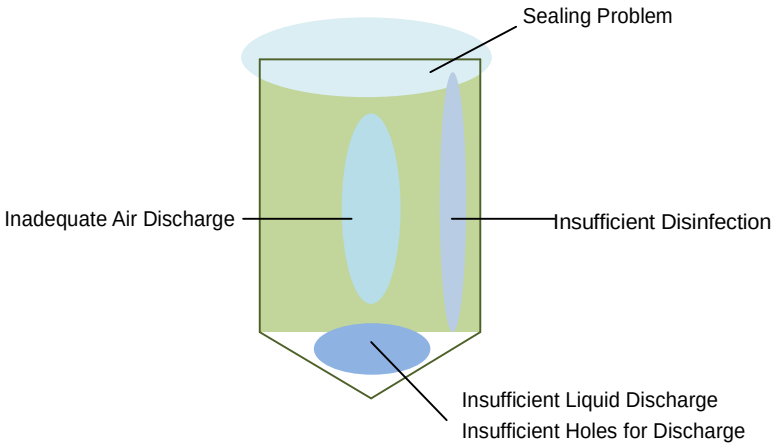
Step	*Process*	*Description*	*Remarks*
5		**Packing** ➢ Spread plastic sheets and make some holes (4cm diameter) at the bottom in order to discharge liquid from grasses. ➢ Put chopped grasses in the pit.	
6		**Adding Salt** ➢ Add the salt into the materials (1kg is enough for $1m^3$ of pit)	

Step	*Process*	*Description*	*Remarks*
7		**Pressing** ➢ Press hardly in order to discharge air from chopped grasses. ➢ Put chopped grasses and press heavily again and again. Continue putting and pressing until the pit becomes full.	
8		**Before sealing** Press again!	

Step	*Process*	*Description*	*Remarks*
9		**<u>Sealing</u>** ➢ Cover the crops/ grasses with plastic sheets to avoid invasion of rain water.	Silage materials should not be exposed to any factors from outside such as air, soil and water. They should be totally blocked from outside.
10		**<u>Sealing</u>** Sealing should be done carefully not to allow water to enter.	High water content will results in getting moldy.

Step	*Process*	*Description*	*Remarks*
11		**<u>Covering by soil</u>** Put soil as a heavy weight on the sheet covering silage in order to discharge air	
12		**<u>Covering</u>** Keep silage at least 3 weeks after packing.	

Step	*Process*	*Description*	*Remarks*
13		**Opening silage**	
14		**Checking silage** ➢ If it is good silage, you may find the materials are still green. ➢ If the color and smells of silage is mold, the silage should be disposed. ➢ Good silage smells “sweet and a bit sour”. ➢ Smelling of ammonia is also not preferable.	

Step	*Process*	*Description*	*Remarks*
15		**<u>Checking and feeding silage</u>** ➢ Good silage can be assessed by taking a handful of silage and compressing it tightly for half a minute. Good quality silage remains compressed as a picture on the left shows. ➢ Provide silage to animals as supplement feed ➢ After removing a part of silage for feeding animals, close the plastic sheet at the pit for storage. Once people open the silage, they should finish using shortly.	
16		**<u>Degradation of Silage Occurs Due to;</u>** There are 3 main causes to damage silage as follows; ➢ Excess air existence in silage (inside of silage); rotting, mold and degeneration ➢ Insufficient water discharge (bottom of silage); rotting and discoloration ➢ Rips of silage top sealing (top of silage); rotting, mold and degeneration Elimination of these factors is a good point to make fine silage.	

2.1 Agro-environmental condition in Borena zone, Oromia region

2.1.1 Climate Condition

Season Name	*Characteristics*	*Remarks*
Bona 	Occurs from December to February. Characterized by long hot dry season.	No crop production in the season without irrigation.
Ganna 	Occurs from March to May. It is longer rainy season. The rainfall is very erratic. Sometimes starts at the beginning of march and stops in April and sometimes stay up to the end of march to start and stops in May.	Suitable crop production under rain-fed condition in the season is; Maize, Haricot bean, Teff, Wheat, Barley, Chick pea, Sorghum, etc.
Adolesa 	Occurs from June to august. Harvesting time form main rain season (*Ganna*). It is characterized by cool dry weather. Most of the time it is cloudy, but it doesn't rain.	No crop production in the season without irrigation.
Hagaya 	Occurs from September to November. It is characterized short rainy season. The rainfall amount and period are also quite erratic year by year. Sometimes it rains only for few days and sometimes the rain is longer than long rainy season (*Ganna*).	Suitable crop production in the season is short maturity crops such as Haricot bean, Teff, Wheat, Barley and Chick pea, etc.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Season	*Bona*		*Ganna*			*Adolesa*			*Hagaya*			*Bona*

2.1.2 Characteristics of Soil

Soil Type	*Characteristics*	*Remarks*
Black soil (Koticha) 	➢ Most fertile soil type in the area. ➢ High water holding capacity because of high clay content. ➢ Hard to cultivate especially during wet condition. Therefore it is important to plow this type of soil during the dry season and make ready for planting before rain starts. ➢ Called also 'Cotton Black Soil'	Suitable crops: Relatively late maturing crop such as Maize and Sorghum.
Red soil (Wayema) 	➢ Most common soil type in Borana lowland according to oral communication with agro-pastoralists. ➢ Lower water holding capacity than black clayey soil. ➢ Less fertile than black soil.	All main crops are grown in Borena. Suitable crops: Early maturing crop types such as Haricot bean, Teff, Wheat, Barley and Chick pea, etc.
Red and black soil (Birbora) 	➢ Mixture of black and red soil. ➢ Intermediate in its fertility, water holding capacity and workability between these soil types. ➢ Easy to cultivate for crop production.	All main crops are grown in Borena. Suitable crops: Early maturing crops such as Haricot bean, Teff, Wheat, Barley and Chick pea, etc.

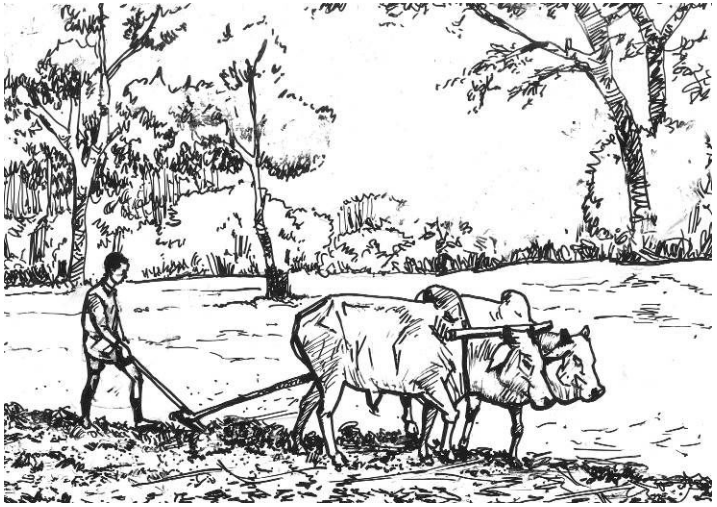
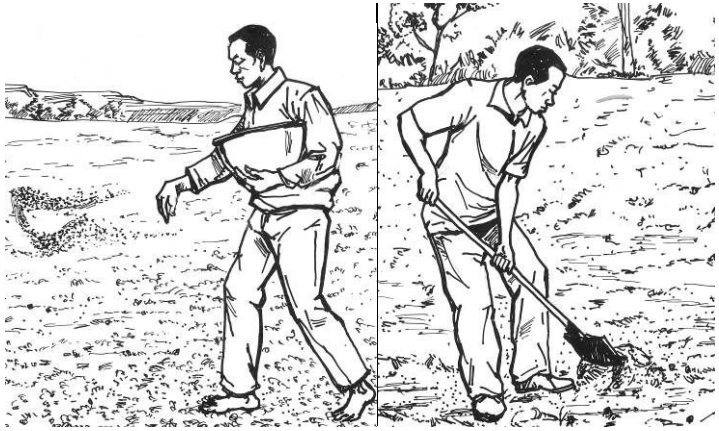
Item	*Characteristics*	*Remarks*
Sandy soil (Mansa) 	➢ Poor in fertility and water holding capacity because of less contained clay and silt. ➢ Highly dry soil. ➢ Easy to be flushed away fertility and soil itself by flood and wind. ➢ Favorable environment for termites.	Not preferable for crop production. It is important to apply manure for increasing its water holding capacity and nutrition.
White soil (Adi) 	➢ Poor in fertility and water holding capacity because of less-contained clay and silt. ➢ Easy to be flushed away fertility and soil itself by flood and wind.	Not preferable for crop production. It is important to apply manure for increasing its water holding capacity and nutrition.

2.1.3 Water Resources

Item	*Characteristics*	*Remarks*
Rain fall 	Bimodal type of rainfall, called *Gana* and *Hagaya*. Average annual rainfall of the lowland area of Borana is 500-700 mm. It is highly erratic of the amount and period.	Suitable crops: Maize, Haricot bean, Teff, Wheat, Barley, Chick pea, Sorghum, ground nut, etc.
River 	Among the ten lowland Woredas, only *Melka soda* woreda and *Arero* woreda has River which can use for irrigation agriculture called *Dawa* River and *Kojo'a* River. These rivers have flow through the year.	Suitable crops: All crops especially vegetables and fruits in small scale.
Pond 	Only artificial ponds are there in Borana zone which are mainly constructed for livestock and human drink. Small ponds around home which are called family pond are used for vegetable and fruit crops production.	Suitable crops: Vegetable and fruit production.
Spring 	There are some water springs in *Teltele* woreda. These are not dried up even in dry season.	Suitable crops: Vegetable and fruits.

2.2 General Rain-fed Agriculture Process in Borena zone

Step	*Process*	*Description*	*Remarks*
1	  ***Very Good!!*** ***Not so Good***	***<u>Land Selection;</u>*** If you can select site for crops, mainly depend on; - Soil type: depends on crops to be grown. - Topography: Flat land is preferable. - Water source availability: near rivers or ponds for irrigation. - Distance to the market: closer is better. - Distance from the Olla: closer is better.	Flat land with black-brown silt soil is highly recommended for all agronomical practices. But it is possible to grow crops in steep land if some water and soil conservation structure can be done.
2	  ***Land Clearing*** ***Fencing***	***<u>Land Clearing and Fencing;</u>*** 1) Select the bushes to be cleared and remained. 2) Clear useless bushes and/or weeds (Uproot) 3) Collect useful branches with spines and fence farmland with them. Just before plowing the ash of some plants can be applied as an organic fertilizer, but ash of some harmful weed as *Parthenium hysterophorus* should not be applied due to those grains.	Some leguminous trees species such as *Acacia tortorse, Acacia albida* are useful for crop production as wind break/ shelter belts, animal feed and timbers besides nitrogen fixing. Pollarding may be required for trees left on farm land if it is too shady for the crop underneath.

Step	*Process*	*Description*	*Remarks*
3		**<u>Plowing;</u>** Heavy clay soils will be difficult to plow if they are dry. For heavy clay soils will produce large clods, especially if the soil has been compacted. It is a good idea to leave these soils until the first rains have moistened them a little before plowing them. The plowed slots depend on the optimum row width for the crop you want to plant; about 75 cm is a common distance. The soft soil can be plowed by hand using a spade and hoe. But some agro-pastoralists have to plow by hand due to lack of animals or equipment even they have compacted /hardpan land.	You may be able to use donkeys to pull the ripper if the soil is light, if the ripper blade (‘*Meresha*’) is narrow, and if the depth is shallow.
4	 ***Chemical Fertilizer*** ***Manure***	**<u>Fertilizer Application;</u>** Fertilizer provides essential nutrition to plant like foods for animals. Plant needs 18 essential nutrients, especially nitrogen (N), phosphorus (P), and potassium (‘*Kalium*’ in German, hence the chemical symbol K) compounds to support plant growth. The NPK needs to be available to the plant in the right ratio. Basal dressing is applied before planting time. Chemical fertilizer and Organic Fertilizer are used for the basal applying. Organic fertilizer such as Manure and Compost are applied at plowing time, and it should be mixed with soil well.	The fertilizer applied before sowing or planting time is called ‘Basal dressing fertilizer’, and that the one applied during plant growing stage is called ‘Top dressing fertilizer’

Step	*Process*	*Description*	*Remarks*
5		**Planting/Sowing;** Sowing in plant holes which are regularly spaced along a straight line. The line to be followed and the spacing of the holes can be marked on a sowing cord, or the lines can be scratched with a cultivator. Sowing in rows is necessary if weeding or ridging is to be done later by animal traction. This method is recommendable especially for Maize and Sorghum for good crop management such as weeding, supplementary irrigation, inter cultivation etc. but also it is useful for other crops such as Haricot bean and Ground nut sowing to maintain soil.	Maize, Sorghum, Haricot bean can also be sown in rows.
6		**Weeding;** 2~3weeks after sowing, weeding should be started by hand, or slash them with a machete, sickle, slather or billhook. You can also use a hoe for weeding, but this disturbs the soil surface. Therefore try not to disturb the soil too much if you use a hoe or other implements. Herbicides are quick and easy to apply, and do not disturb the soil. 2-4D is usually used for Teff production in Borena zone. It is important to use the right amounts of chemicals, mix them with clean water, and handle them safely.	Weeding before flowering is recommendable in order to decrease the weed population in the field not only the current crop season but also the next. Good idea to slash weeds immediately after the harvest and during the dry season to prevent them from producing seeds.

Step	*Process*	*Description*	*Remarks*
7		**<u>Pest and Disease management;</u>** 1) Soil and crop management: improving soil fertility, maintaining a planned crop rotation to limit build-up of pests and diseases, etc. 2) Habitat management: planting hedges of indigenous plant around fields to attract natural enemies, improving field hygiene by timely weeding to remove alternative hosts etc. 3) Direct control: use approved or self-made insecticides and fungicides of biological or mineral origin such as plant extracts and oil.	The name of Agricultural chemicals which can be obtained in Borena zone: Lathine, Dursban. Those chemicals should be used as a last option, when the devastation is at threshold level.
8		**<u>Drying and Harvesting;</u>** Harvesting when the crop reached at harvest maturity is important. Both early and late harvest affects quantity and quality of produce. Some horticultural crops like tomato may be harvested before maturity if it is to be sold at distant market. Taking care during harvest not to waste the produce is also very important. Harvest maturity varies from crop to crop. Each crop has shown different symptoms. Biting or pinching can help you test seed moisture content in case of maize and haricot beans. The loss during harvest is usually low in Borana lowland area because it is done manually.	It is important that check the crop moisture condition at the field. After harvesting, collect the harvested crops at one place and dry it up completely.

Step	*Process*	*Description*	*Remarks*
9	 ***Threshing*** ***Screening***	**<u>Threshing, Screening;</u>** During threshing it is important not to damage the seed or grains. Threshing plots need to be clean to get quality produce. There is loss of produce (quantity and quality) during threshing and winnowing in Borana lowland that needs concern. There is also a need to concern about a loss during packing and transportation. The material usually used for packing has to be strong material that doesn't tear during transportation that usually done on back of donkey in Borana lowlands.	If you store grain in jute or woven plastic bags, treat it first with an insecticide.
10		**<u>Storage;</u>** Grains or seeds have to be stored at storage moisture percent level which varies from crop to crop. Before storage the moisture content of the grain has to be reduced to that level. Rats and mice can be a big problem. They eat the grain and damage it with their urine. It is vital to keep them away from the store: put wire mesh over openings, and fix metal cones on the legs of grain cribs to keep them out. Use treated bait in the store. Cats and owls also help control rats and mice.	Dry grain thoroughly before storing or processing it. It should have less than 12.5% moisture content. This helps prevent damage by pests and diseases during storage.

2.3 Appropriate Crops in Borena zone and those Characteristics

2.3.1 Maize (Zer mays L., Graminaceous / Poaceae family)

Items	***Characteristics***	***How should we do for production?***
Botanical feature 	✓ Longer maturity period compared to other crops such as Haricot bean, Teff and Wheat. ✓ But early matured variety like Melkassa-1 and Melkassa-4 are suitable to lowland Woredas of Borena zone where rainy season is relatively short. ✓ Cross-pollinated crop: difficult to produce seed with good quality unless you grow it nearby other maize field.	✓ It is better to use seed with known history. Use seed which is brought from market may have its own problem. ✓ Site selection has to concern more moisture retention ability. ✓ Pollarding may be important for big tree branches/ tops are left on the field because maize is not shade tolerant
Environmental condition 	✓ Favorable for hot and relatively dry weather condition ✓ Heavy feeder and needs moisture more than other crops so fertile and loamy soil ✓ Preferable to well-drained soils.	✓ Choose a good field for Maize ✓ If the soil is poor and dry, fertilization is essential. Using manure increases not only soil fertility but also improves soil structure. ✓ *Koticha* (Black soil) and *Birbora* (Red black soil) are suitable for cultivation.

Items	*Characteristics*	*How should we do for production?*
Agronomical practices 	✓ Land preparation should be started before *Ganna* season. If it has done soon after *Hagaya/Alfasa* season, it will not to miss the planting timing. ✓ Should clean your filed. ✓ Seeding rate: 25~30kg/ha (14kg/ha for early sowing) ✓ Row planting is favorable for well growth use two seeds/ hill during sowing. ✓ Thinning (Remove one of the weaker seedlings): to reduce seed competition for -water (moisture) nutrients. ✓ Cultivation 3 times hand tool and '*Shilshalo*' during growing to avoid expansion of weed, pest and diseases and to water retention.	➢ Removing and deep plowing a large amount of residue from the previous crops to minimize Stalk borer that nests in residue. ➢ Use seed known good history and avoid using broken seed. ➢ Maize should be covered very well to protect seed from external damage by birds and desiccation. ➢ The space between rows is 0.75m and between plants is 0.25-0.3m. ➢ 1st cultivation would be better doing by hand not to devastate plants. 2nd or 3rd cultivation can be practiced after intertillage '*Shilshalo*' when maize reach a knee height.
Weed   	*'Fincho', 'Hidi', 'Mogorree', Parthinium* are harmful weeds. They are very invasive and can easily expand.	➢ Trying to remove weeds before flowering in order to avoid expansion. ➢ Trying to use the removed weeds for useful purposes such as compost making, crop mulching except harmful weeds as *Partheinium.*

Items	*Characteristics*	*How should we do for production?*
Pest and Diseases  http://www.infonet-biovision.org/default/ct/102/pests	<Pest> ✓ Stalk borer ✓ Army worm ✓ Termite ✓ Grubs (in high manure changed farm land). <Disease> ✓ Smut disease ✓ Gray leaf spot ✓ Bacterial blight of maize ✓ Rust	➢ Weeding in off season: to avoid the growth of any self-sown weeds or crops. ➢ Using pesticide to control army worms. ➢ Making the crop farm and around farm free from any kind of weeds. ➢ Adopting the crop rotation. ➢ Clearing the cultivation field. ➢ Using the early maturing cultivars. ➢ Reduce the physical damage of the cultivation crops during cultivation period especially weeding.
Harvest and Post-harvest 	✓ Harvest as soon as the maize cobs are mature, change color from green to white. Black layer formation and hanging down of the cob are the two main symptom of maturity ✓ Store the dried cobs in cribs and wrap the legs of the cribs with smooth metal sheets to pre-vent rodents from climbing up into the cribs; spray the cribs and the cobs at regular intervals with Atelic. Threshing is a process of separating seed from cobs and making the seed ready for use (consumption, markets and for easy storage and this is done by oxen or hand.	➢ Time of harvesting depends on: Type of maize variety planted (extra-early, early, intermediate or late) and utilization (fresh cobs, grains). ➢ Dry the remaining cobs on a flat concrete surface; the cobs are properly dried if the kernels scatter when the cobs are dropped on a concrete surface or land that is plastered by cow dung. ➢ Maize can be processed for food in different forms. It can be eaten roasted, boiled, or other in forms separately or mixed with other crops.

2.3.2 Teff (Eragrostis tef (Zucc.) Trotter: Poaceae family)

Items	***Characteristics***	***How should we do for production?***
Botanical feature 	✓ Grown primarily as a cereal crop in Ethiopia as well as for livestock forage. ✓ Mainly produced for sale, not for home consumption in Borena zone. ✓ The straw is considered to be excellent forage, superior to straws from other cereal. ✓ Adapted to environments ranging from drought stress to waterlogged soil conditions; altitudes of 1,800 to 2,100m, rainfall of 450 to 550mm, and a temperature range of 10 to 27°C. ✓ Self-pollinated crop.	➢ Not only for food but also for forage, Teff merits being produced even in small scale, if the field is suitable and available for it. ➢ Fine seed bed preparation is important. ➢ If a good yield is wanted, use certified seeds from research institute or reliable private seed companies, even seed contamination by nearby local variety is very less.
Environmental condition 	✓ Flat valley bases are suitable. Slope <5% to prevent surface run off. ✓ Since the growing period is short (80-90days) and relatively less fertilization requirement, Teff can be grown in poor soil. ✓ However, the production will be more than poor soil in fertile soil.	➢ The land should be leveled. ➢ Soil type- *Birbora* (Red black soil)) are suitable; even *Wayama* (Red soil) can be cultivated. ➢ Manure application is highly recommended in order to increase productivity especially if *Wayema* soil or marginal land is used. ➢ Teff has to be sown after the rain moistened the soil well.

Items	*Characteristics*	*How should we do for production?*
Agronomical practices 	Teff production in Borena lowland is not yet studied well, but; ✓ The field should be very clean and fine to facilitate tiny seed bed preparation. ✓ Low seed rate may result in poor stand and high seed rate result in high competition and finally both lead to low productivity and quality. ✓ Yield of Teff is highly affected by weed infestation. Especially grass type weeds are problematic.	➢ Necessary to clean and plow field thoroughly, 3~5times at least. ➢ Seed rate (blanket): 25kg/ha. ➢ For uniform distribution during sowing mixing with sand and sowing in the direction of wind. ➢ Necessary to be sown at very shallow depth or just on top of ploughed land. ➢ Sowing can be done in row 20cm x 20cm.
Weed, Pest and Disease 	Teff is affected by different pests and diseases, but common Teff disease and pests are not yet identified Borena lowlands. Army warm, Grass hopper, '*Fincho*', '*Hidi*', '*Mogorree'*, Parthinium are big problems. They are very invasive and can easily expand. As disease, Rust is common in the Borena.	➢ Regular weeding is required before the weeds flower and set seed. Weeding for Teff is usually difficult by hand so herbicide like 2-4D can be used in case of impossible to weed by hand. ➢ Visit the field regularly to detect pest and disease incidence ➢ Trying to use them for useful purposes like compost making except Parthinium.

Items	*Characteristics*	*How should we do for production?*
Harvest and Post-harvest  http://commons.wikimedia.org/wiki/File:The_Teff_Harvest,_Northern_Ethiopia_(3131617016).jpg	✓ Harvest can be done by hand about 90days after sowing. ✓ Threshing can be done by hand or cattle which walk on the harvested crop. ✓ The straw is mainly stored to feed cattle during drought period. ✓ Farm produce are consumed immediately, sold immediately or stored. Dry seeds to reduce moisture before storage.	➢ It has to be harvested at stage of maturity, i.e. straw of Teff turns pale yellow. Sickle is used for harvesting. ➢ Teff can stay in storage for longer time than other large seeded crops. ➢ Winnowing requires special know how and skill. ➢ Store seeds in cool places in air proof container.
Processing for food and forage  	✓ Teff is mainly produced for selling in Borena lowlands. ✓ Teff straw can be selling item, it can be sold 70-80Birr/block (100*50*50cm3) on March. The straw is used for housing material and feed. ✓ Silage can be also good for feeding to own animals and for sale. ✓ *Teltele* Woreda and *Mega* area in *Dille* Woreda are well known for Teff production in Borena lowland.	➢ Teff is used for *Injera* making, traditional staple food in central Ethiopia. ➢ For marketing, introduction of high yield variety and proper agronomical practice are indispensable.

2.3.3 Haricot Bean (Phaseolus vulgaris.L: Leguminous family)

Items	***Characteristics***	***How should we do for production?***
Botanical feature 	✓ Short matured plant. ✓ Self-pollinated crop. ✓ Fix atmospheric nitrogen in the soil but continuous cropping can reduce yield. ✓ Weak resistant to pest and disease.	➢ Introduce the crop rotation or inter cultivation are effective not only H/bean but also companion crops like Maize and Sorghum. ➢ 2~4years growing interval is necessary. ➢ Once haricot bean improved varieties are obtained it can be used for many cropping seasons by taking care of physical contamination. ➢ Prevent pest and diseases by cultural and biological control.
Environmental condition 	✓ Preferable to hot weather and tolerant to moisture stress ✓ An area suitable to divert flood water to their farm land (*Galcha*) is also preferred. ✓ Favorable fertile soil but not too much. ✓ Not shade tolerant.	➢ *Koticha* (Black soil) and *Birbora* (Red black soil)) are suitable soil types for haricot bean production. But H/beans can be grown in *Wayama* (Red soil) which is less water holding capacity because it's short growing period. ➢ Pollarding should be done if big tree branches/ tops to remove heavy shades.

Items	*Characteristics*	*How should we do for production?*
Agronomical practices 	✓ Land clearing is important: Pest and diseases which may attack H/beans harbor in the soil. ✓ Not require high fertilization but application of fertilizer facilities high yield. ✓ Preferable to be sown on fine soil. ✓ Seed rate: approx.15kg / ha. ✓ Raw planting is favorable for well growth: ewer seed amount makes crop management easier, increases productivity, etc. ✓ Inter-cultivation and weeding is essential: highly susceptible to weed infestation. Leave plants at suitable distance usually 10cm apart so that plants not crowded and 40 cm between rows.	➢ The land for H/bean and the surrounding area have to be cleared thoroughly. ➢ Fine seed bed has to be prepared for H/ bean for better germination and seedling establishment. ➢ Spacing: 40cm between raw and 10cm between plants is recommended. ➢ Dry planting is not recommended because of risks of law germination due to damage, weak seedling and weed load, etc. ➢ Weeding and cultivation usually starts three weeks after planting. ➢ *'Shilshalo'* can be also recommended as inter cultivation and thinning if the seed has sown in raw but in the time small seedling.
Weed 	'*Fincho*', '*Hidi*', '*Mogorree'*, Parthinium are big problems. They are very invasive and can easily expand.	➢ Trying to avoid them before flowering. ➢ Trying to use them for useful purposes like compost making except Parthinium.

Items	*Characteristics*	*How should we do for production?*
Pest and Disease 	Haricot beans are easily attacked by many diseases and pests but not yet identified all of the species by agricultural research center in Borana zone lowlands. e.g. pod borer.	➢ It is important to visit the field regularly to detect a pest and disease incidence. ➢ Use of resistant varieties and good cultural practices like crop rotation, appropriate seed bed preparation, field sanitation (weeding), can protect plants. ➢ Using agricultural chemicals such as pesticide and fungicide and insecticide is a last choice to control the pest and disease.
Harvest and Post-harvest  	✓ Harvest should be done at stage of maturity, when bean pods lose their color. ✓ When threshing special care is required for seeds than grains. ✓ Drying seeds to reduce moisture before storage out of Haricot beans for immediately self-consumption and for sale. ✓ Storage loss of seed and grain is one of the main problems of crop production. Weevils are also raised as major problem by agro pastoralists.	➢ Threshing haricot bean can be done by hand or oxen that walk on the harvest. ➢ Store in cool places. Storage life of haricot bean seed is usually short if not stored in cold store. ➢ If storage chemicals used follow the instruction on container. Store has to be well ventilated. ➢ Storage loss by storage pests can be reduced by mixing Teff or fine sand with using Neem tree seed or leaf powder, cleaning container. ➢ Cleaning the storage and avoiding mixing of the seed and/grain with the previous grain. ➢ If the seed will be stored for a long time, it is important to use the agricultural chemicals, especially pesticide.

2.4. Recommended Agricultural Practices

2.4.1 Land Preparation and Plowing

Items	***Descriptions***	***Remarks***
Land selection 	If you can select site for crops, mainly depend on; - Soil type: depends on crops to be grown, - Topography: Flat land is preferable, - Water source availability: near rivers or ponds for irrigation, - Distance to the market: closer is better, - Distance from the Olla: closer is better.	Flat land with black-brown silt soil is highly recommended for all agronomical practices. But it is possible to grow crops in steep land if some water and soil conservation structure can be done.
Land clearing and fencing 	1) Select the bushes to be cleared and remained. 2) Clear useless bushes and/or weeds (Uproot). 3) Collect useful branches with spines and fence farmland with them. Just before plowing the ash of some plants can be applied as an organic fertilizer, but ash of some harmful weed as *Parthenium hysterophorus* should not be applied due to those grains.	Some leguminous trees species like Acacia tortorse or Acacia albida are useful for crop production as wind break/shelter belts, animal feed and timbers besides nitrogen fixing. Pollarding may be required for trees left on farm land if it is too shady for the crop underneath.
Method of plowing 	✓ Animal driven plowing is recommended in Borena area. ✓ When the clay soil is dry, it is difficult to plow. In that case, it is one effective plowing method after first rain has moistened the soil. ✓ The plowed slots depend on the optimum row width for the crop you want to plant; about 75 cm is a common distance. The soft soil can be plowed by hand using a hoe. But some agro-pastoralists have to plow by hand due to lack of animals or equipment even they have compacted /hardpan land.	You may be able to use ox or donkey to pull the ripper if the soil is light, if the ripper blade (‘*Meresha’*) is narrow, and if the depth is shallow.

2.4.2 Water Harvesting

Items	*Descriptions*	*Remarks*
Tie ridges 	✓ Height of the tie ridge can be 15-20 cm within a furrow depth of 20-30cm. ✓ They are constructed in staggered position along neighboring furrows. ✓ Row spacing and tying interval could range between 1 and 10m. ✓ The steeper the slope, the higher the rainfall intensity and the lower the water holding capacity of the soil. ✓ Row spacing and tying interval dependent on slope of the land, intensity of rainfall and water holding capacity of the soil. ✓ Training and demonstration is needed on how to insert into the traditional implement.	Source: Lakew D. et.al., 2005, Community-based Participatory Watershed Development: A Guidline, MoARD, Addis Ababa
Planting Pits (Zai) 	✓ Planting pits are made on land which low permeability to allow for runoff collection. Planting pits are holes dug to catch runoff and allow time for infiltration and they are usually fertilized with organic matter in the form of plant debris or compost. ✓ Annual and perennial crops are suitable, for example sorghum, maize, millet, cowpeas, sweet potatoes, groundnuts and bananas. ✓ The '*Zai*' are dug with approximately 80 cm apart to a depth of 5 to 15 cm, with a diameter of between 15 and 50cm, but the planting pits also exist in much greater size and with different spacing.	Source: Rainwater Harvesting Handbook, AfDB,
Semi-circular Bunds 	✓ Semi-circular shaped earth bunds with tips on contour. In a series with bunds in staggered formation. ✓ Useful for grass reseeding, fodder or tree planting in degraded rangeland. ✓ Cannot be mechanized therefore limited to areas with available hand labor.	Source: Will C. and Klaus S., 1991, Water Harvesting, FAO, Rome. http://www.fao.org/docrep/U3160E/u3160e00.htm

2.4.3 Fertilization

<table>
<tr><th>Items</th><th>Descriptions</th><th>Remarks</th></tr>
<tr><td><u>What is the fertilizer?</u>
  </td><td>Fertilizer is plant food. Plants need a lot of stuff as a food, especially nitrogen (N), phosphorus (P), and potassium (‘Kalium’ in German, hence the chemical symbol K) compounds to support plant growth. The NPK needs to be available to the plant in the right ratio.

That is made of any organic or inorganic material of natural or synthetic origin, the former is called ‘Organic fertilizer’ and the latter is ‘Chemical or synthetic fertilizer)</td><td>The fertilizer applied before sowing or planting is called ‘Basal dressing / fertilizer’, and that the one applied during plant growing stage is called ‘Top dressing / fertilizer’</td></tr>
<tr><td><u>Organic fertilizer</u>
  </td><td>Organic manure (‘Kosi’) is a material of the cheap organic fertilizer such as Farm Yard Manure (FYM) and Compost by mixing residues.

<u>Farm Yard Manure</u>: is the decomposed mixture of dung and urine of animals along with litter and left over material from roughages or fodder fed to the cattle. After several weeks/months, FYM can be mixed with soil by repeated plowing or cultivation.

<u>Compost</u>: is a process where waste organic materials derived from plants and/or animals are decomposed by microbial action under aeration to produce a friable homogenous product that is added to soil. There are two major methods; ‘Pit method’ is a making process in pits and ‘Piling method’ is compost on the surface.</td><td>The length of time from piling dung the refuse to getting a thoroughly decayed matter depends on the type of animal. When the soil is wet. Usually the recommended rate is 8-10 tones / ha.</td></tr>
<tr><td><u>Chemical fertilizer</u>
  </td><td>Two types of chemical fertilizer, Urea and Diammonium phosphate (DAP), are commonly used in Borena area are shown as follows;

<u><Urea> 46-0-0:</u> formulates 46% nitrogen (N) of total quantity.

<u><DAP> 18-46-0</u>: formulates 18% of nitrogen (N) and 46% of phosphate salts (P_2O_5). Chemical fertilizer rate by crop as follows;

<table><tr><td></td><td>Urea</td><td>DAP</td></tr><tr><td>Maize</td><td>100 kg/ha</td><td>100 kg/ha</td></tr><tr><td>Teff</td><td>100 kg/ha</td><td>80~90kg/ha</td></tr></table></td><td>N should be applied in split, half during sowing (Basal) and half approximately one month after sowing (Top-dressing).

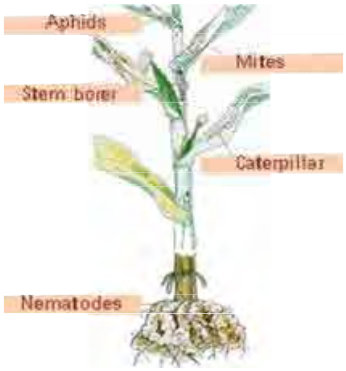
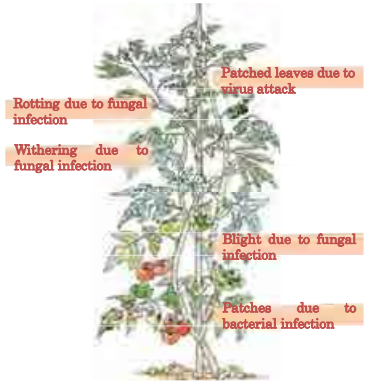
Chemical fertilizers can be bought from Woreda PDO office or agricultural unions in Borena area.</td></tr>
</table>

2.4.4 Planting / Sowing

Items	*Descriptions*	*Remarks*
Broadcasting 	Throwing the seeds around him while walking up and down the field. It is dominant planting method for all crops in Borena zone. This method is easy to practice, but many seeds are wasted because it might not be well covered by soil so that birds can attack. As well as seedling will be wasted by '*Shilshalo*' at weeding time. Difficult for plant management such as weeding, irrigation, and harvesting.	
Sowing in rows 	Sowing in plant holes which are regularly spaced along a straight line. The line to be followed and the spacing of the holes can be marked on a sowing cord, or the lines can be scratched with a cultivator. Sowing in rows is necessary if weeding or ridging is to be done later by animal traction. This method is recommendable especially for Maize and Sorghum for good crop management such as weeding, supplementary irrigation, inter cultivation etc. But also it is useful for other crops such as Haricot beans sowing to maintain soil.	Maize, Sorghum and Haricot bean are suitable for sowing in rows.
Sowing in plant holes/pits 	Making a hole in the ground with a hoe, puts a few seeds in the hole, and closes it. You can use a planting stick or machete to make holes to plant the seed. Cut a hardwood stick from the bush, sharpen the point, and use it to make planting holes. Make the holes in lines at evenly spaced intervals. That makes it easier to weed and apply fertilizer or manure. Adding a sharpened steel tip to the planting stick makes it last longer and easier to use. Such sticks are often available from the village blacksmith.	

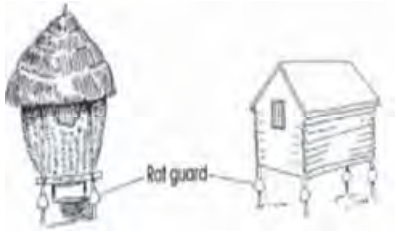
2.4.5 Plant Management

Items	***Descriptions***	***Remarks***
Weeding 	2~3 weeks after sowing, weeding should be started by hand with hoe, or slash them with a machete and sickle. Though weeding is thought the hardest work during the cultivation period, it is necessary to make a high production in the farmland. Considering the weeding time is important to reduce the weed population, removing the weed from the field before flowering is more effective especially. Herbicides are quick and easy to apply, and do not disturb the soil. 2-4D is usually used for Teff production in Borena zone. It is important to use the right amounts of chemicals, mix them with clean water, and handle them safely.	Good idea to slash weeds immediately after the harvest and during the dry season to prevent them from producing seeds.
Inter-cultivation 	Inter-Cultivation in Farming involves operations in rows of standing crop, for example thinning, weeding and keeping water in field by cultivating. Two different means; Hand cultivation: This means loosening the surface of the soil to allow water to penetrate to the roots, and to minimize the evaporation of water from the soil. *Shilshalo*: This is an activity that will be conducted when maize reach a knee height to reduce mechanical damage to maize seedling. *Shilshalo* is a final cultivation for maize during growing seasons and also minimize the impact weed infestation through uprooting and also brake soil surface crusting. It also facilitates thinning and weeding.	Disadvantage of *Shilshalo*: unlike hand cultivation, there is no selection for strong seedlings.
Thinning 	If too many plants are growing in a field, some of them are pulled out of the ground so that the remaining plants do not have to compete with one another (maize, sorghum and haricot bean). Thinning should be conducted soon after germination. *Rouging: means removal of seedling or plant that has an undesirable character and this is done by looking the physically appearance or maturity difference etc. Most of the time this activity is done at time of flowering or maturity of Wheat and Barley.	

Items	*Descriptions*	*Remarks*
Pest Damage 	Pest damage on crops is commonly caused by insects, mites, nematodes and mammals. Insect damage is usually easy to identify: Leaves with holes or missing parts are damage caused by caterpillars or weevils; curled leaves are the result of aphids sucking sap; damaged or rotten fruit are common after being eaten by larvae of fruit flies; withering plants can also be caused by larvae of noctuid or stalk borer; and branches or trunks with holes may be the result of an attack by wood-eating insects. Mites and Nematodes are very small and cannot be seen with the naked eye. Mites infested plants, leaves and fruit turn yellowish. Nematodes mostly attack plant roots resulting in yellowish plants wither and die. Mammals like monkeys and birds like sparrows, starlings and crows can also damage crops.	Ref.: FiBL, African Organic Agriculture Manual Booklet Series,No. 8 Pest and Disease Management http://www.organic-africa.net/fileadmin/documents-africamanual/training-manual/chapter-04/Africa_Booklet_8-low-res.pdf
Disease damage 	Most crop diseases are caused by fungi, bacteria or viruses. Fungi cause the great majority of infectious plant diseases. They are responsible for most cases of spotting, cankering, blighting, wilting, scabbing and rotting on different plant parts. Fungi can cause parts of plants or the entire plant to wither and die. Bacterial infections result in the breakdown of the cell walls of plants, so that the plant starts to rot. Damaged plant tissue or the blocking of water uptake causes early death of the plant, and overgrowth of plant tissue causes tumors. Viruses mostly cause leaves and other green plant parts to change in color. Light green or yellow patches of various shades, shapes and sizes appear in affected leaves resulting in a general reduction in the growth and vigor of the plant.	Ditto
How to control damages? 	1) Soil and crop management: improving soil fertility, maintaining a planned crop rotation to limit build-up of pests and diseases, etc. 2) Habitat management: planting hedges of indigenous plant around fields to attract natural enemies, improving field hygiene by timely weeding to remove alternative hosts etc. 3) Direct control: use approved or self-made insecticides and fungicides of biological or mineral origin such as plant extracts and oil.	Ditto Chemicals available in Borena: Lathine, Dursban,. Those should be used as last option, when the devastation is at threshold level.

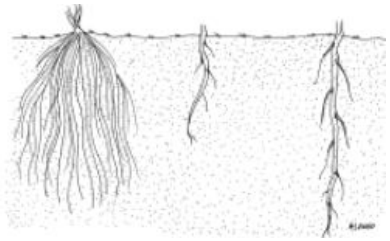
2.4.6 Harvesting and storing products

Items	*Descriptions*	*Remarks*
Harvesting time 	Harvesting when the crop reached at harvest maturity is important. Both early and late harvest affects quantity and quality of produce. Some horticultural crops like tomato may be harvested before maturity if it is to be sold at distant market. Taking care during harvest not to waste the produce is also very important. Harvest maturity varies from crop to crop. Each crop has shown different symptoms. Biting or pinching can help you test seed moisture content in case of maize and haricot beans. The loss during harvest is usually low in Borana lowland area because it is done manually.	Ref: Soniia David (CIAT), Producing bean seed: handbooks for small-scale bean producers
Drying and harvesting 	After drying crops in field for several weeks, harvest is generally done by sickle or machete in Borena zone. However you can also harvest right after maturing ears, grains or pods, and dry them in the sun on the roofs or on the ground mat. In any case, you should dry grain thoroughly before storing or processing it. This helps prevent damage by pests and diseases during storage.	
Using by products 	When harvesting, make sure that the crop stalks and leaves are left on the ground as mulch. Use a machete to cut maize and other tall plants such as sorghum at about 20 cm high, leaving the roots in the ground. Old roots in the soil improve the soil texture and structure, and the standing stalks show clearly where to apply herbicide and plant the next crop. Lay the cut materials between the rows, parallel to them. Because the rows run across the slope, the mulch will help prevent erosion. When cleaning or processing the harvest, use the waste to make compost, or put it back on the soil as mulch.	

Items	*Descriptions*	*Remarks*
Threshing, packing and transporting 	During threshing it is important not to damage the seed or grains. Threshing plots need to be clean to get quality produce. There is loss of produce (quantity and quality) during threshing and winnowing in Borana lowland that needs concern. There is also a need to concern about a loss during packing and transportation. The material usually used for packing has to be strong material that doesn't tear during transportation that usually done on back of donkey in Borana lowlands.	If you store grain in jute or woven plastic bags, treat it first with an insecticide.
Protection from attacks 	Stored grains/seeds are attacked by micro flora like mould fungi and bacteria, arthropods like insects and mites, and vertebrates like rodents and birds. Oral sources during training suggest that insect (weevils-sitophilus spp. And Moth-sitotroga cerealella) attack is the most important followed by rodents, even though their extent of loss is not documented. Agro pastoralists usually store their produce in semi-permanent granaries or on ground within plastic sacks in their dwellings (observation).	Use an approved insecticide to protect the grain from insects. You can mix the insecticide into the grain by hand, with an auger or in a cement mixer.
Storage 	Grains or seeds have to be stored at storage moisture percent level which varies from crop to crop. Before storage the moisture content of the grain has to be reduced to that level. Rats and mice can be a big problem. They eat the grain and damage it with their urine. It is vital to keep them away from the store: put wire mesh over openings, and fix metal cones on the legs of grain cribs to keep them out. Use treated bait in the store. Cats and owls also help control rats and mice.	Dry grain thoroughly before storing or processing it. It should have less than 12.5% moisture content. This helps prevent damage by pests and diseases during storage.

2.5 Cropping System

2.5.1 Crop rotation

Items	*Descriptions*	*Remarks*
What is the crop rotation 	This means changing the type of crops grown in the field each season or each year (or changing from crops to fallow). The Crop rotation facilities; -To improve the soil structure to tap moisture and nutrients, -To increases soil fertility: Legumes fix nitrogen in the soil, -To control weeds, pests and diseases, -To reduces risk of drought, pests. Producing several different crops reduces these risks.	Certain insect pests and diseases may spread easily from one crop to the next through the crop residues. Avoid crop combinations where this is a problem.
Choosing the right crops  Different crops have different types of roots	Points to be considerate; ■ Choose a crop and variety that has the characteristics you want. Make sure you get the right seed. ■ If you find a variety that you like, consider producing your own seed to sow in the future. ■ See if you can modify your existing cropping system. It is easier to adjust an existing system than to come up with one that is a completely new. Consider changing the main crop in your field. E.g. if you normally grow maize, consider planting sorghum next year. If you have several fields, you can use a different one each year to plant your main crop.	Continuous growing of pulse crop (legumes) can lead a soil sickness and, which decreases yield. http://www.fao.org/ag/ca/AfricaTrainingManualCD/PDF%20Files/06CROP1.PDF
Example of crop rotation 	<1st year> -*Ganna*: Maize which has deep roots. -*Hagaya/Alfasa*: Haricot beans which has shallow roots and can fix nitrogen in the soil. <2nd year> -*Ganna*: Any root crop (sweet potato, onion) is highly recommended but maize or sorghum also can be gown. -*Hagaya:* Teff or wheat after root crop or any legumes.	It may be more difficult to find the right combination of crops for your situation. With Agro-pastoralists volunteers, it would be better DAs try out new combinations to see which ones work well on DAs or volunteers field.

2.5.2 Other Cropping system

Items	***Descriptions***	***Remarks***
Inter Cropping 	This means growing a two or more crops in the same field at the same time. It is possible to do this in different ways: Mixed intercropping: Broadcasting the seeds of both crops without any row arrangement. It is easy to do but makes weeding, fertilization and harvesting difficult. Possible to Individual plants may compete with each other because of too close together. Row intercropping: Planting the main crop in rows and then broadcasting the seeds of the intercrop (such as a cover crop). Or planting both the main crop in rows. The rows make weeding and harvesting easier than with mixed intercropping.	Examples: Planting alternating rows of maize and beans, or growing a cover crop in between the cereal rows. A possible problem is that the intercrop may compete with the main crop for light, water and nutrients. This may reduce the yields of both crops.
Relay Cropping 	This means growing one crop and then planting another crop (usually a cover crop) in the same field before harvesting the first. This helps avoid competition between the main crop and the intercrop. It also uses the field for a longer time, since the cover crop usually continues to grow after the main crop is harvested. 	Examples: Relay planting of sweet potato at 50% flowering of maize, or haricot bean starting from 50% flowering to 15 days after flowering of maize. It can prevent soil erosion and weed problem such as '*striga*' since land is continuously used for crop cultivation.
Double cropping 	This means cultivation of two different crops on the same field within the same season one after the other. Double cropping helps to naturally control pests, weeds and diseases while encouraging healthy soil. Success can depend upon weather, season, type of crop and more.  http://www.umanitoba.ca/outreach/naturalagriculture/articles/seededcover.html	Examples: After green ear ('*asheeti*') harvest of Maize, chickpea / grass pea recommended for double cropping on vertisols. It is also recommended to plant, early maturing crops like Teff and Haricot bean after harvest of early maturing maize planted at the beginning of the cropping season.