

BEST FIT PRACTICE MANUAL FOR RHODES GRASS (*CHLORIS GAYANA*) PRODUCTION



Applicable for Mid-Altitude Areas Including Dera, South Achefer, Burie and Jabi Tehenan Districts of North-western Ethiopia

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The CASCAPE project is designed to assist the activities deployed under the Agricultural Growth Programme (AGP) by further strengthening the capacity of AGP stakeholders in identifying, documenting and disseminating best practices in agricultural production. CASCAPE is jointly executed by Ethiopian researchers from Jimma University, Haramaya University, Bahir Dar University, Hawassa University, Mekelle University, Addis Ababa University and Dutch researchers from Wageningen University and Research Centre. In each site researchers from the universities and from the RARIs from different disciplines work on the CASCAPE project. The CASCAPE project is financed by the Dutch Ministry of Foreign Affairs through the Embassy of the Kingdom of The Netherlands.

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Abbreviations

ARARI	Amhara Regional Research Institute
BDU	Bahir Dar University
BoA	Bureau of Agriculture
cm	centimetre
CP	Crude Protein
CSA	Central Statistics Agency
DA	Development Agent
DAP	Di-Ammonium Phosphate
DM	Dry matter
DoA	District Office of Agriculture
FTC	Farmers Training Center
ha	hectare
ha ⁻¹	per hectare
IVDMD	<i>In Vitro</i> Dry Matter Digestibility
K	Potassium
kg	kilo gram
m	meter
masl	meters above sea level
M& E	Monitoring and Evaluation
ME	Metabolizable energy
mm	millimetre
N	Nitrogen
NGO	Non-governmental Organization
P	Phosphorus
SMS	Subject Matter Specialist
t	ton
ToT	Training of trainers
ZoA	Zone Office of Agriculture
2-4-D	2,4 - Dichlorophenoxyacetic acid



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Rhodes grass (*Chloris gayana*) production and utilization

1. Introduction

Ethiopia has a huge livestock population. Currently, it is estimated that the country has 53.4 million heads of cattle, 25.5 million heads of sheep, 22.8 million heads of goats, 2 million heads of horses, 6.2 million heads of donkeys, 0.4 million heads of mules and 1.1 million heads of camels. Most of the livestock population in the country is indigenous breed. According to CSA (2011), about 99.3% of the cattle population of the country is indigenous breed. In addition, the livestock population in Ethiopia is also genetically diverse. About one-third of the national livestock population is found in Amhara National Regional State.

The livestock productivity in Ethiopia and Amhara National Regional State is low. There are several constraints that contribute for the low productivity of livestock in the country. These include poor genetic potential of indigenous breeds, feed shortage (both in quantity and quality), livestock diseases and parasites, lack of adequate livestock extension service, poor infrastructure and others. The livestock production constraints in CASCAPE project intervention areas are similar to the national and regional constraints. Among the livestock production constraints in CASCAPE project intervention areas feed shortage is the main and severe one.

Natural pasture and crop residues are the main feed resources in the region. Feed produced from natural pasture is decreasing due to several factors that include overgrazing, land degradation and other factors. The nutritive value of crop residues is inherently low. In addition, the quality of natural pasture especially during the dry season is low. Especially these feed resources are low in crude protein (CP) content and metabolizable energy (ME). As a result livestock productivity and reproductive efficiency in the region is low. Thus these feed resources require strategic supplementary feed stuffs such as agro-industrial by-products and cultivated improved forages. Rhodes grass is one possible perennial improved grass which can be grown on-farm and used by small-holder farmers. However, improved forages including Rhodes grass, have better productivity and nutritive value when compared with natural pasture (Table 1).

Table 1. Productivity and nutritive value of feed resources found in the region

Feed type	Dry matter yield (ton/ha)	CP (%)	IVDMD (%)	Remark
Natural pasture	4.4	5.5	42 - 57	
Rhodes grass	9.1	7.1	60.6	
Tef straw	-	4.2	53.2	
Maize stover	-	2.84	58.02	
Finger millet straw	-	4.12	55.46	

There are different improved forage species; however, their use is limited due to several factors. Among these factors, lack of awareness, shortage of seed/planting material and land shortage are the main ones. To alleviate the feed shortage problem, demonstration of Desho grass, oats, vetches, Napier grass, oat and vetch mixture, Rhodes grass, sweet lupin and water-logging tolerant grass species was conducted by CASCAPE Project since 2011 in *Dera, South Achefer, Burie and Jabi Tehenan* districts. Rhodes grass had better productivity and acceptability by farmers in these districts. Rhodes grass is a perennial, high-yielder, fast growing, palatable and deep rooted grass. The height of the grass may reach 1.5 meters. Rhodes grass grows under a wide range of environmental conditions. Farmers preferred the grass due to its several useful characteristics including its high yield, palatable by livestock and drought tolerance.

This manual is intended to show how to cultivate and use Rhodes grass. It also presents the experiences of CASCAPE Project on Rhodes grass innovation in different districts. This manual presents the recommended practices for Rhodes grass production and utilization and lessons learned in the project that will help farmers, development agents and experts to produce high quality and more fodder yield from Rhodes grass production.

Feed shortage and feed quality are the main constraints in livestock production in Amhara National Regional State. To alleviate the feed shortage problem more feed production and better utilization of the available feed resources is crucial. Improved pastures are better in nutritive value and dry matter yield when they are compared with communal grazing lands. Farmers can produce more feed from a limited area of land and alleviate the feed shortage problem they are currently encountering if they cultivate improved forages. Rhodes grass is

one of the improved forages that gives better yield and have better nutritive value when it is compared with the natural pasture. In addition, it is has been proved for its wide adaptability and productivity in CASCAPE intervention districts. Moreover, farmers have showed interest in growing and utilizing the grass significantly. With this background, this manual is prepared to show better Rhodes grass production and utilization in the mixed crop-livestock production system in Dera, South Achefer, Burie and Jabi Tehenan districts of Amhara National Regional State.

Adaptability and productivity of improved forage species differs from place to place depending on several environmental, technical and socio-economic factors. Taking these variables into account, demonstration and scaling up of Rhodes grass have been conducted previously by CSACAPE Project in different districts of Amhara Region. Thus, Rhodes grass in these districts was promising in its adaptability and yield. Farmers were also interested to adopt this improved forage as it performed better and alleviated the feed shortage problem. On average, the productivity of Rhodes grass on farmers' fields was from 8 to 9 tons dry matter ha⁻¹ per year on rain-fed conditions. Generally, it is believed that production and feeding of more quality feed to livestock enhances livestock productivity. This manual is intended for extension staff that are involved in scaling up of Rhodes grass production in smallholder livestock producers. This manual is intended to be used as a reference by staff of BoA, researchers, academicians, commercial producers, SMS and DAs that are involved in scaling up of Rhodes grass production and utilization in smallholder and market oriented livestock producers. The manual will be useful and applicable in the mid and highland areas (particularly in the Tepid moist mid highlands /M₃/) of Amhara Region and in areas where the production system is mixed crop-livestock production.

2. Testing Rhodes grass innovation

Rhodes grass evaluations, demonstrations and scaling up practices were conducted at on-farm condition by CASCAPE Project from 2012 to 2014. These activities were conducted in *Dera, South Achefer, Burie and Jabi Tehenan* districts. The altitude, rainfall and temperature of the intervention districts are presented in table 2.

Table 2. Altitude, mean annual rainfall and temperature of the study districts

No.	Attributes	Districts			
		Dera	South Achefer	Burie	Jabi Tehenan
1	Altitude(m)	1500 - 2600	1500 - 2500	700 - 2300	1500 - 2300
2	Rainfall (mm)	1250	1450 - 1594	900 - 1400	1250
3	Temperature (°C)	-	15 - 23	17 - 25	14 - 32

Source, Respective DoA, 2012

The dry matter yield of Rhodes grass in different Districts and across years is presented in table 3. The average dry matter (DM) yield of Rhodes grass was 8.74 and 9.1 ton dry matter (DM) per hectare in 2012 and 2013 in all the intervention districts, respectively (Table 3). Some farmers harvested the Rhodes grass up to three times per season. This result is based on rain-fed conditions. Considering harvesting several times during the rainy season the dry matter yield of Rhodes grass in the study areas is expected to be higher.

Table 3. Mean DM yield (t/ha) of Rhodes grass in CASCAPE intervention districts (2012 & 2013)

Name of District	DM yield /2012/	DM yield /2013/
South Achefer	7.5	8.7
Dera	10.8	-
Jabi Tehenan	7.91	6.1
Burie	-	10.4
Average	8.74	9.1

Rhodes grass was preferred by farmers as it performs better and alleviates farmers' problems. On average, 8.74 and 9.1 ton dry matter (DM) ha⁻¹ was obtained by growing Rhodes grass on farmers' fields in 2012 and 2013, respectively. The result obtained is based on rain-fed condition and farmers management practice (Figure 1 and 2). The yield will be higher if the farmers use irrigation and manage the Rhodes grass better. In general, Rhodes grass yields better and will stay green during the beginning of the dry season due to its drought tolerance when it is compared to other types of forage species.



Figure 1. Rhodes grass production on Ato Fasikaw's field at Abichikeli kebele, in South Achefer district (early flowering stage)



Figure 2. Rhodes grass on Ato Fasikaw's field at Abichikeli kebele, in South Achefer district (full flowering stage)

Field days were conducted to create awareness and demand for the adoption and wider dissemination of Rhodes grass innovation (Figure 3). In addition, attempts were made to publicize the results of CASCAPE project interventions on Rhodes grass innovation to a wider community through Bahir Dar university newspaper (Nile Newspaper).

Growing Rhodes grass is beneficial to increase feed production and to boost livestock production and productivity. As feed for livestock increases by growing Rhodes grass, the productivity of livestock will increase. This in turn results in increase in household income and animal products (meat and milk) consumption. By growing Rhodes grass farmers can produce more feed compared to growing native grasses. Rhodes grass was preferred by farmers as it performs better and alleviates farmers' feed shortage problems to their livestock.



Figure 3. Rhodes grass field day in South Achefer District Abichikeli kebele

Scaling up of Rhodes grass was conducted in 2014 in Dera (Korata kebele), South Achefer (Abichikeli and Lalibella kebeles), Burie (Woyenema Ambaye, Aribisi, Wadera and Zalema kebeles) and Jabi Tehenan (Mana kebele) districts. The objectives of this activity were to scale up Rhodes grass and to identify and document challenges and lessons so as to design an effective scaling up strategy. Those farmers who were willing to produce Rhodes grass were selected and participated in the scaling up activity. The seed rate for Rhodes grass was 15 kg ha^{-1} . The participating farmers were selected together with kebele development agents. A total of 103 farmers participated in Rhodes grass scaling up activity.

During the scaling up process, participating farmers were able to harvest Rhodes grass forage two to three times in rain-fed conditions. The frequency of harvesting will increase if the farmers were able to use irrigation.

Stakeholder's workshop and field day were conducted in August 2014 at South Achefer District. Stakeholders (BoA, BDU, ARARI, DoA and farmers) were involved in the

workshop and field day. The stakeholders appreciated that CASCAPE is working based on the problems identified in each districts and considered as a great advantage to their respective districts. Moreover, it was suggested that preparation of manuals and leaflet on Rhodes grass production and utilization is demanded; so that extension staff will use it in the scaling up process. Moreover, field days were conducted in other CASCAPE intervention districts.

Generally, the following comments and suggestions were raised during the field days. Farmers who adopted Rhodes grass innovation explained their appreciation (productivity and frequency of forage harvesting) to the participants of the field day. Farmers accepted Rhodes grass as a means to solve feed shortage for their animals. Farmers also explained that they desire to expand the area coverage of Rhodes grass and also showed their need to introduce improved animals. Farmers and development agents asked additional training to be given for them concerning Rhodes grass production. Farmers asked the project and district office of agriculture that enough seed of Rhodes grass should be supplied. At the field day farmers clearly exchanged experiences on Rhodes grass production and utilization. The sale of Rhodes grass seed for some farmers was found to be a main source of cash income.

The suggestions and comments from field days, various focus group discussions and project follow up results showed that Rhodes grass was found to be more acceptable by the farmers and it is well adaptable to the project areas. The limitation of Rhodes grass production is that it requires fertile soil and a well prepared seedbed. Moreover, shortage of Rhodes grass seed at a reasonable price was one of the bottlenecks to expand this technology. Therefore, office of agriculture should make a linkage with the national and regional seed producer enterprises and private seed producing institutions so as to make Rhodes grass seed available to the districts and farmers.

3. Development pathways

3.1. Introduction

The promotion of best practices should be designed in the context of the broader development pathway for a selected location and the factors that shape the nature of particular development pathways. What are the comparative advantages for a specific geographic area and its household groups (target groups) and what best practices help develop such

opportunities? What are the factors influencing the spread or inhibition of uptake of the best practices in each path? Farmers adopt best practices that help them exploit the comparative advantages provided by the development path and therefore transform their livelihoods. For example, opportunities for development of high value perishable commodities, such as horticultural crops or dairy, are likely to be greatest in areas with relatively high market access and agricultural potential (Pender *et al*, 2001). Scaling up/out of best practices in horticulture or dairy may be targeted to such areas.

3.2. Possible development pathways for area

For the last three consecutive years, Rhodes grass innovation was introduced at South Achefer, Jabi Tehenan, Burie and Dera Districts. Based on data collected from the base line survey of the project and current observation, the innovation development pathway analysis result has been summarized according to three main factors namely, agricultural potential, population pressure and market access. The results are presented in table 4.

Table 4. Development pathway analysis for scaling up of Rhodes grass innovation

Agricultural potential	Market and infrastructure access	Population pressure
<ul style="list-style-type: none"> • Moderate rainfall • Well-drained fertile soil • Availability of irrigation 	<ul style="list-style-type: none"> • High potential of local and regional markets for livestock and livestock products • Road access • Access to transporting facilities for forage yield like cart • Access to manual bailer • Accessibility of finance for input supply 	<ul style="list-style-type: none"> • High population density (shortage of grazing land and cut and carry system) • High cattle and small ruminant population (Semi-intensive and intensive livestock production). • improved livestock breeds availability • Availability of labour

The development pathway analysis of Rhodes grass innovation in the project areas is given in Table 4. The agricultural potential of the area is characterized by moderate rain fall, availability of irrigation and well drained fertile soil.

The presence of road access in the area gives opportunities for high local and regional market access for livestock and livestock product marketing. Local transportation facilities like animal-driven cart can help to easily transport the forage from one area to another. Baling the Rhodes grass hay will reduce the bulkiness of the material and make easy its transportation, storage and utilization. Access to financial sources to purchase inputs such as seed and fertilizer are crucial for Rhodes grass adoption. The experience of the project showed that Rhodes grass innovation can be scaled up in a wider scale in areas of similar agricultural-potential, market and infrastructure access and population pressure. Rhodes grass innovation can be scaled up in a wider scale in the region as well as in the country.

4. Drivers of adoption for Amhara Region (Dera, South Achefer, Burie and Jabi Tehenan Districts)

According to the results of drivers for adoption study conducted in 2013, district differences, education level of head of the household and average distance to FTC are the variables significantly affecting the adoption levels of forage technology. The variables included in the analysis were district differences, farmer type, sex of head of the household, education level of head of the household, total family size, total land size, access to irrigation, Tropical Livestock Unit (TLU), average home farm distance, average distance to all weather road, average distance to FTC, access to extension service (training), access to credit service, membership to cooperative, annual income and frequency of contact with the development agents. The rate of adoption for forage varieties increases when we go from *Dera* to *Burie* and *Jabi Tehenan* Districts. This is true in reality because *Burie* and *Jabi Tehenan* District farmers have accustomed to grow Rhodes grass and other forage varieties. But there is no significant difference between *Dera* and *South Achefer* farmers in adopting forage technologies. Level of education has a positive significant effect in improved forage technology adoption. The rate of improved forage technology adoption increases significantly for educated farmers in comparison to the illiterate ones.

But the result cannot readily be taken as the study was focusing on forage technologies in general which includes Rhodes grass, oat and vetch, sweet lupin and so on. Of course, when farmers are asked about forage technologies, they usually talk about Rhodes grass more than other forage species.

However, a lot of field days and focus group discussions were conducted focusing on the performance of Rhodes grass. During the focus group discussion and key informant interview, adopters of Rhodes grass and their neighbouring farmers were telling us their interests in Rhodes grass. They said that this grass has a threefold higher dry matter yield advantage when compared with their usual practice fallow land harvest. Due to its yield advantage and palatability farmers are eager to adopt this technology. This important grass can grow in all CASCAPE Districts (*Dera, Mecha, South Achefer, Burie, Jabi Tehenan*). Hence, it can widely be adopted by a range of farming households if the extension system works hard to promote its advantages.

5. Recommendation domains for specific practices

Recommendation domains are defined as a group of farmers whose circumstances are similar enough that the same recommendation can be given (Harrington and Tripp, 1984). In other words, places and sets of conditions for which a particular target technology is considered feasible and therefore good to promote. These specific conditions for this practice are given below (Table 5).

Table 5. Recommendation domain for Rhodes grass innovation

Identifier	Specific Identifier	Remarks
Agro-ecology	Mid to highland	Altitude 1400 - 2400 masl
	Availability rainfall and/or irrigation	Above 600 mm
Resource endowment	Capital (purchasing power for seed/splits and other inputs) or credit access	About Birr 300 is required for the purchase of improved seed to plant 1/8 ha. The costs of fertilizer, labour and other inputs are minimum. So any farmer can easily afford either from his own or credit sources.
	Well prepared farm yard plot	The size depends on the number of livestock. For an average farmer 1/8 th of a hectare is enough.
	Presence of livestock	From one to any number possible
	Availability of labour	
Location	Input suppliers (seed)	
	Nearer all weather roads	
	Nearer to livestock products markets	
Cultural	Consumption pattern of the community	
	Cut and carry system developed	
	Community where attitudes developed towards sharing the limited land for livestock forage production	
	Community where the use of improved forages is developed	

Note: Identifiers in **bold** are deemed more important

This might lead to a recommendation domain for Rhodes grass innovation as follows.

An area in the mid to highlands (altitude 1400 - 2400 masl) which has a reliable input supply (Rhodes grass seed) and the farmer should have a reasonable number of livestock. There should be a market for livestock and livestock products within a reasonable distance, the location of the farmer from all weather roads need not be far to walk on foot. The farmers should have access to capital or credit to purchase improved seed and other inputs as well as transportation means either by their own or by payment.

Rhodes grass can be scaled up in the highland areas. The highland areas that are Tepid moist mid highlands /M₃/ are suitable for this purpose. The soil should be non water-logging. Those farmers who have more land and have more productive and cross-bred animals are preferable. Rhodes grass is suitable in high density population areas. As labour is demanded for planting, managing and cut and carry system of feeding. Those areas that have adequate extension services and which are located near to markets are best areas. As Rhodes grass production will be new to most rural areas, awareness creation and provision of technical advice in Rhodes grass production and utilization to the farmers by extension staff will be crucial. Rhodes grass will be best scaled out in areas where there is experience in improved forage production and animal products marketing such as dairy products.

6. Best fit production practices

6.1. Recommendation domain for Rhodes grass innovation

6.1.1. Suitable agro-ecology

Rhodes grass (*Chloris gayana*) is a stoloniferous perennial grass that grows in a wide range of climates (rainfall and temperature) and soil types. Rhodes grass grows better in areas where annual rainfall is above 600 mm and altitude ranges from 1400 - 2400 masl. Rhodes grass grows on a wide range of soils. It grows well on well drained moderate to high fertility soils. It can also survive on infertile soils although it is unproductive and may eventually die out particularly if grazed regularly. It is not tolerant to water logging. Rhodes grass has some establishment problems on very acidic soils but it is tolerant to saline conditions. Generally, Rhodes grass is a poor shade tolerant forage crop. Once well-established Rhodes grass recovers well after fire. Due to its vigorous fibrous root system, Rhodes grass is moderately

drought resistant. In addition, due to its vigorous horizontal root (stoloniferous) growth and extensive roots, Rhodes grass has great contribution in soil binding and soil erosion control.

6.1.2. Compatibility to the cropping system

Rhodes grass is suitable in the mixed crop-livestock system in the mid to highland areas of Amhara Regionla Regional State. As the livelihood of farmers in this system is based on both crop and livestock production, feed production for livestock is crucial in these areas. Farmers can allocate part of their land possession for Rhodes grass production for their own use. As Rhodes grass is perennial farmers can benefit for several years after once planting the crop. As grass is poor shade tolerant perennial grass it should be cultivated as a pure stand. It can grow well with annual and perennial herbaceous legumes such as vetch, desmodium and local clover. Rhodes grass is not suitable for intercropping and relay cropping purposes.

6.1.3. Resource endowment

From the experience of CASCAPE Project intervention districts, small holder farmers usually plant 0.0625 hectare of land from their land holding. Though, Rhodes grass seed is expensive per kg, any farmer can afford the cost for purchasing seed/root splits for this limited land area. The labour and land requirement of the technology is very minimal and should not be considered as important factors that hinder the scaling up agenda. Rather, the attitudes and practices of farmers in allocating the whole farm land for food crop production might be taken as a possible challenge. The extension system needs to work hard to alleviate this problem.

6.1.4. Location

Proximity to input suppliers: For the timely supply of chemical fertilizers, herbicides and certified seed for farmers, input suppliers such as cooperatives, private traders and seed enterprises should be available near to farmers' village.

Extension services: Kebele DAs should be present near to farmers' village for effective and efficient supervision and management of the Rhodes grass innovation. Moreover, higher level agricultural experts should support farmers with frequent supervisions.

Credit service: Although the cost of input for Rhodes grass innovation is not as such high, it is recommended that credit service should be available at kebele level.

Market access: Market is crucial for Rhodes grass adoption. In addition to feeding Rhodes grass for their livestock farmers can sell Rhodes grass hay, green forage and Rhodes grass seed on market. Therefore, local markets should be available near to farmers' village.

6.1.5. Consumption and production culture

Farmers preferred to produce Rhodes grass forage for their cattle and small ruminants compared to native forages. However, some farmers showed interest to produced Rhodes grass for the sale of hay and seed prior to feeding their livestock. Therefore, this attitude should be improved in the future.

6.2. Forage varieties/species

Even though there are different varieties of Rhodes grass was tested in the project area. Rhodes grass (Masaba) was released (recommended) in 1984 by Holetta Agricultural Research Center (HARC) (MoA, 2013). Rhodes grass is described below (HARC, 2004).

- Name of the variety: Massaba
- Year of release: 1984
- Rain fall requirement: 600 - 900 mm
- Altitude range: 1500 - 2400 masl
- Forage yield: 7 - 12 ton DM/ha
- Seed yield: 70 - 150 kg/ha

6.3. Land preparation

The land should be cleared from weeds and trees before ploughing (ESGPIP, 2008). The land should be ploughed two to three times to get a fine and levelled seedbed. As the Rhodes grass seed is very small it needs a well-prepared seedbed (Fekede, 2000). The seedbed should be ploughed and prepared well. A well-prepared seedbed favours seed germination, seedling emergence and growth.

6.4. Planting time

Planting should be done at the start of the main rainy season when the soil has received sufficient moisture to support germination and establishment. Seed germinates within 7 days after planting (Cook *et al.*, 2005). Sowing too deeply will result in failure or poor germination. Rhodes grass seed will germinate under slightly cooler conditions than most

summer growing grasses. Mid to late summer sowings can be carried out but it gives a shorter growing period in the first season. Root splits should be planted at the beginning of the rainy season when the soil gets moist. In addition, the land should be prepared well before planting.

6.5. Seed rate and planting methods

Rhodes grass can be established vegetatively (root splits) or from seed. Seed rate varies depending on seed quality (germination and purity), sowing method, environmental conditions and land preparation. Generally, the seed rate should be from 3 - 15 kg per ha considering the previous factors. High seed rate is usually important in cooler and high altitude areas. Seed should be sown on the surface no deeper than 2 cm (Cook *et al.*, 2005).

Rhodes grass can be row sown or broadcasted. For broadcasting seed can be mixed with soil or sand. After sowing it should be covered with light soil by using tree branches. Alternatively, sowing the seed and light packing by driving animals before and after sowing is also another option. However, if the labour is available, it can be planted in rows. In this case, the spacing between rows should be 20 cm (HARC, 2004). Planting should be conducted when the soil gets moist. Care has to be taken to uniformly apply/drill the seeds over the prepared land.

6.6. Fertilizer application

Rhodes grass is productive in moderate to high fertile soils. If the soil is infertile, applying nutrients to the soil is essential. Applying nitrogen and phosphorus fertilizers is recommended. Applying DAP fertilizer at the rate of 100 kg ha⁻¹ at planting and urea at the rate of 50 kg ha⁻¹ after establishment and at every cut is essential. Some literature recommend applying 100 kg ha⁻¹ nitrogen after each cut. If available, applying manure is another option. Manure can be applied at the rate of 5 - 10 ton ha⁻¹ (ESGPIP, 2008). In general, grasses have a high requirement for N, P and K. These nutrients should be applied after each cut or grazing. Generally, it is recommended that annual maintenance nutrient requirements for N, P and K is 50 - 300 kg ha⁻¹, 10 - 20 kg ha⁻¹ and 25 - 50 kg ha⁻¹, respectively (ESGPIP, 2008). In addition to biomass improvement, fertilizer application enhances both nutritive value and yield.

Rhodes grass gives an increased response to phosphorus in some areas and usually a spectacular linear response to nitrogen in the presence of adequate phosphorus and potassium, both in yield and in crude protein content. Split applications after each cut or after grazing cycles are better than one basic application with the usual rate of 275 to 400 kg ha⁻¹. Generally, cut and carry system requires more maintenance inputs than the grazing system. If sown pastures are well-utilized and maintained with fertilizers, they will continue to provide high herbage yield for up to five years and start to decline thereafter.

6.7. Plant protection

6.7.1. Weed control

The newly established pasture should be free from weeds. Removing weeds by hand is essential. Removing weeds reduces competition when the grass is weak and it also minimizes the chances of further perpetuation of weeds by seed. Removing weeds at early stage of Rhodes grass production is crucial. As the plant is weak at this stage removing weeds makes establishment easier and enhances further survival. Weeding twice after planting at monthly intervals during establishment is recommended. Harvesting the grass and weeds together using sickle when there is vigorous growth is another alternative to control weeds. Using a herbicide like 2-4-D is also effective to remove young broad leaved weeds (HARC, 2004).

6.7.2. Insect pest control

There are no insects observed on Rhodes grass production during CASCAPE Project intervention in different districts. Insects are more severe with legumes than with grasses. But common pests such as armyworm may attack Rhodes grass pasture.

6.7.3. Disease control

There are no diseases observed on Rhodes grass production during CASCAPE Project interventions in different districts. Diseases are more severe with legumes than with grasses.

6.8. Harvesting, threshing and post harvest handling

To obtain high quantity and quality feed, the Rhodes grass should be harvested at 50% flowering stage. Harvesting Rhodes grass at early stage will ensure higher levels of Crude Protein (CP) in the harvested material. As the harvesting time gets late the crude protein level of the grass gets low. The newly established pasture through seed sowing can be utilized

within 3 - 5 months after sowing. The harvested material can be fed to livestock as fresh or it can be made hay for later feeding. If root split is used as a planting material, first harvest can be done from two to three months provided that there is adequate moisture and fertilizer application.

Rhodes grass can be utilized as green forage or hay. It is very palatable and has good nutritive value. Rhodes grass makes good hay if it is cut at the beginning of flowering or a little earlier. Old stands give low quality hay. It is not suitable for silage making. When preparing hay appropriate hay making procedures should be followed. Rhodes grass can be grazed 4 - 6 months after planting. Highest production is attained in the second year. Rhodes grass is tolerant to heavy grazing and cutting, but production is reduced by very frequent defoliation. In the first year, depending on the soil and environmental conditions Rhodes grass can be harvested in October. After the first year it should be harvested anytime of the year when it reaches the optimum harvesting stage. In areas where frost occurs it should be harvested before the onset of frost. Studies show that cutting in every 28-days is better than cutting in every 14-days interval in irrigated conditions. It is better if cuttings are taken at monthly intervals. This depends on establishment year. It takes several months to harvest Rhodes grass pasture in the establishment year. After that year it can be harvested every month based on availability of rain (irrigation) and fertilizer (manure). If Rhodes grass is used for grazing there should be care. Rhodes grass is very palatable to livestock. So, the pasture can be damaged by overgrazing. So, it is better to adopt cut and carry system when using Rhodes grass pasture. Digestibility and Crude Protein (CP) content declines as the plant matures. So, for better utilization regular cutting and fertilization of the crop is necessary. Over mature Rhodes grass should be cut or burned. Burning is applicable in Rhodes grass as the grass is fire tolerant.

6.9. Productivity and nutritive value

6.10.1. Forage dry matter productivity and nutritive value

On average, the productivity of Rhodes grass on farmers' fields in CASCAPE project districts was from 8.74 to 9.1 tons dry matter ha⁻¹ per year on rain-fed conditions. The mean productivity of native pasture is 4.2 ton dry matter ha⁻¹ based on a study conducted in the central highlands of Ethiopia. Based on several studies, the dry matter yields of Rhodes grass generally ranges from 7 - 25 ton ha⁻¹ per year, depending on variety, soil fertility,

environmental conditions and cutting frequency (HARC, 2004; Cook *et al.*, 2005). Yields in the second year may be double that of the establishment year, but this also depends on management and environmental conditions. Yields of 35 - 60 ton ha⁻¹ dry matter (DM) are reported (Cook *et al.*, 2005). Rhodes grass is persistent and drought tolerant when well grazed and fertilized, but disappears after a few years if not well managed. It also produces more seed. The fine stems are easy to cut and dry rapidly. The usual productive life of Rhodes grass is three years; this can be extended by optimum fertilization.

As the nutritive value declines after flowering, it is important to maintain the plant in a leafy condition by regular defoliation. Crude protein levels vary with age of material and level of available nitrogen and may range from 17% on a dry matter (DM) basis in very young leaf, to 3% in old leaves. The *in vitro* dry matter digestibility (IVDMD) varies from 40 - 80% (Cook *et al.*, 2005). Other sources report that crude protein content and digestibility of Rhodes grass range from 4 - 13 % and 40 - 60% of dry matter, respectively. Young growth is very palatable, but after the plants have seeded they are less attractive. Digestibility and crude protein content decrease as the grass matures and becomes stemmy. To avoid over-maturity regular cutting or grazing should be practiced and over-mature pasture should be slashed or burned. There is no record of toxicity on Rhodes grass

6.9.2. Rhodes grass seed production

For seed production a well-drained land should be selected. The seedbed should be prepared and managed as for Rhodes grass forage production. Rhodes grass should be established better to avoid weeds. The Rhodes grass should be harvested at the same time to get uniform ripening. After cutting, nitrogen fertilizer should be applied. Optimum nitrogen application is 100 kg ha⁻¹. Nitrogen fertilizer should be applied as a single dressing after each cut. This avoids the development of new tillers that will produce new seed heads later. Consequently, this results in mature and immature seed heads later at harvesting time. This will result in low seed quality.

The seed should be harvested 3 to 5 weeks after full flowering. When the seed is mature it can be easily removed by gentle rubbing or shaking. In addition, the seed gets hard and dry and the colour changes during maturity. The seed can be harvested by hand using sickles. Harvesting at optimum maturity is essential to get more seed. Harvest the seed when the maximum amount of seed is ripe. The mature seed should be cut and sweat in shade for up to

three days. The harvested seeds should be threshed when most seed turns yellow and the seed readily detaches from the head. Thresh in a clean ground or material using sticks. Threshing can be done by beating with a stick. After threshing the seed should be separated from chaff and weed seed and dried. Drying should be done in a shade. The dried seed should be stored in a clean and dry place using a bag. Seed yield is from 70 - 650 kg ha⁻¹. Hand picking is satisfactory for small areas, and this seed needs minimal cleaning. It is advisable to keep the Rhodes grass land free from weeds. This is because it is too difficult to clean Rhodes grass seed from weed seeds. Mature seed may have some post-harvest dormancy and should remain viable for up to 4 years depending on environmental conditions (humidity and temperature). The seed should be stored carefully. Its viability lasts for up to two years with mature seed but rarely past the first year for immature seed. Rhodes grass is cross-pollinating. Pure seed plots should be isolated by 30 - 60 m.

Farmers have different seed production experiences in CASCAPE intervention districts. They harvest the Rhodes grass forage one to two times. Then they allow the grass to full flowering. After the seed matures they harvest the seed heads, dry, thresh and make Rhodes grass seeds. Farmers in CASCAPE intervention districts have succeeded in doing so. They make forage as well as seed from a single plot of Rhodes grass. The quality of the seed has not been tested. In this process, farmers produce both seed and forage for livestock feeding. But the quality of the forage farmers get after seed harvest will be low.

6.10. Farmers preferences

Though, data on the demonstrated Rhodes grass was not available to make preference analysis, compared to the local grass species farmers preferred Rhodes grass based on its dry matter yield, rate of growth, palatability by livestock, drought and disease resistance.

6.11. Sustainability assessment

Sustainability of a technology can be favoured or constrained by many factors among others the economic, social and environmental (people, profit and planet) are the main ones. Thus, it will be important to examine the sustainability of a technology by setting indicators for the three parameters and analyse the short term and long-term effects of the technology (Table 6).

The sustainability indicators for the three parameters were selected with the farmers and development agents for the systemic comparison of the conventional (benchmark) that is, private grazing land management with the newly introduced high yielding Rhodes grass innovation that has the following elements.

- high biomass yielding grass variety
- optimal usage of DAP and urea

Where most of the agricultural activities of small-scale farmers are implemented manually, the labour demanding nature of a technology has a lot for its sustainability. The conventional private grazing land management (benchmark) and the Rhodes production both demands less labour compared to other food crop production. Once, the Rhodes grass established well, it requires less labour for applying farmyard manure and protection from domestic animals that make the technology less labour demanding and accepted by the farmers.

Table 6. Summary of sustainability indicators for Rhodes grass innovation

Sustainability parameters/indicators	Conventional method	Rhodes innovation	Remarks
<i>People</i>			
Labour demanding	±	-	At the time of first establishment Rhodes grass needs intensive land preparation compared to the conventional. Afterwards both demands equal labour for manure application and protection
Competing claim on land	±	-	People start to allot certain portion of their land from other cropping to grow Rhodes grass, it could potentially reduce the household crop production
<i>Profit</i>			
Revenue	±	++	Biomass yield has increased two-three over the conventional. Moreover it has high nutritive value
Resource efficiency	±	++	Since Rhodes grass can be harvested two to three times in one growing season its land use efficiency is higher than the conventional that is nearly harvested only once
Input supply	±	--	Accessibility and affordability of inputs mainly Rhodes grass seed is the limiting factor for its dissemination at wider scale
Additional income source	±	+	In addition to the grass (biomass) those farmers who grow Rhodes grass get additional income from the sale of Rhodes grass seed
<i>Planet</i>			
Soil erosion	±	±	The new technology neither trigger nor reduce soil erosion
Soil nutrient depletion	±	-	In terms of soil erosion the two methods are similar. However, the new technology seems to deplete more K from high biomass harvest
Biodiversity loss	±	-	Since both the conventional method and Rhodes grass production didn't use any pesticide and /or insecticides the damage to biodiversity loss in the vicinity is less. However, Rhodes grass will exclude other herbs and grass species that affect slightly the number of various species that would have existed otherwise

Once the indicators are set and their relative magnitude is evaluated then spider graph will simplify the comparison of indicator through visualization (Figure 4)

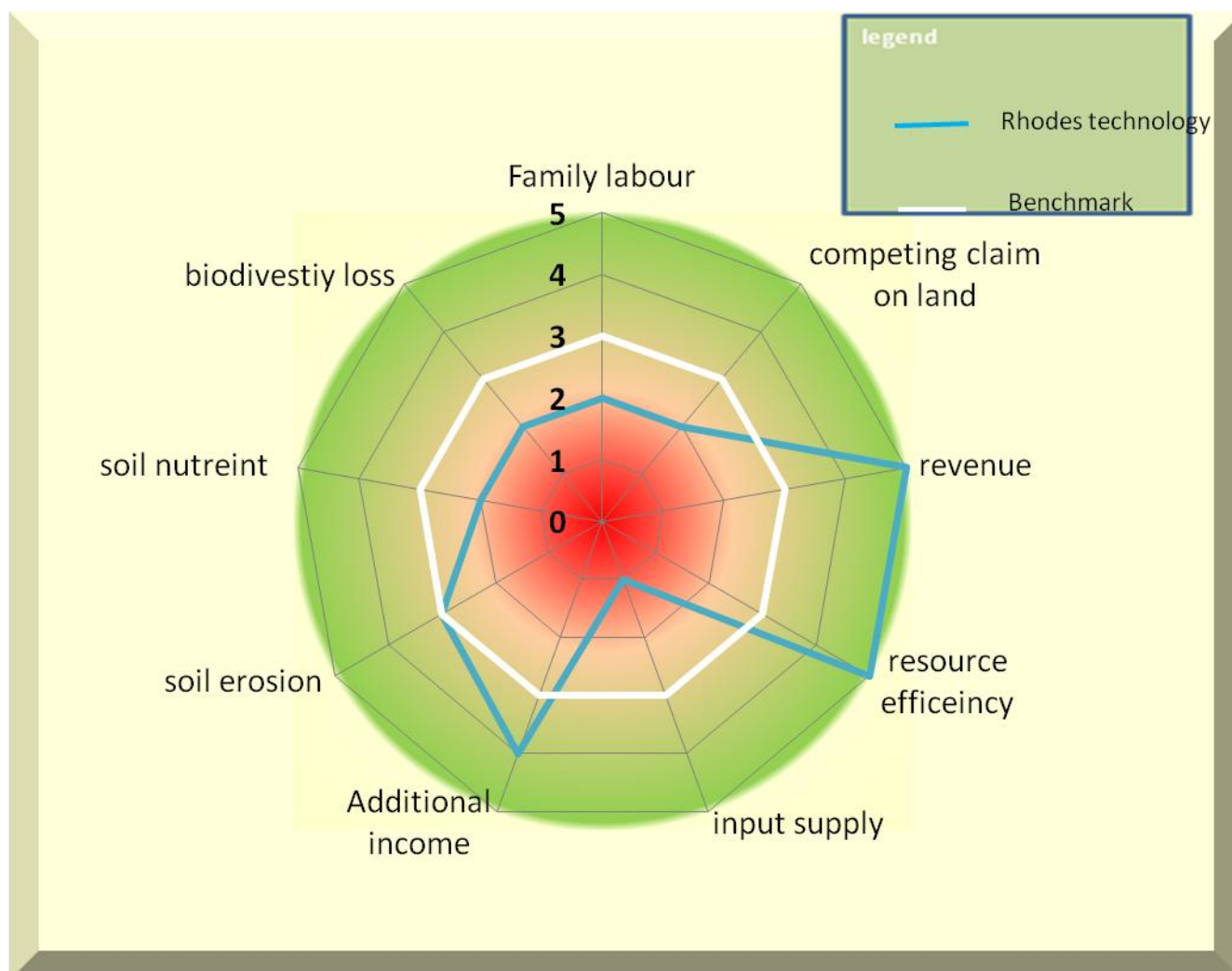


Figure 4. Spider graph of Rhodes grass innovation versus benchmark

Farmers started to allocate certain portion of land for Rhodes grass. This has created a context of competing claim on land. On the one hand it has shown how much farmers are in need of this technology and on the other hand it could potentially reduce the revenue from the crop that might have effect on the family food security. However, there is compromise for prevailing farming system in that farmers are using other technologies that are efficient in land use i.e. giving high yield per unit like potato production technology, maize minimum tillage and new maize variety. Thus, they don't feel competing claim on land rather they felt better synergy concerning the existing mixed farming system. Moreover, the maximum

allotted land for Rhodes grass by individual households will not exceed a quarter of a hectare because this size is deemed enough to feed their livestock. This showed a competing claim would fall within a limit, which means it will not extend indefinitely to threaten the production of other food crops.

The higher biomass yield of Rhodes grass and its efficiency in terms of land use have created higher demand for the technology. Moreover, the good nutrition value of Rhodes has helped the farmers to keep their cattle both productive and healthy because it offered larger portion of the energy requirements for their cattle during the rainy and dry season in the form of hay. Farmers consider the additional benefit from the sale of Rhodes seed as attractive business.

The unavailability of seed on market and its relative higher price are the possible challenges that may have negative impact for its sustainability. Besides, the additional cost for DAP and urea may constraining its wider adoption.

Rhodes grass pasture and protected grazing land (benchmark) give good ground cover to the soil throughout the year thereby reducing soil erosion. However, Rhodes grass pasture seemed to take more nutrient particularly potassium that is mainly associated with high biomass harvests. Since both the conventional method and Rhodes grass production didn't use any pesticide and /or insecticides the damage to biodiversity loss in the vicinity is less. However, Rhodes grass may slightly reduce the number of some grass species that would have existed otherwise.

6.12. Contribution of Rhodes grass innovation to nutrition and gender aspects

As feed shortage is the main constraint in livestock production system, alleviating feed shortage through the promotion of Rhodes grass innovation will increase livestock productivity. This in turn results in more meat and milk production that will be available to the household. This will contribute for better nutrition of the household members including children. As there is malnutrition problem in the region, better nutrition of animals will result in for better human nutrition. This intervention has no negative impact on women. Increased income, has a positive impact on women through increased income from the sale of Rhodes grass seed and livestock products.

7. Suggestions for points of attention for BoA and extension officers

7.1. Identification and involvement of relevant stakeholders

Identifying and participating the key stakeholders is the priority task to share responsibility and maximize the effort of each stakeholder for the successful scaling up Rhodes grass production in a wider scale. The key stakeholders and their role are listed down in Table 7.

Table 7. Relevant stakeholders and their involvement for Rhodes grass innovation

Identified stakeholders	Stakeholders' role
Model farmers	<ul style="list-style-type: none"> • Joint planning and execution of scaling up • Seed multiplication • Apply recommended practices • Share their Rhodes grass production, handling and utilization best experience to other farmers
Kebele office of agriculture	<ul style="list-style-type: none"> • Assist farmers in site selection • Provide training and technical backstopping to farmers • Facilitate credit service
Kebele Administration	<ul style="list-style-type: none"> • Mass mobilization
District office of agriculture	<ul style="list-style-type: none"> • Facilitate inputs supply to farmers • Participate in joint planning • Provide training and technical backstopping to farmers and Das Linking the research output with farmers and DAs
District office of administration	<ul style="list-style-type: none"> • Facilitate timely availability of input • Arranging market availability to farmers • Participate in joint planning and mobilizing the community
BoA and livestock Agency	<ul style="list-style-type: none"> • Provide training and technical backstopping to ZoA and DoA • Facilitate timely availability of inputs • Linking the research output with farmers and DAs • Policy direction
Quarantine Agency Seed enterprises	<ul style="list-style-type: none"> • Seed quality inspection, control and certification • Multiply and supply certified seed of Rhodes

	grass seed to farmers
Research institution and centers	<ul style="list-style-type: none"> • Provide training to BoA, DoA, ZoA and DAs • Technology demonstration and evaluation • Supply basic and pre-basic seeds for farmers and seed enterprises • Conduct research
Cooperatives	<ul style="list-style-type: none"> • Organize local seed producer cooperative and provide training at different levels • Supplying chemical fertilizers and herbicides to farmers
Traders	<ul style="list-style-type: none"> • Supply herbicides to farmers
Universities	<ul style="list-style-type: none"> • Provide training and advisory services • Technology demonstration and evaluation • Conduct research
Credit institutions Projects and NGOs	<ul style="list-style-type: none"> • Provide credit to farmers for purchasing input • Support logistics and participating in capacity building • Participate in input supply and technology transfer • Dissemination of technologies

7.2. Joint planning

Joint planning, monitoring and evaluation should be done by the cooperation of the relevant stakeholders based on their specified role listed in table 7.

7.3. Training at different levels

Experts from BoA, research centers, universities and NGOs, should provide both theoretical and practical training of trainees (ToT) for ZoA and DoA. Similarly, ZoA and DoA should train development agents. Finally, development agents should provide training to farmers.

7.4. Availability of inputs

The very important input in the case of Rhodes is seed. It is expensive and not found in sufficient amounts. Farmers need to have capital or credit access at the starting year of adoption. Once established, it can deliver yields for about five years without additional needs of seed. Fertilizer and labour are the other inputs which are required to adopt Rhodes grass innovation and any farmer can afford the costs of these inputs. With regard to land, Rhodes grass gives high dry matter yield per unit area which is to mean land shortage is not as such a

limiting factor to adopt this technology as far as the farmer is determined to allocate his plot of land for livestock feed production.

7.5. Market access

Rhodes grass is cultivated mainly to feed animals in order to get better yields from them. Hence, we do the market analysis based on the presence and potential market opportunities for our livestock products such as milk, meat, and live animals. The growth rate of human population is very high which results in more demand for crop lands and a reduction in the size of the grazing land. The increase in the number of human population means an increase in the demands of livestock products. On the other hand, the decrease in the size of grazing lands limits the production of livestock feed and decreases livestock productivity. That means the gap in the demand and supply of livestock products is increasing. Hence, there is a reliable market for livestock products.

However, the markets of Rhodes grass either in dried or green forms is not as such developed, though there are some practices in few localities. But the future for Rhodes grass market looks promising mainly because the adoption of the cut and carry system is highly promoted by the extension system.

7.6. Joint monitoring and evaluation

A. Definition

Monitoring is a management process that systematically seeks to supply to the stakeholders information on the progress of implementation of a program/project in order to facilitate timely decision making. Monitoring means keeping track of where you are with a project in relation to where you planned to be. Evaluation is a periodical review of the status of implementation and of achievement of a project or program.

Joint monitoring and evaluation is where all stakeholders involve in the monitoring and evaluation process either alone or together. Each stakeholder has a role to play in the process and need to participate to make the process effective by creating sense of ownership in the whole process of production, harvesting, processing, utilization and marketing. Farmers need to follow the day to day events of the production process because they are the nearest stakeholders for each activity than anyone in the system. They can know what is happening in

the planted seedlings, in the status of weeds, in the emergence of diseases, in the process of harvesting and marketing on a daily bases. They can also evaluate the efficiency and effectiveness of the system better periodically. In so doing farmers can deliver correct and fresh information for other stakeholders who are located relatively in far areas from the field, for instance for district and regional stakeholders and subject matter specialists.

The other stakeholders can follow up the process as timely as possible and can support technically as well as with resources. For instance, the technical people at district or region can advice on the technique of planting, weed and disease control, harvesting processing, marketing and utilization based on their periodic follow up or information obtained from farmers.

B. Data collection

Qualitative and quantitative data should be collected regularly by stakeholders and should be centrally organized, analyzed and communicated again to stakeholders. The tools used to collect qualitative data are focus group discussion, key informant interview, storytelling and attitude and perception measures. Similarly, there are a number of tools which we can use to collect quantitative data. To mention some, structured formats developed and agreed up on stakeholders, reports, surveys, transect walks, field visits, etc.

C. Data analysis

All the data collected by different stakeholders should be brought into experts/department of the respective organization for reorganization and analysis. Some of the parameters considered during the analysis include yield, productivity, environmental impact, profitability, income, land requirement, labour demand and so on. Summary tables can be produced focusing on:

- Different attributes/indicators;
- Comparison between planned and actual;
- Comparison between different areas (*kebeles*, *District s*, zones and regions) ;
- Comparison between years;
- Compare the performance of different interventions; and
- The average performance at *kebele*, district , zone, region and at country level.

In most cases the above analysis relate to the quantitative data. However, if this is complemented with the qualitative data which will be generated by the qualitative surveys it will help to answer why the interventions are performing as observed in the quantitative data. For example, the quantitative data about training can be complemented with the trainee's feedback result on the same issue. This type of information can explain why things are happening (or not happening) in a particular manner and provide significant insights for decision making purposes.

D. Communication

The M&E information collected through the established M&E process can only be used for accountability, learning and decision making, as well as input for re-planning of program/project if there is a clear plan for appropriately communicating it to the stakeholders of the programme. Communication can be done through periodical reports, stakeholders meetings and critical reflections, brochures, leaflets, using electronic means (telephone, e-mail, etc), vocal, workshop, field days, seminar, training and in so many other means. Communication should be done timely.

E. Capacity building for M&E

For the joint monitoring and evaluation process to be effective, capacity building need to be given intensively. Farmers should be given appropriate training on how to record information and on how to communicate it. They need also be supported by necessary materials. The other stakeholders in the process need to get the capacities which enable them to discharge the monitoring and evaluation process effectively. Moreover, need based training for other stakeholders have to be given on data collection analysis and communication.

In general, the monitoring and evaluation activities must be done jointly and in participatory ways. Otherwise, lack of sense of ownership and carelessness may appear in some stakeholders and will lead to total failure in implementing the innovation as a whole. This is usually appearing in most projects and programs.

7.7. Sharing lessons and challenges faced

Rhodes grass is better adaptable and more productive in the highland areas. It performs better if the soil fertility is good. Protecting the Rhodes grass land from free grazing is better to

protect the crop from damage by animals. Rhodes grass is very suitable for dairy farmers who practice cut and carry system. Rhodes grass is best in areas where irrigation is available. As continuous harvesting removes nutrients from the soil continuous fertilizer application is essential.

Sharing lessons learned and challenges faced is crucial. After demonstration/implementation all stakeholders should be involved in the monitoring and evaluation process. Those challenges faced should be sorted out. Further scaling up should be planned considering the lessons learned and the challenges faced. In some instances, farmers do not manage the crop as effectively as expected. They also plant the crop on degraded lands and far from their homestead. This will result in low yield. A few farmers do not add adequate urea or manure after harvesting. This will reduce yields in the coming year. Some of the farmers do not use the recommended seed and fertilizer rate. They do not weed the forage crop adequately. In some instances, free grazing is observed. The Rhodes grass seed and fertilizer should be provided to the farmers on time. Farmers will plant other crops on suitable lands for Rhodes grass production if Rhodes grass seed is available on time. As mentioned earlier in this document, Rhodes grass has several advantages to livestock producers. It is used for dairy cattle and small ruminants feeding. Those farmers who plant Rhodes grass have higher social status by stakeholders. They are considered as innovative and early users of technology.

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