Science et Environnement 34 (2018) 40-55 40
ISSN 2409 -6245, http://www.scienceetenvironnement.dj/

Technological Interventions to Improve the Livelihood of Vulnerable Djibouti Communities

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Abstract

Over ninety percent area of Djibouti is Desert and which is characterized by the severity of its climate. The climate is hot and dry. Temperatures are high (from 30 to over 45 ° C) causing a high potential evapo-transpiration more than 2000 mm on average. Annual rainfall is low (150 mm / year on average) and irregular. This harsh climate is coupled with poor edaphic characteristics as soils are poor in nutrients, calcareous and over lying with pebbles of volcanic rocks. The soil erosion is high due to run off as topography of most of the areas is sloppy. The vegetation of the region is thorny scrub type mainly dominated by Acacia-Ziziphus-Calotropis community. Agriculture in these areas is totally dependent on irrigation but that too is limited as fresh water is only available in Sothern part of country. In the rest of areas water is saline and not suitable for irrigation. In spite of all adverse edapho-climatic factors, the primary sector agriculture still plays a very modest role and contributing 4% to the GDP. Agricultural development is highly dependent on irrigation possibilities. It is estimated that 1,700 units the size of farms. These are often small farms of 0.5 ha, mostly located on the terraces of wadis to have better access to water.

In the agricultural GDP Livestock sector plays an important role and contributes 75% to its GDP. Nearly 16% of the population is directly involved in the livestock husbandry and plays an important role in the economy of the rural areas. These drylands are further degraded because of over grazing, deforestation and over exploitation of underground water. But no efforts have been given to improve the rangelands as well as on rain fed agriculture . If these land are properly treated by suitable technologies than they can be brought back to their original position. This paper describe the technology for the pasture development, dry land agriculture and rain water harvesting and conservations to improve economy of rural people of the Djibouti.

INTRODUCTION

The Republic of Djibouti is situated between longitude 40 and 43° east and from 11° to 12°40′ north latitude covering total surface area 23,000 square kilometers. The climate ranges from arid in the north eastern coastal region to semi-arid in central, northern, western and southern part of the country. The rainfall ranges between 100 mm to 200 mm annually, depending on the ecological regions and that too is irregular and there is an absent of continual water sources. The dense hydrological net work of wadis cover the country. Water sources that are dry except for during the rainy season, which flow from two to eight times a year depending on the rains. The average daily maximum temperature in January recorded 25.6°C and 35.6°C in July. The evapotranspiration (ETP) is very high 2800 mm/year. The mountainous relief composed of volcanic rocks with a few collapsed pits with alluvial deposits quaternary colluviums purposes. The soils are calcareous and poor in nutrients. Over 90% of the land is desert. Due to harsh climate and poor soils the vegetation is typical of the desert and semi-desert consisting of thorny scrub and palm trees. which is mainly dominated by *Acacia-Ziziphus-Calotropis* community. Agriculture in these areas is totally dependent on irrigation but that too is limited as fresh water is only available in Sothern part of country. In the rest of areas water is saline and not suitable for irrigation. In spite of all adverse edapho-climatic factors, the primary sector agriculture still plays a very modest role and contributing 4% to the GDP. Agricultural development is highly dependent on irrigation possibilities. It is estimated that 1,700 units the size of farms. These are often small farms of 0.5 ha, mostly located on the terraces of wadis to have better access to water.

In spite of very adverse conditions, approximately a quarter of populations live in the rural areas that depends on pastoral livestock production for their livelihood. The live stock GDP contributes 82.2% of Agriculture DGP. Over half of the population derives its income from livestock: goat, sheep, cattle and camel, and their population is very high. In 2004, Djibouti had an estimated 512,000 goats, 466,000 sheep, 297,000 cattle and 88000 asses. But their productivity is abysmally low because of poor fodder resources. Though country has 13000 sq km of rangelands, but they are over grazed with scanty vegetation

(Photo 1). The most of the perennial grasses vanished, only annual grasses/herb exist growing during rainy seasons.

Studies conducted in Indian arid zone showed that in protected rangelands perennial grasses dominate while in unprotected mainly annuals and unwanted species dominate (Table 1).

Photo 1: Over grazed rangeland

Table 1: Botanical composition of grassland community under protected and overgrazed land

Site	Species	Relative Density	Relative Frequency	Relative Cover	Relative Biomass
Protected (P_1)	*C. ciliaris*	21.87	9.43	44.81	74.28
	Digitaria marginata	5.79	3.77	3.48	1.26
	Borreria hispida	8.22	8.49	8.15	0.91
	Other species	64.12	78.31	43.56	23.55
Over grazed	*Oropetium thomaeum*	44.34	9.40	48.96	71.97
	Sporobolus diander	15.59	9.40	10.95	5.60
	Cyperus rotundus	13.04	9.40	1.76	3.22
	Dactyloctenium sindicum	7.97	6.58	12.92	7.12
	Other species	19.00	64.86	25.34	12.18

Identification of grassland types:

Due to overgrazing, the Gauchars/Orans (community grazing lands/sacred groves) loose their productivity and in these areas grass production become very low (< 500 kg/ha) whereas if these are reseeded or properly maintained, than their productivity can

be increased to 2500-4000 kg/ha depending upon the land forms and grassland types. Before implementation of the technology for improving their productivity it is very essential to study the grass cover of that region. The grassland cover of Indian Arid Zone with particular reference to western part of Rajasthan is of *Dichanthium-Cenchrsu-Lasisurus* type (Dabadaghao, 1960). But under this cover, several potential grassland types exist in different ecosystems. Based on edaphic factors and rainfall the vegetation cover may conveniently be treated under the following heads:

Sand Dunes and Sandy Plains

Fifty eight percent of total geographical area of western Rajasthan is under sand dunes and sandy plains with annual rainfall ranged between 150-250 mm. The common perennial grasses and legumes under existence are - *Lasiurus scindicus, Panicum turgidum, P. antidotale, Cymbopogon jawarncusa, Eleusine compressa, Dactyloctenium sindicum, D. aegyptium, and Cenchrus ciliaris. The annual grasses are Aristida descensionis, Cenchrus biflorus, Eragrostis tremula and Tragus biflorus*. The common legumes found *Indigofera cordifolia, I. linifolia, Tephrosia purpurea*.

Sandy Alluvial Soils

Cenchrus ciliaris and *C. setigerus* predominate on these types of soils. The other grasses associated are *Aristida funiculate, Eragrostis ciliaris, Cenchrus biflorus, C. prieurii, Eleusine compressa, Pactyloctenium sindicum, Urochlora panicoides, Tragus biflorus etc. The common legumes are Indigofera cordifolia, I. linifolia, Tephrosia purpurea, Phaseolus tribolus* and *Rhyncosia minima*.

Sandy-Clay-Loam to Clay-Loam

Dichanthium annulatum predominates on such type of soils; it associated with *Heteropogon* sp., *Eremopogon fovelatus, Aristida funiculate* and *Brachiaria ramos*e. Among the legumes *Cassia auriculata, Alysicarpus vaginalis, Tephrosia purpurea, and Indigofera cordifolia* are common.

Low Lying Heavy Saline Soils

In such type of soils *Sporobolus marginatus, Chloris verigata, Deplectenia fusca (Karnal grass), Echinochloa colonum, Eremopogon foveolatus* and *Eragrostis ciliaris*

grows. In addition to grass Halophytic succulents also present. These are: *Suaeda*, *Salsola*, and *Haloxylon salicornicum*, *H. recurvum*.

Grass cover in Djibouti

The common grasses in Djibouti are *Cynodon datylon*, *Dactyloctenium sindicus*, *Lasiurus sindicus*, *Panicum thrgidnm*, *Pennisetum ciliaris*, and *Cyperus laevigatis*. Among top feed species, *Acacia tortilis*, *Acacia seyal* and *Ziziphus* species are very common and widely distributed in the country. Audru *et al.* (1997) have classified Djibouti pastures in three zones (Table 2) but their productivity is very low (500 kg to 1000 kg/ha), which can sustain only 1.6 to 3.5 ACU (Adult Cattle Unit/LU) per 100 ha of pasture.

Table 2: Dominant pastures in Djibouti

Region	Dominant pasture types
Mountainous areas and include the Arat, Ali Sabieh, Goda and Mabla massifs	Grass pastures and fodder tree species
Depressions and valleys in the western parts	Irrigated grass pastures of both exotic and local *Panicum species*, *Leucaena leucocephala* and date palm leaves
Littoral zones especially around the Gulf of Tadjoura	Halophyte flora

Bhimaya and Ahuja (1969) have classified Indian rangelands in to five different classes depending upon their productivity (Table 3).

Table 3: Different conditions class of rangelands

Condition classes	Forage production (kg/ha)	Carrying capacity (ACU/100 ha)
Excellent	>1500	25-30
Good	>1000	20

Fair	>720	17
Poor	>500	13
Very poor	>200	6

Studies conducted by CAZRI, Jodhpur (India) over the period of years revealed that pasture productivity can be enhanced by 4-5 times through improved pasture management techniques like protection, controlled grazing, re-seeding with improved strains of pasture grasses and moisture conservation measures in Indian arid zone (Table-4).

Table 4: Effect of improved technology on carrying capacity of grassland in arid zone (Animal Cattle Unit per 100 ha)

Particulars	300 mm rainfall & below	Above 300 mm rainfall
Present	4-8	14-20
After protection	8-20	24-30
After moisture conservation & re-seeding, etc.	20-30	40-48
Increased carrying capacity due to improved practices	16-22	26-28
Increased yield of forage (2.5 t/ACU)	40-55	65-70

Source: J. Venkateshwarlu *et. al.* 1992.

Therefore, pasture lands in Djibouti may be rehabilitated through improved pasture and silvipasture techniques by selecting suitable combination of pasture grasses and fodder trees/ shrubs to enhance fodder availability, which would support animal health and production and ultimately the livelihood of the pastoralist.

Pasture improvement techniques

- **Protection of the site:** The area which is to be developed must be protected from biotic factors. The protection can be done either angle iron 6′×1½″×1¼″ post with

barbed wire (four to five stands) or it can done by stone wall fencing. In Djibouti huge quantity of Volcanic boulders (round stones) are available and they can be used for protection of pastureland. Pasture productivity cane be doubled simply by the protection followed by controlled grazing.

- **Soil and water conservation:** Most of the rangelands of Djibouti are rocky, gravelly and highly eroded and falls under the category of land use classes IV to VIII. Therefore, soil and water conservation measures on these lands are essential. Contour furrows (60.96 cm wide and 22.06 cm deep) with a cross section of 929 sq cm at a distance of 8-10 meters across the slope have invariably proved to be more effective than any other conservation measures. By adopting this simple technique, the grass production can be increased from 500 kg to 1500-2000 kg/ha in a period of 5-10 years.
- **Reseeding:** The selection of grass species is very important. As in Djibouti, there are different land forms and each have different grass species for example hilly and piedmont regions, low lying heavy saline soil, sandy clay loam to clay soils. The grass species suitable to these are:

  Hilly and piedmont: *Sahima nervosum Dichanthium annulatum, Symbopogon* sp. *Eremapogon foveolatus, Heteropogon contourtous*

  Clay-loam to clay: *Dichanthium annulatum*

  Low lying heavy saline soils

  Sporabohus marginatus, Chloris virgatata, Echinocloea colonum, Sueda fructicosa, Haloxylon salicornicum, cyp etc.

  Well drained sandy alluvial soils

  Cenchrus ciliaris, C. setigerus, Panisum antidotale.

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Method of Reseeding

The following two methods may be used-

- Sowing of seeds behind the cultivator
- Pallet seed sowing

For smaller area, seed sowing behind the cultivator is most suitable. The preparation of grass seed pallets required special skill. For preparing pallets grass seeds are mixed with clay, farm yard manure and sand in the ratio of 1.0:1.25 (seeds) : clay 30 : 5 (FYM) and : 5 (sand) (Yadav, 1997). Seed pellets may be developed in a pellet making machine (Photo 2). It is simple rotatory tyre. The pallets of about 0.5 cm diameter are prepared. Each pallet contains 2-5 spikelets.

Photo 2: Grass seed palleting machine

Table 5: Seed rate of some significant pasture for different agro-ecological zones

S. No.	Name of pasture grasses	Seed rate (kg/ha)	Suitable rainfall zone (mm)	Suitable habitat
1	*Lasiurus sindicus*	7-8 kg	150-350 mm	Sandy, Sand dunes
2	*Cenchrus ciliaris*	5-6 kg	250-750 mm	Sandy, plains, sand dunes
3	*Cenchrus setigerus*	6-8 kg	400-750 mm	Sandy, plains, semi-rocky
4	*Dichanthium annulatum*	2.0-2.5 kg	>400 mm	Plains with heavy soils

Note: Root slips of pasture grasses may also be used for propagation.

Production: Once the degraded rangelands reseeded with adopted perennial grass species, the production of rangelands can be increased from 500 kg/ha to 2500 kg or even 5000 kg/ha depending on the condition of site.

Photo 3: Reseeded rangelands

Pasture utilization

The best way to utilize arid rangelands is through controlled grazing based on carrying capacity. Therefore, a balance between the productivity of rangelands and the number of grazing animals, need to be maintained by continuous and careful observations on peak forage production, morphological and physiological characters of the range vegetation. In this region due to highly erratic rainfall, the forage production of rangelands varies year to year and so a relatively low stocking rate is needed to avoid over, grazing. The stocking rate can vary within the region and different seasons depending upon the habitat and the vegetation type of the rangeland, but the objectives always should be achieve efficient utilization of the available forage while aiming at improvement of the range condition.

Grazing:

After reseeding in the first year animals are not allowed to graze, because newly germinated plants will be spoiled by trappings or uprooted by grazing animals. Therefore, first year cut and carry system is to be followed. Second year on wards, grazing can be allowed adopting rotational grazing/deferred rotational system of grazing. In this methods, one area each year should be protected so as to allow natural reseeding. If such system of management followed than reseeded rangelands can be productive for 8-10 years or even more.

Mixed grazing: Since ranges have grasses, shrubs and trees. If only cattle are allowed to graze in the rangelands than shrubs and trees (top feed) will not be utilized and in due course of time, shrubs and tree will dominate and grass cover will be decreases.

If only sheep allowed to graze than only low height grasses will be grazed and unutilized grasses will be woody and palatability of range grass will declined.

If only goat and camel allowed than both will only browse the shrubs and trees and understory grass will not be utilized (Table 6). Therefore for the optimum utilization of rangeland mixed grazing is recommended (Harsh and Shankarnarayan, 1982).

Table 6: Regeneration of Bushes under Different Intensities of Grazing

Animals	Treatments	Cover in June	Cover August (after no grazing)	% Regeneration
Sheep T_1	7.36	13.70	86.14	
	T_2	5.72	11.23	96.85
	T_3	3.13	8.41	168.68
Goat	T_1	8.29	9.79	16.27
	T_2	4.72	9.27	96.44
	T_3	3.26	4.73	75.00

Improvement in pasture quality:

Through perennial grasses lived for more than 10 years but as soon as monsoon reseeds, the grasses starts drying and their crude protein value declined from 12 or 16% to 4 to 5%. Therefore, after November or December these dried grasses are like a roughes and are not nutritive to maintain milch cattle. To maintain their high nutritive value, the following measures are to be adopted.

Introduction of fodder legumes:

Paul et al. (1981) studied the intercropping of forage quality and found that about 65% crude protein can be increased over dried grasses. Harsh and Mauria 1985 studied the introduction of Stylo (forage legume) in Marvel grass stand (*Dichanthium annulatum*) and reported that crude protein have increased by 48 to 87% over control (Table 7).

Table 7: Average Dry Forage Production and Percent Crude Protein (In Parenthesis) of Stylo-Marvel Grass Pasture

Treatments	Yield (q/ha)		Total yield	Percent forage yield over control (+/-)	Crude protein (q/ha)	Percent crude protein over control (+/-)
T_1- *Stylosanthes hamata*	-	14.12 (12.53)	14.12	(-) 57.34	1.77	(+) 40.47
T_2- *S. scabra*	-	14.38 (9.89)	14.38	(-) 56.55	1.43	(+) 13.49
T_3-*S. hamata* + Marvel grass	33.38 (4.18)	38.63 (11.42)	72.01	(+) 117.42	5.61	(+) 345.2
T_4- *S. scabra* + Marvel grass	36.87 (4.04)	1.30 (11.05)	38.17	(+) 15.25	2.88	(+) 128.57
T_5 – Marvel grass (control)	33.12 (3.81)		33.12	-	1.26	-

Silvi-pastoral system: A series of studies on grazing systems by Bhimaya and Ahuja (1969), Paroda *et al.* (1980) and Mertia (1994) have given account of effect of different conventional grazing systems on primary and secondary productivity on arid rangelands. All these studies infer adverse impact on rate of body weight gain or decline in secondary productivity of range animals due to decline in quantity and quality of fodder on these arid rangelands. The deliberate introduction of fodder trees and shrubs has a high potential for increasing the sustained productivity of rangelands. Adoption of this system offers, without impairing the growth of trees, an extra yield of grass during the wet season and browse materials in the long dry season. The natural occurrence of top-feed species in this region in different habitats indicates the potential of leaf fodder from dominant species *Prosopis cineraria, Ziziphus nummularia* and *Halaxylon salicornicum*. Higher leaf fodder is contributed by P. cineraria. Maximum browse (1140 kg/ha) is available in Alluvial plains and minimum (1100 kg/ha) in saline depressions(Sharma et.al.,2001). Effect of canopy of naturally growing top feed species indicates higher forage production under P. cineraria and lowest under *Tecomella undulata*. This brings into sharp focus the need for optimization of the tree density of desired species on rangelands in silvi-pastoral systems (Shankar, 1980) has given a comprehensive review of silvi-pasture to view this land use system in wider spectrum for arid grazing lands. Recent attempt of introduction of top feed species *Colophospermum mopane*,

Dichrostachys nutans, *Prosopis cineraria* and *Ziziphus mauritiana* has indicated encouraging establishment and potential leaf fodder yields (Mertia, 1994). During the dry period, the quality and quantity of range grasses declined. If in the rangeland top feed species also allowed to grow with in grasses, than in the lean period, top feeds (Leaves & pods) can be fed to livestock. They are very rich in nutrients (C.P., minerals, fiber etc.) (Bohra and Abichandani, 1997) The top feed species are *Acacia's*, *Prosopis cineraria*, *Ziziphus* sp., *Mopan, Leucaena leucocephala* etc. can be grown as top feed species.

Establishment of live fodder bank:

Live fodder bank may be established by plantation of fodder trees and shrubs along the road sides, railway track, river, canal etc. Some important fodder trees/shrubs may be suitable for different agro-ecological situations of Djibouti are *Colophospermum mopane, Dichrostachys nutans, Salvadora oleoides, Zizyphus nummularia, Calligonum polygonoides, Azadirachita indica, Prosopis cineraria, Acacia* species, etc.

Fodder conservation

Conservation of surplus quality fodder for lean period through silage and hay making is essential for sustainable animal husbandry.

Hay: If the grasses harvested at 50% flowering stage and stored as hay, than their crude protein value can be maintained up to 7-8% while dried grasses have only 4.0% C.P. Mauria and Harsh (1984) have also studied the effect of stall feeding of conserved hay on the heifer on their body weight gain, and it was reported that stall fed animals gain higher body weight than animals grazing on dried grasses. The gain in body weight was 38.4 kg/heifer in animals grazed on dry grasses while animals fed on conserved hay gain 51.2 kg/heifer i.e. 34% higher.

Silage: A chaffed green fodder of cereals preserved under anaerobic conditions through fermentation.

Preservation mechanism

- Soluble carbohydrates of green fodder is converted in to Lactic acid under anaerobic conditions by *Lactobacillus* bacteria.

- Anaerobic fermentation starts about 48 hours after silo is filled.
- Lactic acid helps in preservation of green fodder.
- Before starting the anaerobic stage there is an aerobic phase in which respiratory function of living cells present in green chaffed fodder utilises oxygen in air tight conditions and releases water & carbon dioxide. After finishing the oxygen, the anaerobic phase starts.
- Bacteria & fungi which depends on oxygen cannot withstand in CO2 atmosphere in Silo.
- Silo must be airtight after filling of chaffed fodder to create anaerobic conditions.

Significance of Silage

- Surplus green fodder may be preserved for the use of lean period.
- During scarcity period, it provides quality fodder to animals and helps in maintaining their health and productivity.
- Silage keeps all parts of fodder in appropriate condition for feeding.
- Silage is tasty & flavoured. It increases appetite of animals.
- Due to the presence of lactic acid in silage, it is easily digestible to animals. Therefore, energy required for digestion is used in milk production.

Treatment for Quality Improvement of Silage

Following additives may be added for making quality silage

- 1 kg urea, 2 kg jaggary/molasses, 1 kg common salt, 1 kg mineral mixture & 1 litre of whey per ton of chaffed green fodder.

Feeding of silage

- After 8-10 weeks, silage is ready to feed for animals.
- Open silo initially from one side. If it is not in use, then cover it carefully with plastic sheet so that air will not go inside the silage.
- Initially fed animals with 5-6 kg silage by adding it with chaffed green fodder to develop taste to animals.
- Once animal likes sweet-sour taste of silage; it will eat it with good liking.

Alternative land use system

Henna: Henna (*Lawsonia inermis* L., family Lythraceae) locally known as Mehndi, is a multi branched woody perennial crop commercially cultivated for leaf production, which

is a source of natural dye. The aqueous paste of henna leaves powder is used to stain body parts for beautification by ladies, particularly palm and feet on different festivals and wedding ceremony throughout India. Its use on head removes dandruff and provides conditioning besides staining to the hair. During summers, it is used on palm, feet and head to minimize the effect of heat stroke on human body. For Beautification planted as hedge in orchards, in front of home and offices. Flowers are used to make perfume.

The optimum plant geometry for henna is 30-50 cm x 50 cm. It may also be planted in the form of alleys at 30 cm x 250 cm spacing and inter row space may be used for intercropping of seasonal crops like green gram, cowpea, cluster bean, etc. The average yield of henna leaves is about 800-1200kg/ha (Sharma 2010).

Aloe vera: Aloe vera cultivation may be another option for resource generation. It can be cultivated under poor soil conditions with minimum water availability. The plant has multiple uses like vegetable, medicinal value, cosmetics and pharmaceuticals. A good crop of Aloe vera may yield 70-80MT/ha.

Senna: Senna is another least water demanding crop. It may be cultivated on a variety of soils including poor and degraded soils. Senna leaves have lot of value in medicine and pharmaceutical industries. So it may be another option for livelihood support in Djibouti.

Other options:

- Ber orchard of improved varieties like Gola, Seb, Umran, Ilaichi, etc may be established. Even local germplasm may also be improved through budding of improved varieties.
- Thornless cactus may be another option for animal feeding.
- Plantation of Boswellia sacra, B. frareana *Anogessus latifolia* & *Acacia senegal* on rocky and gravelly areas to generate additional income through oleo-rasin-gums, gum, wood and leaves.
- Grafted *Prosopis thornless on thorny Prosopis* is another option to produce higher sweet pods for livestock
- *Prosopis cineraria* was also introduceslong back which can also be explored as leaf fodder which is one of the best leaf fodder in Indian arid region.

Conclusion:

A vast area in Djibouti is underutilized, which may be rehabilitated through improved pasture and silvipasture and other suitable plant species. Such type of technological interventions would generate lot of fodder resources and other options for livelihood support of vulnerable Djibouti communities as well as national income. Further, it would also address the issues of soil and water conservation as well as climate of the country.

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