Summary

Grasslands (also called greenswards) are areas where the vegetation is dominated by grasses; forbs, sedges and other herbaceous species are common associates. Grasslands occur naturally on all continents except Antarctica, and in many other areas they have replaced the natural vegetation due to human influence. Grasslands are mainly of two types: Tropical and Temperate grasslands. In India we find mostly Tropical Grasslands.

Grassland is one of the most important natural resources and ecologically productive land (Trivedi *et al.*, 2007). However, despite the acceptance of their ecological and socio-economic values, grasslands were improperly managed in the country (Jadhav *et al.*, 2001). The first countrywide grassland survey was conducted by ICAR during the year 1954-62 and selected more than 500 sites throughout the country and described their broad ecological characteristics (Dabadghao and Shankarnarayan, 1973).

In Gujarat, mostly the areas covered by the Grasslands are Saurashtra and Kachchh (Jadhav *et al.*, 2001). But in past few years the grasslands have started to expand in the North-East Gujarat also. The reason behind the establishment of these grasslands might be arrestation of a succession phase. Most of these grasslands are fodder resources of the area. These grasslands are mainly of two types: i) Free grazing plots ii) Hay plots. Free grazing plots are cultivable and non - cultivable waste lands around villages and urban areas. Cattle are allowed to graze freely in these plots during the growth period. The growth period is monsoon (June-October). While Hay plots are government owned, mainly by the Forest Department as reserve grasslands (vidis). They are well protected by the govt. staff atleast during the active growth period.. The

vegetation of the studied grassland is of considerable ecological interest because it presents distinct conditions of topography, climate, soil and vegetation. Many research works have been published on Indian grasses after Duthie (1988) particularly in Western India. However, no detailed work has been done on the grassland vegetation of Eastern Gujarat. The only documentation of grasses has been done by Shah (1978), Santapau (1953, 1962), etc. The major issues of the present day are proper identification of grass species, palatability preferences, storage practices and the responses to the management of valued grassland biota.

This study includes a series of the procedures beginning with selection of the best quality of seed source through collection, processing, storage and pretreatment to germinate besides that it also includes documentation of successional changes in the study area. The investigations reported here were made during the period from 2007 to 2010.

Study area

The grasslands selected in the present study fall in two major forest divisions of Gujarat (India) which are Godhra and Baria. The two main grasslands studied are **i) Bandheli** which comes under the Godhra forest division of Panchmahal district and **ii) Rampur** which comes under the Baria forest division of Dahod district. Bandheli grassland is situated 16 km away from Godhra town and it comprises of 754.04 ha. It is surrounded by Sampa, Segwa, Vansia, Kanaji, Bakkhar, Doli, Chalali villages. Rampur grassland is situated on the left side of Dahod-Godhra highway, and it includes mainly three grasslands. Kalitalai (658.68 ha), Muvalia (750.43 ha) and Rozam (378.40 ha). The total area is 1987.81 ha (Forest Dept., Gujarat Goverment). These are commonly known as Rampura grassland, situated near Dahod (N: 22 53' E: 74 19'), Dahod District, Gujarat. Both the grasslands are presently managed

under grass bir working circle for the purpose of production of grasses. Both of these areas are well protected by the Forest Department especially from late June to December for the production of hay. Because these months show active growth period for grasses, during December forest officials start cutting them for hay. After December, these protected areas are open for local tribals and their cattle. The grasslands of Rampur were formed as a result of human activity. Earlier the whole area, except for some rocky plateau, was covered with thick teak forests, the remnants of which are still seen in some valleys. Large scale cutting and hunting of wildlife made the area totally blank except some areas where grassland came up, when these forests were cut through millennia.

In present study area, much more efficient management of the present grasslands is needed, so that their prolific use can be enhanced and their status can be improved. Such efforts were made by us and depending on that we selected some key objectives which are as follows:

Objectives of the present study

1. To document the grasses and other associated species in the area.
2. To find out the reproductive potential of selected grass and legume species.
3. To select a simple and economical harvest and cleaning technique for grasses.
4. To assess the seed quality.
5. To assess nutritive value and palatability of fresh and stored material and its impact.
6. To observe temporal climatic changes and their effect on grassland vegetation during successive years of the study.

Biodiversity documentation

All selected sites of the study area were visited frequently at a regular interval of about 15-20 days. Field visits were subsequently conducted to collect the species specimen and to confirm the consistency and variation in the species composition of the study area.

At each site the plots were placed randomly. Herbaceous vegetation and grasses was analyzed using 1 m x 1 m randomly placed quadrats at the time of the peak cover. Each tiller of the grass clump was considered as an individual plant. The Quantitative parameters assessed were diversity, frequency, density, abundance, richness, IVI and were determined as per Curtis and McIntosh (1950). Different indices for plant community were also calculated.

Poaceae and Leguminosae are two largest families of both the regions.In Bandheli grassland, a total of 173 species were encountered that belong to 43 different families and 125 genera. Leguminosae was the most dominant family (with 42 species) followed by Poaceae (with 32 species). The proportions of family to genera, family to species and genera to species were higher in Rampur grassland than the Bandheli grassland.

Simpson index was higher for Bandheli grassland (0.52) i.e. =/> 0.5 infers clubby occurrence of dominant species while the same index of Rampur grassland is 0.48 (=/< 0.5) which infers somewhat gregarious occurrence of dominant species. Thus, in the Bandheli grassland few species were dominant which indicating lower stability of this grassland and the Rampur grassland seems more stable.

Reproductive potential

It was assessed by the total seed output determined by recording:

1. Average Plant height (cm)
2. No. of Inflorescence / plant
3. No. of Flowers / Inflorescence
4. No. of Fruits / Inflorescence
5. Seed output / plant
6. Seed output / unit area

Obtained phenological data can help in collecting seeds for regenerating pure patches for desired species or fodder for cattle at appropriate stage with good quality. While results of seed output per plant gives details about individual plant species and can help in getting knowledge about seed quantity for collection. Among grasses *Apluda mutica, Cynodon dactylon, Dichanthium caricosum, Digitaria adscencence, Digitaria granularis, Thelepogon elegans w*ere found to have high seed potential and legumes like *Aeschynomene indica, Crotalaria leptostachya, Crotalaria nana, Desmosium giganticum, Indigofera enneaphylla, Indigofera tinctoria, Sesbania sesban, Tephrosia villosa* showed high regenerative potential because of higher seed output.

Seed Processing

The present study deals with recent advances in seed harvesting and processing and gives outline about the quality seed production for the selected grasslands. The steps followed were:

- Harvesting and Seed Collection
- Post-harvest seed conditioning
- Seed Drying
- Seed Cleaning
- Seed Extraction
- Seed storage

Along with this, through appropriate technology, an attempt was made to design and create a modified model of a manual grass seed cleaner. It consisted of two units; the sieves stand and seed thresher. The sieve stand was used for the removal of bigger trash and seed thresher for the removal of minute chaff particles. The machine consisted of two units; the sieves stand and seed thresher. The sieve stand was used for the removal of bigger trash and seed thresher for the removal of minute chaff particles. Both of these equipment were designed based on basic sieving process and considering the physical properties of seeds. Instead of conventional large machines with high power consumption, these two manual handy ones are affordable and is a new attempt to get quality seeds in forage reestablishment i.e. mainly for minute forage grass seeds. The sieving process of the sieve stand separates bigger trash while thresher separates associated chaff.

In total about 50% of collected forage grass species could be efficiently cleaned up to pure caryopses level. Even though, these species shows minor dimensions of their seeds whose manual separation is next to impossible. For better field establishment, separation of such small sized forage grass seeds through such sieve stand and handy, conventional seed thresher might be so promising for future revegetation programs. Our work has highlighted alternative methods of harvesting and processing that will go a long way towards coping with stand establishment problems of a diverse range of the grasses found in the study area. Prepared seed thresher and sieve stand can be used for other grass species based on its mentioned performance. Obtained pure caryopses will be more helpful in pasture regeneration program.

Seed quality testing

Seed quality is essential to assess the physical and biological aspects of seed. These tests are commonly done immediately after seed processing, before

sowing and then periodically on seed lots kept for long storage. Several techniques have been designed to evaluate the seed quality. These quality tests are essential at several stages during the progress of seed from the parent tree to the seed bed. Efficiency and success for establishment in plantations also depends on the quality of the seeds used.

The major physiological aspects for measurements of seed quality were:

Physical purity	Seed density
Maturity index	Viability
Germination	Vigor

Seed lot screening with X-ray imaging.

The study was done to assess seed quality with the help of x-rays by which immature, mature and damaged seeds sorted out. The germination ability of these seeds was also seen to observe the correlation.

Germination process was intensely studied, by comparing the germination curves for increasing and decreasing temperature regimes (IT and DT) and also by examining the effects of other eco-physiological parameter (viability) on the germination patterns in the test system, we could extract information on the germination characteristics of individual seed populations: the presence or absence of induction or breakage of dormancy by certain thermal (temperature) regimes, the permissible or optimal temperature range for the germination of non-dormant seeds and, the range of thermal time required for germination in different storage durations.

The results of the germination study show numerous instances where the different species showing similar kind of seed characteristics reoccurs in association with species of same ecology. And such information can be used

through the extrapolation in regeneration activities. It also can be a satisfactory analysis in which laboratory results are complemented by studies of production and chance of seeds under natural conditions.The present study indicated that, along with temperature and dormancy, seed longevity i.e. seed viability play a crucial role in determining germinability due to which seedling establishment can be regulated in the field condition. Thus, the seed distribution of seeds in field condition is expected to determine the proportion of germination and also act to maintain seed banks over a time.

Seed Lot Screening was done by specially modified X-ray technique.

Almost all grass seeds and many of legume seeds studied using x-raying was very small and study with normal characterization was not possible. For these efforts were done with modifying the specifications, successful results could be obtained and results stands as one of the major achievement and can be successfully used in the field of pasture development.

The findings show that the method is reliable and can be used for detecting empty, filled and mechanically damaged seeds or fruits. The applications of x-ray radiography in pasture development for good quality seed collection, seed processing, nursery practice, seed trade and plant quarantines, and for research etc. is now possible.

The main benefit of x-ray imaging is that, on the basis of % of mature seeds, we can assume that how much seeds may be viable. The ration of the mature seeds can predict the quality of seed lot of the particular species.

Palatability and nutritive value assessment

In this study, the attention was paid to evaluate the effect of the different maturity stages and storage period on the palatability of the hay. For this

study we estimated the nutritional values (carbohydrate and protein content) and palatability values (Cellulose, Hemicellulose, ADF, NDF, crude fiber content).

The values for nutrition and palatability were assessed for fresh as well as mature (before seed setting) stored plant material

- Nutritive values were assessed by estimating total soluble sugars and the protein contents.
- Palatability for the selected grasses was assessed by estimating their ADF (Acid detergent fibers), NDF (Neutral detergent fibers) values, ADL (Acid detergent lignin), Lignin, Cellulose, Hemicellulose and Crude fiber contents.

A checklist of palatable grass species from both the studied grasslands was compiled to understand the status of fodder potential of grasslands. The grasslands are dominated by un-palatable species as these species are slowly replacing palatable species. Common and most palatable grasses in the study area include *Apluda mutica* (Karedi), *Bothriochloa pertusa* (Zinzavi), *Cenchrus ciliaris* (Anjan), *Chrysopogon fulvus* (Khad), *Coix lachryma-jobi* (Kaha), *Dichanthium annulatum* (Zinzavo), *Echinochloa crusgalli* (Samo), *Eragrostis tenella* (Bhumsi), *Heteropogon contortus* (Sukli), *Sehima nervosum* (Shaniyar), *Sehima sulcatum* (Seran), *Themeda triandra* (Bhathedu), etc. While common legume species include mainly weed forms i.e. *Alysicarpus monilifer* (Lipodi), *Alysicarpus vaginalis* (Lipodi), *Atylosia scarabaeoides* (Ajimo), *Cassia tora* (Puvad), *Indigofera cordifolia* (Gobaru), *Indigofera echinata* (Gobaru), etc. it was observed that some species were rare but still can be consumed by cattle and species like *Iseilema laxum,* an excellent fodder grass can be established as pure patches in the grassland. Other rare species like *Eragrostis japonica, Eragrostis nutans, Eragrostis tremula, Eragrostis unioloides, Isachne globosa,*

Ischaemum indicum, Oplismenus burmannii, Sporobolus halvolus, etc. are good fodder grasses; which can also be established in pure patches in the grassland. As a result of this cultivation the forest department as well as local tribals can overcome the problem of fodder for the cattle and that is specially in scarcity period when availability of forages is about to zero or very less. Among the selected grasses, *Coix lachryma-job* is showed maximum amount of nutritive values for freshly collected plant material, while *Cenchrus ciliaris* showed maximum amount of nutritive values for stored material. The results of palatability assessment showed that among structural components maximum amount of ADF was present in *Bothriochloa pertusa* in fresh as well as stored material. While NDF amount was maximum for *Coix lachryma-jobi* for fresh material and for stored material the maximum amount of NDF was present in *Cenchrus ciliaris* and *Coix lachryma-jobi.* Likewise, amount of lignin was maximum in *Dichanthium annulatum* and *Sehima nervosum* for fresh material while for stored material it was maximum in *Bothriochloa pertusa*. The amount of hemicellulose was maximum for fresh as well as stored material in *Bothriochloa pertusa* and *Coix lachryma-jobi.* The maximum amount of crude fibers was present in *Dichanthium annulatum* in fresh as well as stored material. Ash content was maximum in fresh material of *Cenchrus ciliaris* and *Dichanthium annulatum* while in stored material it was maximum in *Sehima nervosum.* Obtained results suggest that the promotion of highly palatable species like *Bothriochloa pertusa, Cenchrus ciliaris, Coix lachryma-jobi, Dichanthium annulatum, Sehima nervosum, etc.* must be enhanced. While spread of unpalatable or less palatable species like *Cymbopogon martinii, Sorghum halepanse,* etc. should be controlled. Other less palatable species can be used during drought periods.

Temporal climatic changes and its impact on grassland Diversity

The study was conducted to observe temporal climatic changes and their effect on grassland vegetation during successive years of the study**.** For this vegetation surveys were conducted during monsoon and post monsoon periods for successive years.

Comparison of Species Composition

To compare species composition within differential habitats, we assembled geographical data for selected three study area of studied grassland. In total nine study sites differing in their topography and microclimatic conditions were selected. Quadrats of 2m x 2m square (with triplicates) were laid down in the selected sites. In a particular quadrat the occurrence of different grasses and herbaceous legumes along with their abundance were documented. The relative abundance of species was recorded as different categories i.e. abundant, frequent and rare.

Observations for phenology and temporal changes

The developmental stages of different species were also recorded and they are categorized into seedling stage, vegetative stage, flowering stage and fruiting stage, etc. The observations were recorded at each stage of succession.

Soil Analysis

Soil analysis was done for the soil samples collected from the study area. Which includes: Soil pH, Electrical Conductivity ($S \cdot m^{-1}$), Organic Carbon/Total Nitrogen (%), Soil organic matter, P_2O_5 (Kg/Ac), K_2O (Kg/Ac), Sulphur (ppm), Zn (ppm), Fe (ppm) , Mn (ppm), Cu (ppm). All tests were performed at Gujarat State Fertilizer andChemicals Ltd. (GSFC), Vadodara.

In our selected study sites, the environment was very fluctuating during these years. The rains were very erratic; temperature fluctuation level was very high which directly affected the plant growth. Another effect of these fluctuating environments was that, at the time of seed setting, the plants got dried. Thus, almost all dominant perennial palatable grass species of the study area like, *Apluda mutica, Bothriochloa pertusa, Cenchrus ciliaris, Chrysopogon fulvus, Dichanthium annulatum, Heteropogon contortus, Sehima nervosum, Themeda triandra* and many other less dominant species did not show seed formation. This affected the community composition and species diversity in the next season.

At both the grasslands, one unexpected result observed during our studies was that in certain portions of the land where the grasses were left uncut, with the assumption of allowing them to rot and so add humus to the soil; the grass, however, was so fibrous that it did not decay but laid on the ground acting as a denuding agent, effectively killing vegetation, preventing germination of seeds and preventing percolation of rainwater to the ground. The areas which had been denuded in this manner by the overlying debris were in the following season invaded by ruderals such as *Vicoa auriculata* (Sarpankho). It is therefore suggested, that the grass produced must be cut, grazed (but not over-grazed) or burnt if it is not to form an obstacle to next year's growth. Overgrazing also caused an increase of ruderals such as *Echinops echinatus.* Improvement of such areas is distinctly possible. The first essential is fencing, so that the free movement and indiscriminate grazing of cattle may be checked. Low edge of local stone along the contours check run-off, allow accumulation of silt and form starting places for tussock/bunch grasses**.** Thereafter some simple system of rotational grazing or cutting is all that is needed.