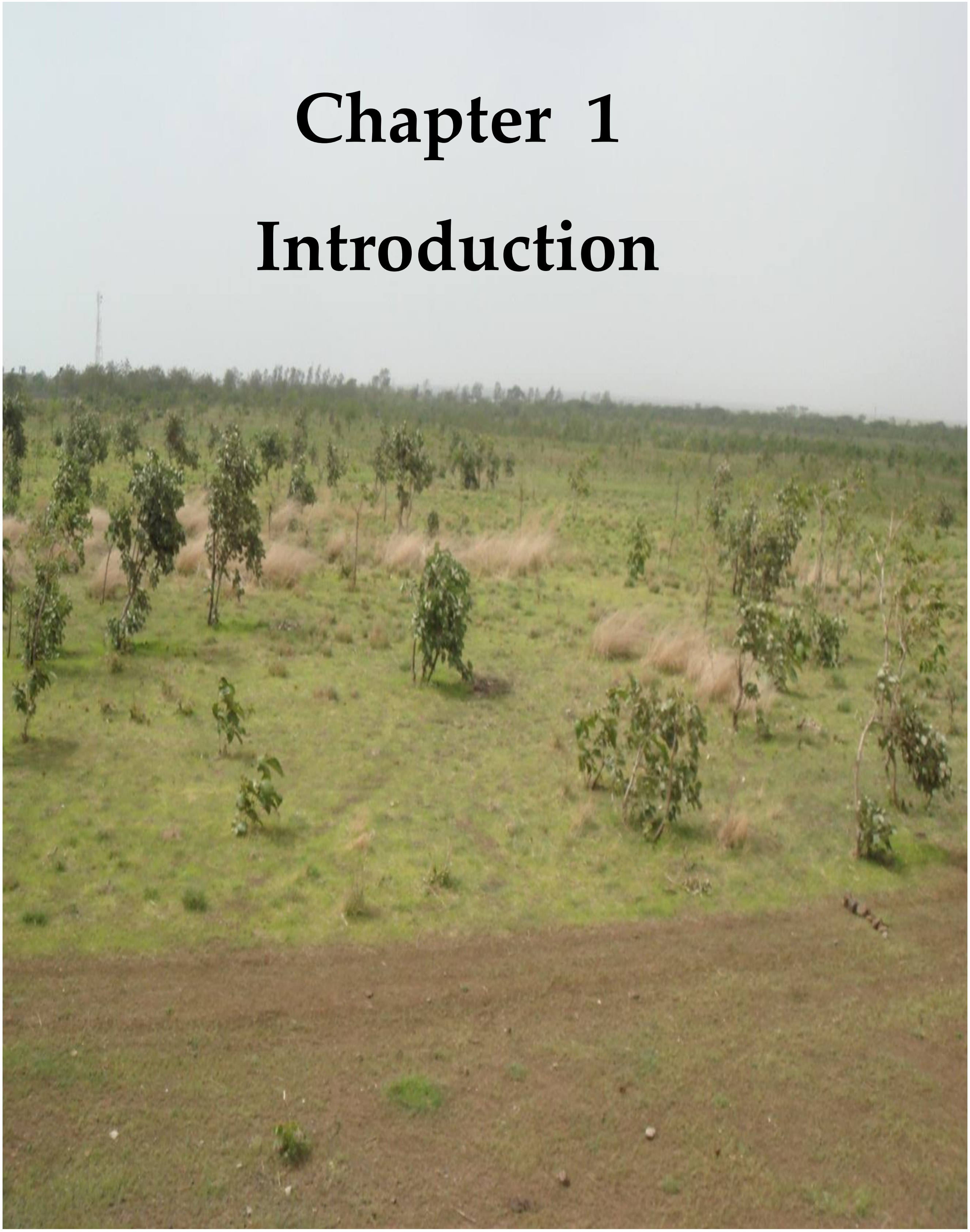
# Chapter 1

# Introduction



# Chapter 1

# Introduction

Grasslands are irregularities in the context of world vegetation units, as they simply should not exist in the natural world. However, they have managed to more than 'exist' and have flourished and extended their range to become one of the most successful of all of the world vegetation types and also to become one of the most commercially important of all species. The reason for the remarkable success of grasslands is contained in the phrase commercially important because grasslands have been utilized by generations as the source for food and need for the people.

A variety of grasses, herbs, and several species of insects, birds and mammals have evolved so that they are adapted to these wide-open grass covered areas. The animals are able to live in conditions where food is plentiful after the rains, which they store as fat and subsequently use it during the dry period when there is very little to eat. Man began to use these grasslands as pastures to feed his livestock when he began to domesticate animals and became a pastoralist in ancient times. As used in the general sense, grassland includes both grasses and legumes which occupy land continuously for more than one year. The grasslands used for grazing and occur in humid regions are usually termed "pastures" and those which occur in sub humid or semiarid regions are usually designated as "ranges".

The native grassland is a community that is composed of native grasses as well as a range of other species that include herbs and shrubs; whereas a native grass pasture can be defined as native grassland that has undergone modification in the form of grazing and the introduction of legumes. Native grasses are perennial and naturally adapted to local soil and rainfall conditions. Many of these grasses have the potential to be as productive and nutritious to stock as our introduced pasture species. The term grassland is used to refer the ecosystem in which the dominant vegetative component is comprised of nearly 20% of the landscape of herbaceous species (Coupland, 1979). The earth is covered by grass dominated vegetation which includes communities with a prominent tree component (Savannas) and those without trees (Steppe).

**Grassland evolution**

In the Miocene and Pliocene Epochs, which spanned a period of about 25 million years, mountains rose in Western North America and created a continental climate, favorable to grasslands. Ancient forests declined and grasslands became widespread. Following the Pleistocene Ice Ages, grasslands expanded in ranges as hotter and drier climates prevailed worldwide. The Cenozoic rise to dominance of grasses undoubtedly influenced climate systems and was central to the evolution of grass-eating animals (Jacobs et al., 1999; Pagani et al., 2009). Understanding of this ecological transformation provides the evolutionary context for today's grass-dominated ecosystems and may help us to sort out their complex controls as well as predict how they will respond to ongoing anthropogenic climate change. Grassland plants evolved under the influence of periodic droughts, frequent burning, and grazing animals and got adapted to all the three impacts. This adaptation for grasses is manifested in their ability to die down to underground organs and only expose dead tops above ground (Gleason, 1922). Grasses can escape drought, by having growing tips beneath the soil that are not exposed to desiccation. Grazers can remove aboveground tissues, but new shoots can emerge from below ground once the grazing pressure is removed (Tainton and Mantis, 1984). The adaptation of grasses to fire, drought, and grazing animals may represent a preadaptation of grasses to one or more of these factors; however, grasses and herbivores likely co-evolved based on other features of grasses.

**Types, Distribution and Status of Grasslands**

The grasslands of the world constitute a major par
t of ecosystems in different parts of the world and have characteristic properties. The grasslands populate almost all ecological regions and can be grouped into six categories, namely

- Tropical and subtropical grasslands
- Temperate grasslands
- Flooded grasslands
- Montane grasslands
- Tundra grassland
- Xeric and desert grassland

Grasses are the plants that are found from the edges of the sea to high up in the mountains, and in every continent except Antarctica. The largest areas of grasslands are found in central and southern Asia (Lavrenko and Karamysheva 1993; Singh and Gupta 1993; Ting-Cheng 1993), southern South America (Soriano 1992), Africa (Herlocker et al. 1993; Le Houkrou 1993a; Tainton and Walker 1993) and central North America (Coupland 1992). **(Figure: 1.1 - Map of the distribution of grasslands in India adapted from https://iasmania.com/natural-vegetation-of-india/).** Smaller areas occur in Europe (Lavrenko and Karamysheva 1993; Le Houkrou 1993a) and Oceania (Gillison 1993; Mark 1993; Moore 1993). To a large extent the potential distribution of grassland ecosystems is determined by climatic variables, principally temperature and precipitation (Whittaker, 1975).

The tropical grasslands can be defined as "A continuous cover of tall grass understory and a discontinuous overstorey". They are located near the equator, between the tropic of Cancer and the tropic of Capricorn. They cover much of Africa as well as large areas of Australia, South America and India.

It is conservatively estimated that nearly 25% of the Asian landscape was under grasslands, much of this is now being converted to agricultural land. In tropical Asia, grasslands are ecologically indispensable as they are the most efficient and effective natural biotic force which can rehabilitate disturbed and degraded land, protect and conserve exposed soils and convert a hostile physical environment into one which is more hospitable for the development of woody vegetation if left undisturbed. In India, majority of grasslands are regarded as Savannas which constitute landscape systems of grass-cover with scattered islands of trees and shrubs occupying an ecologically intermediate position between forest and steppe. In India, sale of green fodder through retail outlets is a common practice. Cultivation of perennial grasses such as Napier and Napier X Bajra hybrids are becoming popular. Intensive fodder cultivation is restricted to States such as Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh and Karnataka. The area cultivated for fodder amounts to ~4% of the total cultivable area. However, exclusive pastures and grasslands are widespread and are grazed by domestic animals. The total area of permanent pastures and grasslands is about 12.4 M ha or ~3.9% of the country's geographical area. An area of ~15.6 M ha, classified as wasteland is also used for grazing. Forests, and their associated grasslands and fodder trees, are another major source of grazing and fodder collection. Rural systems and the seasonal movement of tribes along with their livestock from lowlands to highlands (called transhumant systems) are experienced in and around the villages where community grasslands and forests are the major source of feeding. The transhumant system is practiced in order to locate the best herbage resources from pastures and grasslands. Silvipasture systems with trees such as *Acacia, Leucaena, Albizia, Melia* and understorey grasses like *Cenchrus, Chrysopogon, Panicum, Pennisetum, Dichanthium* and legumes specially *Stylosanthes* and *Macroptilium* are becoming very popular with the farmers. The deterioration of Indian pastures, grasslands and other grazing lands may be attributed to the large bovine population, free grazing practices, lack of management, and natural constraints like extremes of temperature, steepness of slopes, variable precipitation, and scarcity of moisture in arid and semi-arid situations.

In Gujarat, mostly the areas covered by the Grasslands are Saurashtra and Kachchh (Jadhav et al., 2001). But in the past few years the grasslands have started to expand in the North-East Gujarat also. The total geographical area, status of grasslands and production in Gujarat is as follows:

| | |
|---|---|
| Geographical Area | : 196024 Sq. Km. |
| Total Forest | : 19145 Sq. Km. |
| Total Grassland area (Permanent pasture and other grazing lands) | : 8505 Sq. Km. |
| Total reserved forest | : 14368.27 Sq. Km. |
| Total protected forest | : 389.56 Sq. Km. |
| Total unclassed forest | : 4388.13 Sq. Km. |
| % to total geographical area of state | : 9.76 % |
| Grass Production (from reserve Vidis) | : 19608.60 tons |

Source: Forest Dept., Working Plan Circle, Vadodara (2001)

**Factors affecting the grasslands**

The abiotic as well as biotic factors are instrumental in shaping the structure and function of these grassland ecosystems. These factors operate differentially in the different types of grassland ecosystems according to their respective environmental conditions and play fundamental roles in survival of the grassland ecosystem.

The sustainable use of these ecosystems requires an understanding of basic ecology, particularly environmental factors that determine their structure and function, and their susceptibility to disturbance. The researchers were particularly interested in trying to determine how much we can use the savanna type of grasslands before it changes and how much they can change and still recover its original composition or not. As a consequence, researchers have focused on developing a predictive understanding of the ways in which the grassland ecosystem responds to natural and anthropogenic stresses and disturbances (Frost et al., 1986). Evidence suggests that four key environmental factors responsible are:

1. Plant available moisture (PAM)
2. Plant available nutrients (PAN)
3. Fire regime
4. Herbivory

The correlation between grassland occurrence and climates especially with seasonal rainfall patterns is a clue that water availability is a key factor affecting this community. Water availability at a site will depend on the annual rainfall, water infiltration capacity, evapotranspiration, soil texture and the hydrologic regime at the site. Unfortunately, this is difficult to quantify in order to get an insight into the influence of water availability on ecosystem structure, we have to compare sites with large differences in rainfall, but similar in other characteristics such as soil type.

Nutrient availability is largely a function of soil moisture and dry season nutrient uptake and nitrogen mineralization in particular; it is limited by low levels of plant available moisture. Significant plant growth is only possible during periods of high plant available moisture that releases available nutrient via mineralization.

Fire is an important landscape-scale determinant that impacts all of the world's grasslands and plays a vital role in the grassland biodiversity. Fire is an inevitable consequence of the annual cycle of profuse herbaceous production during the wet season followed by curing of this material in the dry season, when climatic conditions are ideal for burning. Large proportions of grassland regions are burnt each year for a variety of reasons; land clearing, livestock management, property protection, conservation management and cultural purposes. Fire has a major role in restricting tree establishment and growth. Frequent fire events can reduce tree seedling establishment. This limitation on tree establishment enables grass persistence and growth, maintaining the fuel load. The aerial stems of small seedlings and suckers are often killed during the fire but the individuals are able to re sprout from lignotubers or from other underground and stem basal tissues.

Mammal herbivores are typically categorized as grazers, browsers or mixed feeders, who can vary their diet depending on food availability. The importance of herbivory as a determinant varies between different regions and appears to largely reflect the abundance of the large herbivores present. The effects of large herbivores on grassland vegetation include

1. A change in the species composition of the vegetation, e.g. grazing pressure may lead to a decrease in perennial, palatable, grazing-sensitive tussock grasses and an increase in less palatable and /or prostrate perennial grasses, annual grasses and forbs.
2. The density of woody vegetation may increase at the expense of herbaceous vegetation (called woody encroachment). Different mechanisms may be involved. For example, the decrease in grass biomass following grazing leads to a reduction in the number and intensity of fires, so that survival of young trees is enhanced.
3. Trampling by large animals, especially those with hooves compacts soil and degrades its structure. This reduces water infiltration into the soil, and leads to increased aridity and nutrient uptake. It can also increase runoff and consequent soil erosion and nutrient removal from the system.

This vegetation structure is determined by environmental factors, primarily water availability, soil nutrient availability, fire and herbivory. With the interaction between grasslands and animals, the existence of grasslands is made possible because without the grazing by animals, they will be colonized by shrubs quickly and become woodland. They occur in tropical regions where there is a transition between abundant rain and short-term drought within a one year period. To cope with such conditions, savanna organisms have developed a wide range of morphological, physiological and behavioral adaptations. Tropical grasslands are dominated by grasses, often 3 to 6 feet tall at maturity. They may have some drought-resistant, fire-resistant or browse-resistant trees, or they may have an open shrub layer. They develop in regions where the climax community should be forest, but drought and fire prevent the establishment of many trees. Tropical grasslands are found in tropical wet as well as dry climates. These areas are hot year-round, usually never dropping below 17 $^{0}$C. Although these areas are overall very dry, they do have a season of heavy rain. Annual rainfall is from

~20-50 inches per year. It is crucial that the rainfall is concentrated in almost four months of the year, followed by a long period of drought when fires can occur. If the rain were well distributed throughout the year, many such areas would become tropical forest. The seasonality of the climate also imposes a seasonal response in growth and senescence of the vegetation, particularly of the grasses. (Fig. 1 – a photographic time sequence from dry season to wet season and back to the dry season).The soil of tropical grasslands is porous, with rapid drainage of water. It has only a thin layer of humus which is the organic portion of the soil created by partial decomposition of plant or animal matter and it provides vegetation with nutrients.

**Physiological efficacy and taxonomy**

Grasses, members of family Poaceae, are among the most important extant clades of vascular plants. The group, which now inhabits all major land masses, exhibits a tremendous taxonomic richness (~11, 000 species), ranging from herbs to the treelike bamboos, and occupies warm and cold deserts to rainforests (Gibson, 2009). Grasses that grow best under warm and often dry conditions (warm-season) typically have $C_4$ photosynthesis system, and those that grow best under cool and generally moist conditions (cool-season) typically have $C_3$ photosynthesis. Due to having both photosynthesis pathways, the grass family has a wide range of adaptation to temperature and soil water conditions with one or more species being found in nearly every environment. There are nearly 700 genera and 18,000 species of legumes (Polhill and Raven, 1981). This group is second only to the grasses in providing food crops for agriculture. Legumes are widely used as food for man and as livestock forage, oilseed crops, soil improvement, wildlife habitat and beautification. Their symbiotic relationship with *Rhizobia* makes them valuable components in forage mixtures with grasses and in rotation with cereal grain crops to decrease dependency on fertilizer N.

Biotic introductions are also intermediate, because while mild habitat conditions facilitate establishment of invaders, existing levels of biodiversity constrain resource availability. Finally atmospheric changes in $CO_2$ will have a relatively high impact on grasslands because of the frequent mixed composition in terms of $C_3$ and $C_4$ species. After considering all mentioned interactions, grasslands were ranked in the upper half of the biomes studied, in terms of altered biodiversity. Thus, we can say that grasslands are the ecosystems where some of the largest changes in biodiversity are expected to be taking placed.

**Role of Grasslands**

Grasslands cover about 70% of the world's agricultural area (Soussana and Luscher, 2007). Their use in economically, environmentally and socially sustainable way is a major challenge faced by many countries. Clearly they play an important role in food production. However, there is increasing recognition of the need to approach grasslands from the viewpoint of 'multi-functionality' i.e. they are also important as sources of population among plants, particularly for livestock production, whilst at the same time delivering important ecosystem services and underpinning the tourism, amenity and leisure industries in many parts of the world. The changing considerations concerning the use and management of grasslands have been recently reviewed (Kemp and Michalk, 2007). Grassland ecosystems often comprise high plant species richness at fine scale and thus contribute to biodiversity conservation at larger scale (Gillet et al. 2016).

The conservation value of grasslands is becoming well known, although the mere presence of grass does not constitute conservation. The grasslands can be used for hay, silage, and pasture, when properly managed, they are exceedingly effective in controlling soil and water losses and in restoring the soil's capacity to take in and store moisture for use by other crop roots. Perennial grass and legume roots are effective in increasing the porosity and ventilation of the soil for all vital activities of the crop roots, and for the activities of beneficial micro and macro-organisms of the soil.

Grasses are Earth's most important crop plant (e.g., rice, corn, cereals) and supply humans with important building material (bamboo) and biofuels (e.g. *Panicum virgatum* - switch grass). Grass-dominated habitats, which encompass temperate grasslands, tropical savannas, and cropland, cover up to 40% of Earth's land surface (Gibson, 2009). Through unique ecosystem properties (e.g., high albedo, low carbon storage capability, high silica reservoir), grasslands exert strong influence on global climate as well as the carbon and silica cycles (Kidder and Gierlowski-Kordesch, 2005; Sage, 2004).

**Threats to the Grasslands**

The main threat to tropical grasslands is the increasing human population. Along with this, climate change, farming, overgrazing, irrigation, desertification, erosion, exotic plant species, etc. are other major threats to the tropical grasslands. Continued global warming could turn current marginal grasslands into deserts as rainfall patterns change. About 16% of tropical grasslands have been converted for agriculture or urban development. Desertification is being a significant threat, seems to appear from a mixture of climatic change and population growth. A number of exotic plant species have been introduced to the savannas around the world. Amongst the woody plant species are serious environmental weeds such as Prickly Acacia (*Acacia nilotica*), Lantana (*Lantana camara* and *L. montevidensis*). These introductions have the potential to significantly alter the structure and composition of grasslands, and have already done in many areas through a number of processes including altering the fire regime, increasing grazing pressure, competing with native vegetation and occupying previously vacant ecological niches.

Grassland biodiversity is negatively affected by two sources of land cover change: cropping and forestry. These activities differ in their impacts on ecosystem structure and function. Cropping changes above and below ground plant biomass in a sudden fashion, but it also promotes large changes in soil organic matter (Burke, Elliott and Cole, 1995). In contrast, forestry changes land cover more slowly, from a grass dominated to a tree dominated system. A forest dominated system changes the light environment, but can also change soil nutrient dynamics (Ong et al., 1991).

Biodiversity in grassland ecosystems is seriously threatened by human activity. Grassland ecosystems, in two of three possible scenarios of biodiversity change for the year 2100, appear to be the most threatened biome (Sala et al., 2000). Grasslands are most sensitive to land use change, which means the conversion into croplands that implies plowing of native grasslands and sowing of monospecific crop. This activity clearly results in the local extinction of all the native plant species that, in turn, determine the major characteristics of habitat of animals and microorganisms. Consequently land use change drives all plant species to local extinction and drastically affects the diversity of other organisms (Anderson, 2008).

Grassland “land use” includes all human activities involving grasslands. Grasslands have been and still are the central to the production of food and fibers for human use (Redman, 1999). Grasslands provide crucial grazing land and pastures for the domestic and migrated livestock, which forms important livelihood for the majority of the population in and around the grasslands. Sometimes because of overgrazing the grassland become barren and appears degraded not allowing the other herbaceous flora to come up. These degraded sites can be covered by supporting the natural process of regeneration and supplementing it through artificial regeneration of native species existing indigenously in the area. In order to allow the regeneration of the native species of this region a proper authentic documentation of the diversity of the species growing in this region is to be well analyzed. **In the present study, efforts have been made to document the diversity of grasses and other associated herbaceous species in the selected grasslands.**

The main land use in grasslands is agronomy and animal husbandry which involves four main activities:

- Extraction of resources (e.g. Mineral nutrients)
- Changes in energy and material transfer (e.g. Individual plant growth and mineralization)
- Changes in species composition (e.g. Addition of crops and weeds) and substances (e.g. Fertilizers)
- Changes in disturbance regime (e.g. Cultivation and grazing)

These activities introduce major changes in the structure and functioning of the grassland ecosystem. However, superimposed on land use changes, grasslands are experiencing changes in other drivers such as climate, atmospheric composition, non-planned species exchanges, and these changes combine to threaten ecosystem integrity on a global scale (Vitousek et al., 1997).

**Management**

The improvements that are possible by application of experimental and practical findings to grassland management are as spectacular and significant as for any type of crop production. The improvement of grasslands was limited to the attention given to hay crops until about 25 years ago. During the last quarter-century, recognition has been growing for the value of all pastures and ranges along with the possibilities of improving the total supply of feed, its seasonal distribution, and its nutritive value. Also, the opportunities for more effective utilization of the feed produced, by intelligent management of both grass and livestock, are now much more clearly realized by agricultural leaders. In spite of the accumulating knowledge derived from actual field experiments and the practical trials of farmers and researchers, the application of such knowledge to all grasslands is still not enough or is spotty. The nature of the improved treatments and management practices covers a very wide range. The importance of these grasslands to the nation is very great, and permanently productive agriculture must include the proper utilization and management of nearly million acres of grasslands as well as the million acres of all other harvested crops.

**Relevance of the Present Study**

Grassland is the focal point in many regions of Gujarat but successful management for production and biodiversity poses several dilemmas for conservationists and forest managers. 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. 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. Thus the present study is confined not only to the study of the grassland associations; it also includes the 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.

**Soils:** Throughout out the tract, the soil varies considerably in composition and constitution. Due to the mixed nature of granite and trap rock formations, the soils vary in fertility also. In general the Eastern areas have shallow sandy

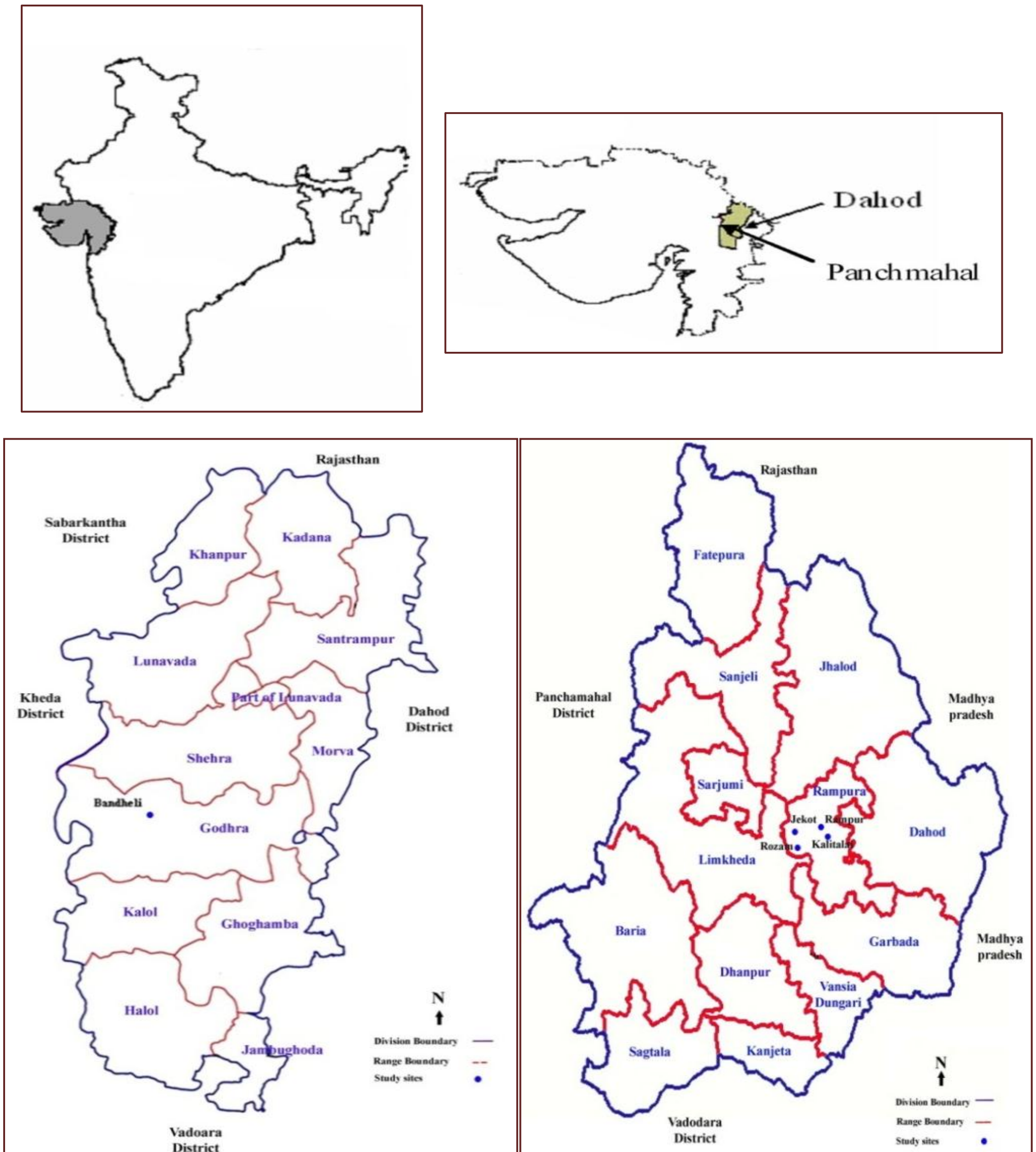



Figure 1.2 – Map of the Study area

soils whereas the Western areas have fertile soils. Near the Mahi river in the North-West of Godhra, the soil is alluvial; towards South of this, there is a belt of black soil. To the North-East of Godhra a rich medium black soil is seen. In Dahod, the soil is hard and murramy brown or red with little black soil and is not very fertile. In Baria taluka light gravelly (goradu) soil is the most common soil, black soil being rarer. In the tract as a whole, the soil can be classified as sandy loam, the proportion of sand and loam varying from place to place. The hilly areas have generally very shallow and poor soils and may be totally devoid of soils at many places.

**Climate and Rainfall:** The climate of the study area is characterized by hot summer and general dryness, except in the monsoon season. Rainfall is very irregular and erratic. It consists of few heavy showers, interspersed with long spells of drought. Northern areas of Godhra Forest Division receive less rainfall in comparison to Southern areas in general. Total rainfall varies widely from year to year and from place to place. There is scarcity after every two to three years particularly in the northern parts. The average rainfall in this division varies from 400 mm to 800 mm **(Gujarat Forest Statistics, 2010-2011).**

**Temperature:** Seasonal variation of temperature is very wide. During the past years, temperature ranges from 10 -45 $^{0}$C in Godhra Forest Division while it ranges from 7 – 46 $^{0}$C in Baria Forest Division. The climate is warm and uncomfortable during summer months. Generally, in the months following good monsoon, there is persistent heavy dew up to the end of February. This phenomenon plays an important role in the vegetative growth. **(Gujarat Forest Statistics, 2010-2011).**

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.

**Each Objective was achieved by following, proper methodology, scientifically collecting, analyzing and interpreting the data that is represented in the subsequent chapters separately.**

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