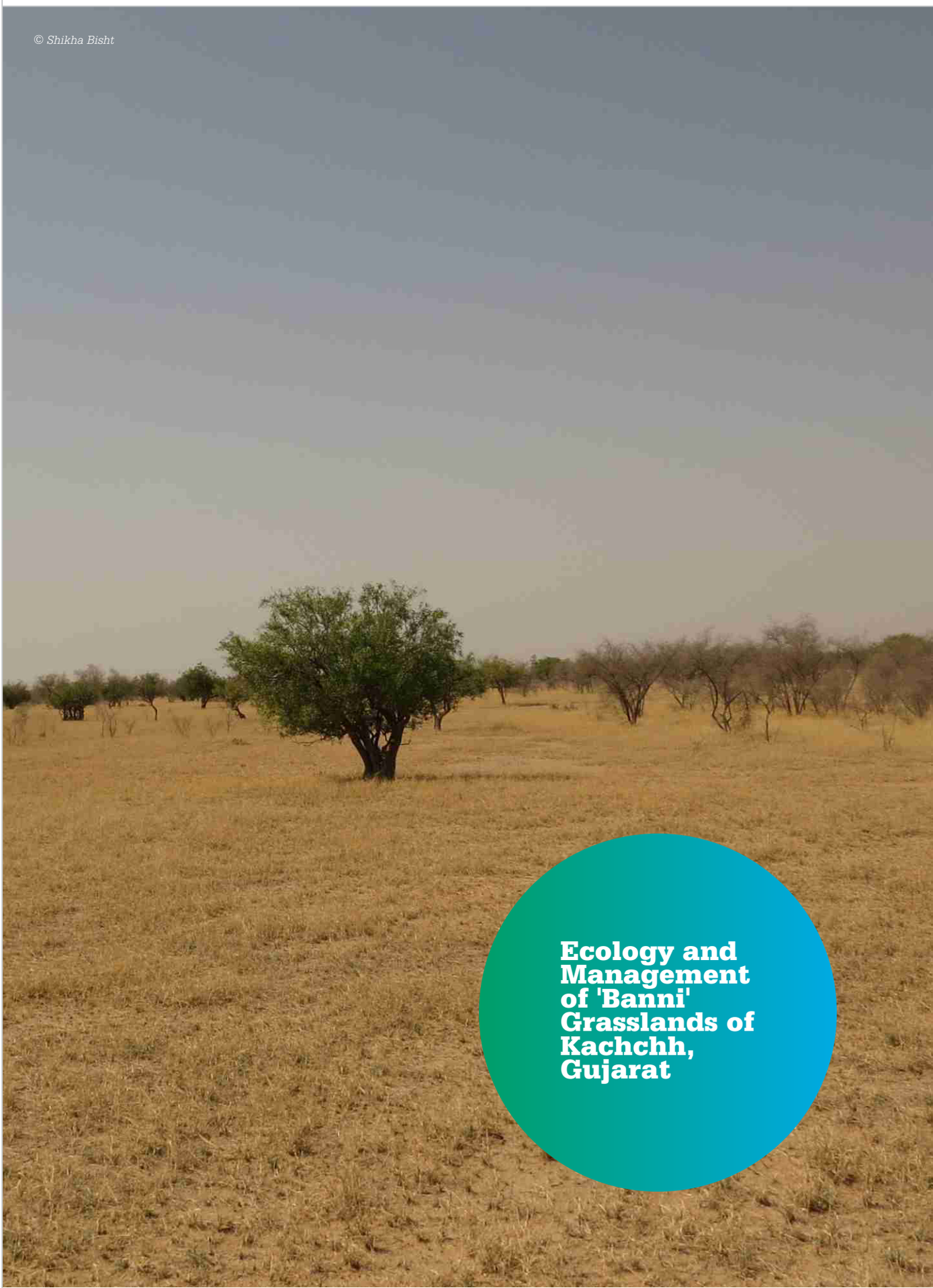

© Shikha Bisht

Ecology and Management of 'Banni' Grasslands of Kachchh, Gujarat

03

Abstract

Banni grasslands, located along the northern border of Kachchh district in the state of Gujarat, are among the largest stretches of contiguous grassland in India. These grasslands are spread over an area of ca. 2618 km^2, and account for approximately 45% of the pastures in the state. Consisting of two ecosystems in juxtaposition, viz., wetlands and grasslands, Bannis fall under *Dichahnthium-Cenchrus-Lasiurus* type of grass cover. These grasslands harbor a rich array of flora and fauna including 192 species of plants, 262 species of birds, several species of mammals, reptiles and amphibians. Traditionally, Banni grasslands were managed following a system of rotational grazing. With the disintegration of traditional management practices, these grasslands are degrading rapidly due to excessive pressure from livestock grazing and increased soil salinity leading to invasion of *Prosopis juliflora*, water scarcity, climate change and desertification. This article provides a review of current status in terms of biophysical features, land use practices, threats and long term management strategies of these grasslands.

Key words: Banni grasslands; Desertification; Kachchh; Livestock grazing; *Prosopis juliflora*.

Introduction

Grasslands are defined as land covered with graminoid vegetation having less than 10% tree and shr ub cover (White, 1983; House and Hall, 2000). Worldwide, grassland ecosystems are predominant in the areas of low-moderate annual precipitation, relatively thin soil, and naturally controlled by fire, grazing, drought and extreme fluctuation in temperatures (White et al., 2000). Much of the land surface in western India is characterized by such biophysical conditions which support one or other type of grassland, scrub savanna or savanna woodland. These habitats support a rich array of fauna, obligate to grasslands. In terms of land use, most of the arid and semi-arid grasslands have been used for livestock grazing by local communities since several centuries.

Kachchh district in the state of Gujarat is characterized by having vast stretches of saline desert, salt marshes and grasslands. The grasslands in this district are popularly known as 'Banni' which are spread over an area of ca. 2618 km^2 (SAC, 2002; GUIDE, 2007) and account for about 41% of the geographical area in the district. Flanked by Greater Rann of Kachchh in the north **(Figure 3.1)**, Bannis represent the largest stretches of contiguous grasslands in India. The word 'Banni' is derived from Kachchhi dialect, 'Bannai', which means freshly made, signifying the land that has been formed by detritus and sediments brought down by the rivers such as Indus, Luni, Banas and Saraswati, which in recent geological past, flowed through this area from the north and the east (Kadikar, 1994).

Banni region has a very fascinating history, geography, biodiversity and culture. Altogether, 13 different communities inhabit the area and vast majority belongs to the Maldharis who reside in 48 villages or 'wandh'. There is a traditional form of human-livestock-grassland interaction, which is still predominant in Banni. Maldharis have inherited traditional fresh water harvesting system known as Virda, traditional knowledge of medicinal plants and breeding drought tolerant highly productive livestock. The herders, especially the Maldharis of the area keep animals of superior breeds, supplying them to various parts of the state and even to other neighbouring states. However, due to establishment of milk co-operative societies, the people of Banni are inclined towards selling the animal products such as milk and butter. The Livestock of Banni area include cattle, buffaloes, sheep, goats, horses, donkeys and camel. There are two breeds of cattle, viz., Kankrej and Gir, of which Kankrej is the heaviest breeds of the Indian cattle and known for excellent drought resistance capacity.

V. Vijay Kumar*, Arunn Kumar Roy Mahato and Rohitkumar Patel

Gujarat institute of Desert Ecology,
Bhuj-Kachchh, Gujarat, India

*Email: vijay196129@gmail.com

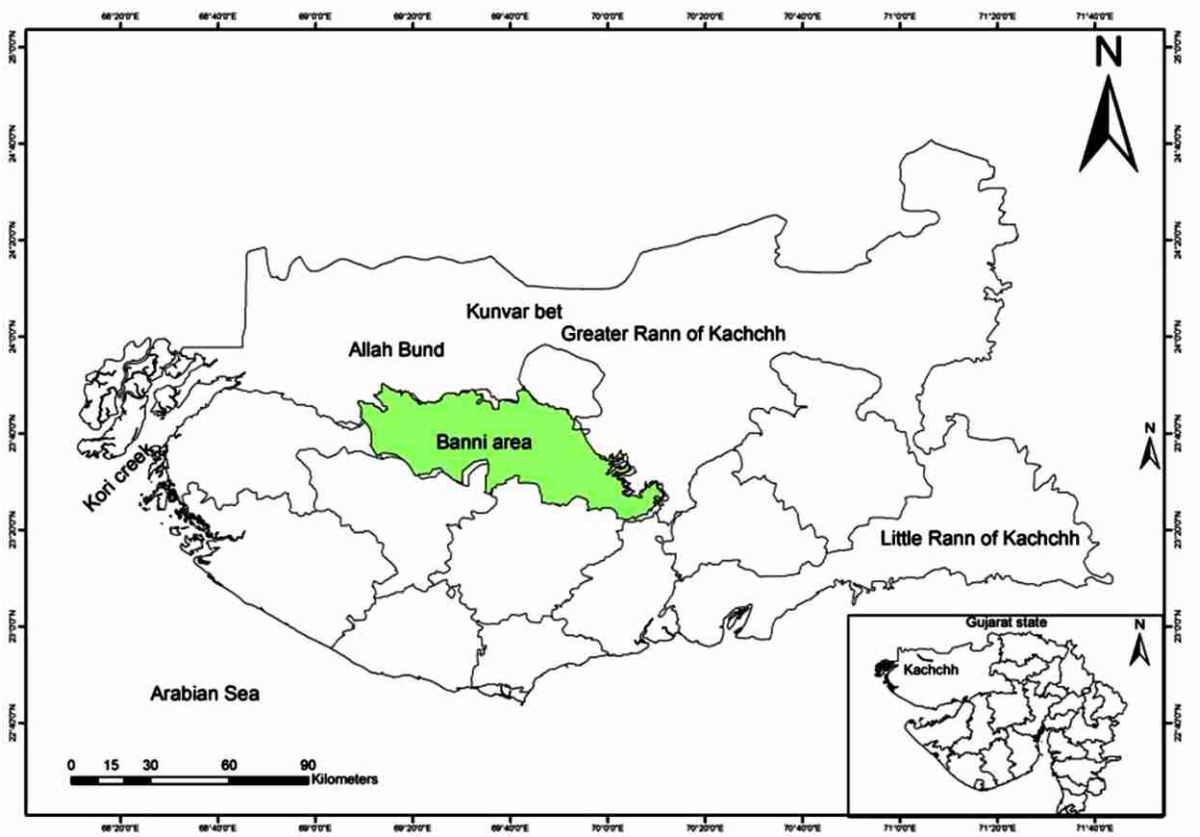

Figure 3.1. Kachchh District – Map Showing Location of Banni Grassland

Besides serving as a major grazing ground for the local herders, Banni grasslands serve as important habitat for a variety of wild fauna. However, unregulated grazing coupled with frequent droughts has led to degradation of Banni grasslands in recent decades. Several authors have raised concern over habitat degradation, desertification and increased salinity in and around Banni grasslands, e.g., Bhimaya and Ahuja (1969), Parikh and Reddy (1997), Singh and Jha (1992), Kanzaria (1994). Currently Kachchh district supports ca. 1.7 million heads of livestock which has increased from 9.40 lakh in 1962 to 17.02 lakhs in 2007 (GUIDE, 2010). This implies that these grasslands are the key to socio-economic growth in the state. Considering this, many government and non-government agencies have carried out investigations and suggested some remedial measures to improve the overall range condition of Banni (GoI, 1966; Ground Water Institute, 1974; ICAR, 1978; National Research Council, 1986; Soil Survey Division, 1986 and WRD and CDO, 1989). However, most of such recommendations were either never executed or were executed without an ecological approach. Therefore, rejuvenation of Banni and restoring it into a sustainable productive ecosystem calls for a holistic ecological approach.

This article deals with the ecological status of grasslands in western Gujarat with special reference to Banni grasslands of Kachchh. We present here a detailed account of its ecological status based on past studies by various agencies, recent assessments and suggest long term conservation and management strategies.

Biophysical Features of Banni Grasslands: An Overview

Banni grasslands consist of two ecosystems in juxtaposition, viz., wetlands and grassland. They provide habitat for resident as well as migratory birds, ideal conditions for many soil fauna and important habitat for typical grassland ungulates such as chinkara and blue bull (Plate 3.1). As per the classification of Dabadghao and Shankarnarayan (1973), Banni grasslands fall under *Dichanthium-Cenchrus-Lasiurus* type. Ecologically, these grasslands belong to the mid-successional/subclimax type of grasslands (Roy and Singh, 2013). The working plan of Kachchh Forest Division (1972) reveals that Banni was declared a 'Protected Forest' under section 29 of the Indian Forest Act (FCA), 1927, under the former Kachchh Government Notification No. HR/155/55 dated 11-5-1955, with an intention to manage the area under the jurisdiction of the State Revenue Department. The vegetation Banni of grasslands is dominated by grasses, few herbs, fewer shrubs and trees. Puri et al., (1959) made some observations on the grasses of Banni area and reported the

occurrence of 12 important grass species from Banni. They included the Kachchh grasslands under desert grasslands and reported that there was a patch of *Acacia nilotica* forest at Bhirandiyara, which is located at central part of Banni grassland. Patel et al., (1961) studied the effect of cutting treatments on the grass yield and chemical composition with reference to the nutritional value of grasslands in the Banni area. Plant associations were also reported at Dhordo village, which is located at western part of Banni where the major association recorded, was *Prosopis with Salvadora* species (Pandya and Sidha, 1982).

Patel, et al., (2012) recorded a total of 49 herbaceous plant species, being used as fodder by livestock. In which, the maximum numbers of 21 species were recorded in *Echinocloa* and *Cressa* habitat; followed by 20 species in *Sporobolus* and *Eleusine* habitat; and 19 species in *Desmostachya-Aeluropus* and *Cressa* habitat. A total of 21 highly palatable species were recorded from *Echinocloa-Cressa* communities followed by *Sporobolus-Eleusine-Desmostachya* (18 species) and *Aeluropus-Cressa* (17 species). Based on a detailed floristic study conducted by GUIDE (2010), it is revealed that there are at least 192 species of vascular plants in these grasslands belonging to 142 genera and 50 families in Banni Grasslands **(Table 3.1)**. These species represent herbs (89 species), shrubs (31 species), trees (17 species), twiners and climbers (12 species), grasses (37 species) and sedges (6 species).

Table 3.1: Floral Diversity of Banni (Source: GUIDE, 2010)

Order	Monocotyledon	Dicotyledon	Total
Family	3	47	50
Genera	28	114	142
Species	45	147	192

The shrub and tree strata mainly consist of *Prosopis cineraria, Acacia* spp., *Salvadora* spp., *Capparis decidua, Tamarix* spp. *Prosopis juliflora*. Density of *P. juliflora* ranges from 96 to 1450 plants per hectare across Banni villages (GUIDE, 2010 and Patel et. al. 2012). The average density recorded during winter in western Banni was 668 individuals/ha, 858 individuals/ha in central Banni and 560 individuals ha^{-1} in eastern Banni. Altogether more than 37 grass species were recorded, some of the perennial and palatable grass species with high productivity being Sporobolus, Dichanthium, Cenchrus and Eragrostis. During the period between 2008 and 2012, the biomass studies were carried out in Banni grassland. It was found that total productivity was 3096.16 kg/ha of which only 33.06 per cent (1023.66 kg/ha) was of palatable, while rest was unpalatable. Of this, the productivity of palatable grass species was 483 kg/ha while that of herbs was 539.45 kg/ha (GUIDE, 2004).

Total 262 species of birds belonging to 153 genus of 51 families under 14 orders of Aves were recorded in Banni during the period between 2009 and 2011. Among the recorded birds, 118 were resident to Banni, 76 species were resident and rest of 68 species were migratory. On analysing the feeding habitats of recorded birds, it was found that, 87 species were insectivorous, 69 species omnivorous, 68 species carnivorous, 20 species granivorous, 15 picivorous, 2 species frugivorous and one nectarivorous species. According to the Indian Wildlife (Protection) Act, (1972), 3 species of the total recorded birds fall under Schedule I, Part III and rest of the 259 species belong to Schedule IV. Among the total recorded species of birds, 4 species are Critically Endangered category (CR), one species in Endangered (EN), 8 species under Vulnerable (VU), 11 under Near Threatened (NT) and rest of 238 species under Least concern (LC) category of IUCN Redlist 2011. Further, among the recorded species of birds, 166 species are terrestrial whereas rest of 96 species were aquatic (GUIDE, Unpublished data). Herpetofauna in Banni grasslands include five species of amphibians and 13 reptiles belonging to 13 families. Common species seen in these grasslands are *Naja oxiana* (Black cobra), *Trapelus agilis* (Brilliant Ground Agama), *Uromastrix hardwickii* (Spiny tailed lizard) and *Varanus bengalensis* (Bengal monitor lizard). The seven species belong to two suborder Souria (agamids) and serpent (snakes), they are reported under the family Agamidae (lizards), Scinsidae (skinks), Boidae (*Erix jhonii*) and Colubridae (*Tyas mucosus*). A total of six individuals of *Ophisops jerdoni* was recorded from *Suaeda* Scrub and also recorded in *Suaeda-Prosopis* and *Salvadora-Prosopis* habitats. *Uromatrix hardwikii* was recorded from five different habitats i.e. dense *Prosopis, Prosopis-Capparis, Prosopis-Suaeda-Callotropis* mix, *Suaeda-Prosopis* and *Suaeda* scrub. One individual of snake species, i.e. *Erix jhonii* was recorded in dense *Prosopis* habitat. The *Prosopis-Capparis* mixed forest had only one lizard species of *Calotes versicolor* and one snake species *Tyas mucosa*.

A total of 12 species of mammals belonging to 9 families were recorded in Banni area. They include 6 species of carnivores and 2 species of herbivores. The species recorded are *Gazella bennetti* (Chinkara or Indian gazelle), *Canis*

lupus (Indian wolf), *Canis aureus* (jackal), *Boselaphus tragocamelus* (Nilgai), *Hyaena hyaena* (striped hyena) and *Vulpes bengalensis* (Indian fox).

Pattern of Habitat Use by Wildlife and Domestic Livestock

A study on the distribution pattern and habitat ecology of birds in Banni was conducted by GUIDE (Koladiya et al., 2014). A total of 91 species were recorded in various habitats of Banni grassland in which, 45 species in were recorded dense *Prosopis*, 56 in moderate *Prosopis*, 60 in sparse *Prosopis*, 28 in *Prosopis-Capparis* mixed, 50 in *Prosopis-Suaeda-Calotropis* mixed, 30 in *Prosopis-Salvadora* mixed and 40 in *Suaeda* dominant. Among the 7 habitats, sparse *Prosopis* habitat harbours diverse bird species with lowest mean population density of 9 individuals/km^2 whereas *Prosopis-Capparis* was the least preferred by the bird species. Thus, bird species diversity and their population density varied among various heterogeneous habitats of Banni grassland both in time and space.

On analysis of seasonal distribution of bird species in 7 identified habitats of Banni grasslands, it was found that sparse *Prosopis, Prosopis-Suaeda-Calotropis* and dense *Prosopis* were the preferred habitat during monsoon season; moderate *Prosopis*, dense *Prosopis* and *Suaeda* dominant are the preferred habitat during winter season while moderate *Prosopis* and *Prosopis-Suaeda-Calotropis* are the most preferred habitat during the month of summer. Mean population density (Mean ± SD) of birds was recorded highest during monsoon season (19.49 ± 4.64) and least density during summer season (4.12 ± 0.98). It was found that the highest population density of birds found in *Prosopis-Capparis* mixed habitat (29 individuals km-2) during monsoon and least density recorded in sparse *Prosopis* habitat (2.8 individuals km^{-2}) during summer season.

The livestock owned by Maldharis generally graze within or around the vicinity of village and have definite grazing routes. Cattle mainly feed on grasses in low to moderate saline areas while buffalo sustain with *Suaeda* which grow in high saline areas. Livestock and wild herbivores share the same habitat for grazing which may overlap at some places.

Key Drivers of Change

Banni, though declared as a protected forest in 1955, till recently was under the administrative control of the State Revenue Department. However, today the scenario has changed and the management control of Banni has been transferred to the State Forest Department. A detailed working plan for Banni was prepared for effective management of Banni (GUIDE, 2010). With the working plan in place, the management of collection, manufacture and removal of the forest produce, cutting of grasses and livestock grazing are being regulated. However, Banni grasslands continue to face degradation. Main drivers of change include increasing soil salinity, invasion by *Prosopis juliflora*, grazing pressures, water scarcity, climate change and desertification. These drivers are discussed below:

Soil Salinity

The soil of Banni is alluvial and sandy with inherent salinity. The soil salinity is highly variable from 1.0 to >15.0 M mhos/cm and the pH ranges between 6.5 and 8.5. About 60% soil consists of moderately fine texture with higher proportion of silt and clay (Singh and Kar, 2001). As a result, 70 per cent area of Banni falls under very slow to slow permeability range (0.00 to 0.13 cm/hr), which along with low elevation (without any gradient) causes flooding and water logging in many parts of Banni during rainy season (GUIDE, 1998).

Though the inherent salinity was existing during the early days in Banni, the rivers (Khari, Bhurud, Nara, Kalia, Kaswati and Panjora), which were flowing from the Kachchh mainland to Banni were not only depositing the detritus but also leached the salinity of the area during good rainfall years. Therefore, the salinity was not a serious problem in earlier days. Six medium dams namely Rudramata, Nirona, Nara, Kaila, Kaswati and Gajansar were constructed after 1960 along the rivers which completely stopped the fresh water flow into Banni and reduced the nutrient supply and leaching of the salinity except during very heavy rainfall years (GUIDE, 1998).

In addition to this, the Greater Rann has a depressed terrain lying between Banni and the Allah-Bund, which extends from the Kori creek eastwards up to Kuver bet, has been inundated by tidal waters of the Arabian Sea through the Kori creek. This has resulted in salinity ingression in about 12 out of 48 villages located along the nor th-western fringes of Banni. The spread of saline area in Banni is rapid during the recent years, about 50 per cent of the area contains very high (>15 M mohs/cm), 40 per cent moderate to high (3-15 M mohs/cm) and 10 per cent area facing low salinity (1-3 M mohs/cm) problems (GUIDE, 1998). In addition to these, the ground water in Banni is old sea and is unsuitable for any agricultural purposes except adding soil salinity through capillary actions and evaporations.

Further, break down of traditional management systems of the Banni people also forms a major problem in the increase of salinity of the area. During the earlier days, the dung of the grazing livestock was naturally ploughed back into the Banni soil that worked as the best natural manure and it also reduced the salinity of the area to some extent. However, of late, the farmers from Kachchh mainland have been buying cow dung from Banni in large quantities and carrying it to distant place from Banni. This has resulted in disruption of natural mineral cycling and decreased the soil fertility.

Such soil conditions with high level of salinity, low nutrients, low permeability and water logging minimize the potentiality of the area in terms of agricultural production and therefore grassland-based animal husbandry remains the only viable economic option in this area.

Invasion of *Prosopis juliflora*

The period 1960-61 was an important benchmark year in the ecological and socio-economic history of the Banni area when Gujarat State Forest Department took one of the major management interventions to stop the advancement of Rann on the northern fringes of Banni. As a follow-up of the recommendations of 3rd Planning Commission of Government of India, an area of about 31,550 ha was planted with exotic woody species, *Prosopis juliflora* for its ability to establish and survive in the saline soils and low moisture regimes, without evaluating its ecological and associated socio-economic consequences in the future.

The soil salinity situation favours hardy *P. juliflora* which has largely invaded into the ravines and wastelands in Gujarat (Pasiecznik et al., 2001). Though *P. juliflora* is able to thrive moderate (4-8dS/m) to strong (8-15dS/m) saline soils (density 970 individuals ha-1), their growth is better in non-saline or low saline soils (density 2,440 individuals ha-1) and this could be one of the major reason for its invasion into pristine grasslands (Deepa and Lakhmapurkar, 2009).

This is one of the major reasons for its invasion into the pristine grasslands of Banni. Further, the diversity of natural vegetation is low and includes species like *P. cineraria, Capparis decidua, Acacia nilotica* and *Salvadora* spp. These species occur in very few pockets in Banni and their density is low which could not be projected. This clearly indicates the replacement of native vegetation by *P. juliflora*. The principal factor in the process of invasion is the rapid and prolific seeding of mature *P. juliflora* (Zimmerman, 1991) and then facilitated by a curious reciprocal relationship with cattle. During late summer, in the absence of any grass or herbs, nutritious pods of *P. juliflora* forms a greater portion of diet of cattle and buffaloes.

Mature *P. juliflora* could produce ca. 630,000 to 980,000 seeds tree^{-1} year^{-1} (Felker, 1979) and Shukla et al., (1984) reported average pod production capacity as 20 kg/tree. As per Deepa and Lakhmapurkar (2009), average density of *P. juliflora* in all soil conditions is 2053 trees ha^{-1} in Banni. With the existing coverage, the P. juliflora has the capacity to produce 32, 99,446 Tons of pods per year (41 tons ha^{-1} year^{-1}). The seeds of *P. juliflora* have a thick seed coat that necessitates a treatment for quick germination otherwise, it takes long-time to disintegrate the seed coat and germinate under natural conditions. However, when livestock consumes the pods of *P. juliflora*, the seeds get required treatment in the digestive tract of livestock and the animal eventually void the seed through their excrement, frequently a considerable distance from the parent plant. The seeds, still viable, and well fertilized with adequate moisture (cow dung), show a surprisingly high germination rate. The ensuing southwest monsoon in Kachchh that is during late June or mid July supports the treated seeds for recruitment and regeneration.

As per an estimate, cattle defecate 14 times per day (Weeda, 1967) and taking this into account, 60,417 livestock in Banni (Census, 2007; GUIDE, 2010) alone would defecate over 8, 00, 000 times/day and possibly at different locations. This highlights an alarming rate of distribution of treated *P. juliflora* seeds in the Banni area. Further, use of stem as fuel wood by rural folk involves frequent lopping, upon which the root mass enlarges with rich food reserves, aiding rapid and robust regeneration. Further, trials conducted in many parts of the world and in India proved that the eradication of P. juliflora is impossible due to its hardy nature, root morphology and physiology and high level of coppicing capacity.

A study conducted by Space Application Center highlighted the spread of *P. juliflora* at the rate of 2,670 ha. year^{-1} during the period between 1980 and 1988, while it was 4,800 ha. year^{-1} during the period between 1988 and 1998 (Jadhav et al., 1992 and 1998). The results clearly showed the dominance of *P. juliflora* in Banni (86,569 ha) and a comparative analysis showed that during 1997 it occupied about 6.16 % of the total area of Banni increasing to 33.07 % in 2009. Sastry et al., (2003) reported that *P. juliflora* is expected to cover 56.42 % of Banni by 2020. Moreover, decrease in the *P. juliflora* with other vegetation by 74,012 ha. has indicated an aggressive encroachment of *P. juliflora* with the decline of native flora (Table 3.2). Further, the ratio of matured and recruitment category of *P. juliflora* estimated was 1:3 ratio (GUIDE, 2004) in Banni, which highlights the fact that if undisturbed or unmanaged, there could be an increase by three folds. Due to invasion of *P. juliflora*, most of the grassland area has already been turned into woodland and further increase of this species eventually reduce the grassland area of Banni. The pastoralists of Banni have adapted to these changes in plant species composition (due to *Prosopis* invasion), with major changes in livestock composition - principally shifted from more susceptible cattle to sturdy buffalo.

Besides, the area under *Suaeda* scrub and barren land has also increased by 15,684 ha (26 %) at the rate of 1,206 ha year^{-1} indicating an increase in soil salinity levels in Banni during the past 13 years.

Table 3.2. Major Landuse Classes in Banni (Percentage values given in parenthesis)

S. No.	Major Land Use Classes	Area (in ha) in 1997	Area (in ha) in 2009	Change in Area (in ha) 1997-09	Change in Area (in ha) 1997-2009	Per year Change in Area (in ha) in 1997-09
1	*P. juliflora* Dominant area	16,134 (6.16)	86,569 (33.07)	70,435	436.56	5,418
2	*P. juliflora* with other vegetation	1,17,879 (45.03)	43,867 (16.76)	-74,012	62.79	-5,693
3	Grass with sparse *P. juliflora*	51,396 (19.63)	44,091 (16.84)	-7,305	14.21	-562
4	Suaeda scrub (including Barren land)	60,889 (23.26)	74,998 (29.25)	15,684	25.76	1,206
5	Water bodies	15,474 (5.91)	10,672 (4.08)	-4,802	1.03	-369
	Total area	**2,61,772 (100)**	**2,61,772 (100)**			

Disintegration of Traditional Regulation on Livestock Grazing

During the period of princely rule (before 1947), the then Maharao declared Banni, with an area of 2,144 km^2 as a reserve grassland (Rakhal), where grazing by milching cattle and buffaloes was only permitted while sheep and goats were strictly prohibited. Further, the then Maharao did not permit Maldharis and Banniyaras (residents of the Banni) to settle in Banni. Hence, nomadic pastoral practices had prevailed for many years (Ramsingh Rathod, *Pers. Com.*). However, the situation has changed today and the Maldharis of Banni have adopted sedentary mode of pastoralism thereby exerting a constant pressure on the resources.

The traditional practices of regulated livestock grazing have disintegrated in the area and it has been seen that different species of livestock from other parts of the state and neighbouring states gained free entry into the area totalling to over 2 lakh livestock immigrate into Banni for grazing (GUIDE, 1998). Moreover, there is neither a declared grazing policy nor any systematic programme on improvement of grasslands in the state.

It is to be noted that, the water holes (Virdas) of the Banni villages played an important role in regulating the livestock grazing of an area. The grazing of livestock from one village to the boundary of the other was controlled only by banning the use of water to them. In the adverse climate, it is near impossible for the livestock to move over longer distances without adequate supply of water. Thus, the grazing of the livestock was permitted only within the vicinity of their village settlements. Today the scenario has changed and water, is no longer a factor, which governs the livestock grazing due to slacken in the use of virdas and water supply through pipelines. The 600 km long network of Banni pipeline is damaged by the Maldharis at places for providing drinking water to their livestock. This has also encouraged the massive immigration of livestock from other areas, thus, leading to overgrazing and degradation of the area. Heavy grazing coupled with stochastic events (temporary droughts, changes in soil conditions) may convert perennial vegetation into ephemeral vegetation (Christina, 1992). This situation leads to loss of soil cover, which further aggravates the degradation of the area. Among the three regions (east, west and central) of Banni, the eastern Banni has already lost its capacity and the western Banni is slowly losing its capacity to sustain both human and livestock populations. As a result, a maximum concentration of human and livestock population is located at central Banni region (GUIDE, 1998), exerting excessive pressures in this area which may lead to massive degradation due to over exploitation of resources.

The livestock population in Banni was 25,555 in 1977 which increased to 60, 417 in 2007. Overall animal composition in Banni has increased from 21939 ACU (Adult Cattle Unit- 1 Adult Buffalo is equallent to 4 Goats or 4 Sheep) in 1977 to 57898 ACU in 2007. The ACU has increased by 164 percentage which subsequently enhance the fodder demand from 153 tonnes/day in 1977 to 405 t day^{-1} in 2007 (7kg/ACU/day, as per Ahuja, 1994) highlighting a minimum fodder requirement of 1,47,825 t $year^{-1}$. Shrinking grassland due to invasion of *P. juliflora*, increasing salinity, and thereby decreasing the grassland area and its productivity has a cumulative impact on livestock based sustenance of Maldharis in Banni.

Climatic Factors

The climate of Kachchh is typically arid that experiences scanty and highly erratic rainfall with an average annual rainfall of 335 mm with high coefficient of variation. Drought is one of the most important natural phenomena

responsible for grassland degradation in Kachchh. However, through process of evolution, grass species have adapted to drought conditions that enable them to survive as a species, even though individual plants may succumb. Nevertheless, a severe drought causes drastic deterioration of the plant community regardless of severity of grazing pressure. Once the dry spell ends, the grassland recovery depends upon precipitation (moisture availability).

During the period between 1932 and 2013 (a span of 82 years), Kachchh district experienced a total of 48 drought years (59% of the period between 1932 and 2013) in which 26 years faced severe to very severe droughts. It is important to note that the number of severe droughts as well as severe consecutive droughts is on an increasing trend. Two consecutive severe droughts occurred during 1963-1964 and 1968-1969 followed by three consecutive droughts during 1972-1974 and 1985-1987, followed by four consecutive droughts from 2004 to 2007 **(Table 3.2)**. This situation predominantly affected the soil moisture and led to grassland degradation. Prolonged droughts affect the soil water balance and soil organic matter affecting biodiversity of soil biota. Soil stability may well decline as organic matter decreases, resulting in slower warming in summer, and also increased runoff and erosion (Bridges, 1997). Thus, soil and climate, the two of the most critical environmental parameters of life on earth are intimately interrelated and brought together. These factors have contributed to the deterioration of a major part of the grasslands of Banni as well as in Kachchh.

A recent study (between 2012 and 2015) by GUIDE assessed the impact of climate change on livelihoods in Kachchh including Banni. In which 403 respondents were interviewed through a structured questionnaire **(Figure 3.2)**. Majority of 43.7% of the respondents stated that the climate change is impacting on grasslands while 27.8 per cent of the respondents stated that animal husbandry will be impacted. A total of 75 per cent respondents stated that climate change is impacting animal husbandry and grasslands which is one of the prime livelihood resources for the inhabitants of Kachchh.

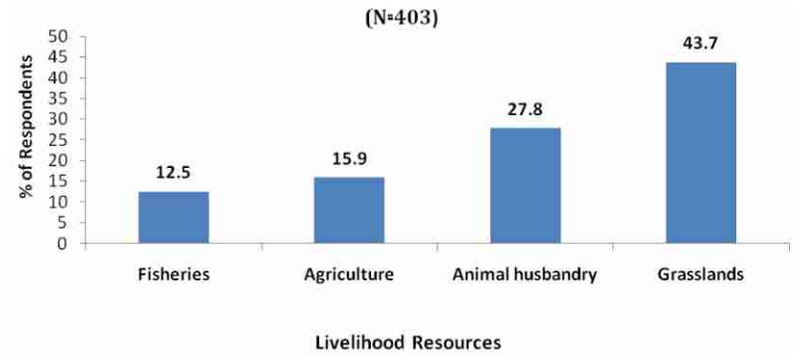

Figure 3.2. *Impact of Climate change on livelihood resources as perceived by local people around Banni Grasslands*

Another interesting fact is the occurrence of heavy rainfall in a single day that has increased drastically during recent years. The **Figure 3.3** highlights that the heavy rainfall days has increased from 1 day in a year during the period between 1973 and 1980 to 3 days in a year between 2001 and 2013. During the period between 2001 and 2013, very heavy rainfall (124.5 to 244.4mm) occurred 6 times, heavy rainfall (64.5 to 124.4mm) occurred 11 times and rather heavy rainfall (35.6 to 64.4mm) occurred 26 times in Kachchh **(Figure 3.3)**.

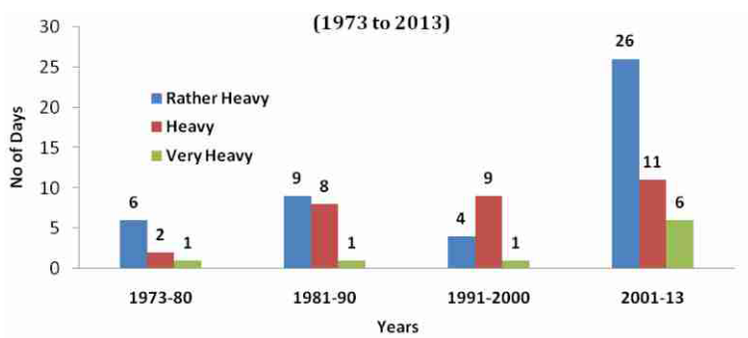

Figure 3.3. *Rainfall pattern in Kachchh from 1973-2013 (Source: GUIDE)*

Banni soil consists of recent alluvium mixed at places with aeolian sandy deposit and the entire area has deep to very deep clay and coarse textured soils in discontinuous patches. The presence of high silt and clay content lessen the vertical and lateral movement of surface and subsurface water and creates water-logging and flooding in low lying areas after monsoon (GUIDE, 1998). Thus the recent heavy rainfall in a single day creates water logging in low lying areas of Banni for number of days. The grasses and grass seeds submerged under water for long duration would decay or fail in germination. Flooding may also increase the incidence of soil-borne fungal diseases (Yanar et al., 1997.

Management Options

The degradation of Banni grasslands is largely attributed to breakdown of traditional resource management system which had helped in the maintainance of equilibrium between environmental system and human activity since several centuries (National Research Council, 1986). Recent interventions such as introduction of *P. juliflora*, introduction of additional livestock have led to reduction in carrying capacity of these grasslands. There is a need to improve the productivity of the existing grassland resources and also reclaim or restore the degraded grasslands to a possible extent. This would enhance the sustainability of the system and help in copping up with the increasing demands from the human and livestock sector. It is essential to maintain fewer and better breeds of livestock to avoid over grazing. This not only reduces the pressure on grassland and maintenance cost of the animals, but also generates sizeable income to the Maldharis. Development of grassland area for fodder security and grazing regulations are essential for maintaining the grassland in a sustainable manner. Appropriate management plan is required for managing *P. juliflora* as an alternative livelihood options and employment generation in Banni and Kachchh. *P. juliflora* has many economic values; pods (after removing the seeds) are highly nutritious which could be used to prepare cattle and human feeds. The seasoned wood of matured *P. juliflora* of more than 20 years old tree is comparable with teak wood for making essential household furniture. Further, being a leguminous plant, apart from enriching soil nitrogen content, it also reduces soil salinity and alkalinity to some extent.

Research to identify suitable remedial measures to control the soil salinity is the need of the hour. This is a core problem for all other issues including expansion of *P. juliflora* and barren lands as well decreasing grassland diversity and its productivity. Drains to leach soil salinity and introduction of saline tolerant grass/herbs would be an option under the scenario. In drought years, the fodder situation worsens which results in large quantities of fodder being imported by the government agencies. The main focus of the government agencies is to provide relief supplies to relieve immediate suffering as though the conditions involved were the result of true natural disasters that were unpredictable and basically temporary in nature. No effort is made to evolve strategies for permanent solutions. In addition, the livestock is forced to migrate to other parts of district or state, which leads to a host of new problems. During high rainfall years, it is flood that affects the animal and human beings and many times causes various diseases, fodder problems, shelter problems, etc. Appropriate disaster management for Banni region is essential to tackle during such calamities.

GUIDE, GEC and GSFD have initiated many grassland development programmes. The programmes need to be strengthened to cover more areas under restoration and undertaken through active participation of local villagers. This apart from fodder security generates employment opportunities to local villagers, enhance the land quality and improve the biodiversity.

To conclude the grassland degradation in Bannis is largely due to lack of management policy or failure of the policy. It is a prerequisite that the planning and policy needs to be integrated using the scientific and local knowledge for developing and utilizing the resource in a sustainable manner. The Banni working plan (2012) is in place and a separate Banni division was formed under the Kachchh Circle of the Gujarat State Forest Department. The forest law and regulation would help in better management of collection, manufacture and removal of the forest produce, cutting of grasses and pasturing of cattle, hunting, etc. However, appropriate awareness and cooperative approaches should be initiated to make this successful.

Plate 3.1: An overview of a grassland

References

Ahuja, L.D. (1994). Livestock production pasture/grass lands in the Indian Arid Zone. Pp: 179-190. In: Sustainable development of the Indian Arid Zones. (Eds.) R.P. Singh and S. Singh. Scientific Publishers, Jodhpur. 335 Pp.

Bharara, L. P. (1993). Socio-economic aspects of Banni pastoralists and factors effecting changes in their perceptions towards the future. Pp 1-7. Proceedings of the workshop on Transhumant pastoralism in Gujarat, July 24-25, 1992 (Cincotta, R.P. and G. Pangare, eds.). Institute of Rural Management, Anand, India.

Blatter, E. J. (1908). On the Flora of Kutch. Journal of Bombay Natural History Society, 18: 756-777.

Blatter, E. J. (1909). On the Flora of Kutch. Journal of Bombay Natural History Society, 19: 157-176.

Bridges, E.M. (1997). World Soils. 3rd Edition. Cambridge University Press, Cambridge.

Christina, S. (1992). Dynamics of savanna ecosystems. Journal of Vegetation Science. 3: 293-300.

Clements, F. E., and Shelford, V. E. (1939). Bio-ecology. John Wiley & Sons, Inc., New York, N.Y. 425 Pp.

Dabadghao P.M. and Shankarnarayanan KA. (1973). Grass cover of India. Indian Council of Agricultural Research, New Delhi, India.

Davison, E. M. (1997). Are jarrah (*Eucalyptus marginata*) trees killed by *Phytophthora cinnamomi* or waterlogging? Australian Forestry 60: 116-124.

Deepa G. J. and Lakhmapurkar, J. J. (2009). Soil Salinity versus *Prosopis juliflora* Growth – A Case of Banni Grasslands. Proceedings of the National Symposium on Prosopis: Ecological, Economic Significance and Management Challenges, February 20-21, 2009, Gujarat Institute of desert Ecology, Bhuj-Kachchh.

Felker, P. (1979). Mesquite. An all purpose leguminous arid land tree. In: G.A. Ritchie (Editor), New Agricultural Crops. Westview Press: Boulder, CO.

Ferrouki, L. (1994). An ecological ground water harvesting system under threat. A case study of the Banni pastoralist's knowledge in the grasslands of Kachchh district, Gujarat state, India. M.Sc Dissertation, Dept. Of soil sciences, Swedish University of Agriculture.

Gadgil, M. and Meher-Homji, V. M. (1985). Land use and productive potential of Indian Savanna. (ed. By J. C. Tothill and J. J. Mott), Australian Academy of Science, Canberra, 107-113 pp.

Gadgil. M. and Sinha, M. (1985). The biomass budget of Karnataka, In C. J, Saldanha (ed.) Karnataka state of Environment Report, 1984-85, Centre for Taxonomic studies, Bangalore, 19-30 pp..

Garwood, N.C., Gores, D.P. and Brokaw, N. (1979). Earthquake-caused landslides: a major disturbance to tropical forests. Science 205: 997 – 999.

GIAP (1989). Kachchh and its agriculture: Problems and potential. The Gujarat Institute of Area Planning, Ahmedabad.

Government of India (1966). Report on the Reclamation and development of the Great Rann of Kachchh. A report submitted to the Ministry of Agriculture, Govt. of India.

Groombridge, B. (ed.) (1992). Global Biodiversity, status of Earth's living resources (complied by World Conservation Monitoring Centre). London, UK: Chapmen and Hall.

Ground Water Institute, Pune (1974). Report on preliminary survey of ground water resources. - For providing drinking and / or irrigation water to Banni area of Bhuj taluka, Kutch district.

GUIDE (1998). Status of Banni Grassland and exigency of restoration efforts, Gujarat. Gujarat Institute of Desert Ecology, Bhuj. 66 pp.

GUIDE (2004). Grassland action plan for Kachchh. Final report submitted to Gujarat Forest Department, Gandhinagar. Gujarat Institute of Desert Ecology, Bhuj. 346 pp.

GUIDE (Gujarat Institute of Desert Ecology) and GSFD (Gujarat State Forest Department) (2010). An Integrated Grassland Development in Banni, Kachchh District, Gujarat States. Progress Report, Gujarat Institute of Desert Ecology (GUIDE), Bhuj - Kachchh (Gujarat), India.15 pp.

House, J.I. and Hall, D.O. (2000). Tropical savannas and grasslands. In Mooney, H., J. Roy, and B. Saugier (eds.) Terrestrial Global Productivity: Past, Present and Future.

Indian Council of Agriculture Research (1978). Report of the ICAR committee on Research and Development Programmes in the Kachchh district (Gujarat). ICAR, New Delhi.

Jadhav R. N., Sastry K. L. N., Thakker P. S. and Chavan S. A. (1998). Bio-diversity threat through exotic sp., using remotely sensed data. A case study of Banni (Kachchh) Gujarat.

Jadhav, R.N., Kimothi, M.M. and Kandhya, A.K. (1992). Grassland mapping / monitoring of Banni, Kachchh (Gujarat) using remotely sensed data. Land Resources Division, Remote Sensing Application Group, Space Application Center. Ahmedabad.

Kadikar, P. (1994). Status of Banni (Kachchh, Gujarat) grassland by 2000 AD using Multitemporal remote sensing satellite data. Dissertation. Gujarat University, Ahmedabad.

Kanzaria, M.V. (1994). Soils of Kutch-An ecological perspective. In: A dossier on Kachchh. Proc. of workshop, 20-21st January, 1994 at Bhujodi; Organized by GEC and VRTI.

Kempa, D. R., Guodongb, H., Xiangyangc, H., Michalkad, D. L. Fujiange, H., Jianpingf, W. and Yingjung, Z. (2013). Innovative grassland management systems for environmental and livelihood benefits. Proceedings of National Academy of Science, 110(21): 8369–8374.

Koladiya, M. H., Mahato, A. K. R., Gajera, N. B. and Patel, Y. S. (2014) Distribution pattern of birds in Banni Grassland of Kachchh district, Gujarat, India. Journal of Research in Biology 4(1):1228-1239

Leafe, E. L. (1988). The history of improved grasslands. In M. B. Jones and A. Lazenby. Chapmann and Hall (Eds.) The Grass Crops. 1-20 pp.

National Research Council (1986). Proceedings of the conference on common property resource management. Washington, D.C. National Acadamy Press.

Pandya, S.M and Sidha, V.K. (1982). Ecological studies of arid regions of Kutch (Gujarat State). Final Progress Report, Dept. Of Biosciences, Saurashtra University, Rajkot.

Parikh, J. and Reddy, S. (1997). Sustainable regeneration of degraded lands. Tata McGraw- Hill Publ., New Delhi.

Paroda, R.S., Mann, H.S. and Verma, C.M. (1980). Management of Indian arid land. CAZRI, Technical Bulletin, No 4. Jodhpur.

Pasiecznik, N.M., Felker P., Harris, P.J.C., Harsh, L.N., Cruz, G. Tewari, J.C., Cadoret, K. and Maldonado, L.J. (2001) The *Prosopis juliflora -Prosopis pallida* Complex: A Monograph. HDRA, Coventry, UK. Pp.172.

Patel, B.M., B.G. Shah and Murthy V.V. (1961). Indian J. Agri. Sci.31 (4):246-255. Reffered in: Pandya, S.M and V.K. Sidha, 1982. Ecological studies of arid regions of Kutch (Gujarat State). Final Progress Report, Dept. of Biosciences, Saurashtra University, Rajkot.

Patel, Y., Dabgar, Y.B. and Joshi, P.N. (2012). Distribution and Diversity of Grass Species in Banni Grassland, Kachchh District, Gujarat, India. International Journal of Scientific Research and Reviews1(1):43-56.

Premadasa, M.A. (1990). Tropical grasslands of Sri Lanka and India, Journal of Biogeography. 17: 395-400.

Puri, G.S., S.K.Jain and Deshpande, U.R. (1959). Proc. Ind. Sci. Cong. Pt.3:291. Reffered in: Pandya, S.M and V.K. Sidha, 1982. Ecological studies of arid regions of Kutch (Gujarat State). Final Progress Report, Dept. of Biosciences, Saurashtra University, Rajkot.

Roy, A. K. and Singh, J. P. (2013). Grasslands in India: Problems and perspectives for sustaining livestock and rural livelihoods. Tropical Grasslands – Forrajes Tropicales (1): 240 – 243.

SAC (2002) Grassland mapping in Gujarat using Remote Sensing and GIS techniques: Kachchh District, Space Application Centre, Ahmedabad. 36 pp.

Sastry, K.L.N., Thakker, P.S. and Jadhav, R. (2003). Biodiversity threat through exotic species monitoring and management using Remotely Sensed data and GIS techniques, - A Case Study of Banni (Kachchh) Gujarat, India. Forestry & Biodiversity, Map India Conference 2003.

Shukla, P. C., Talpada, P. M. and Pande, M. B. (1984). *Prosopis juliflora* pods, a new cattle feed source. Animal Nutriton department, Gujarat Agriculture University, Anand, Gujarat, India.

Singh, J. S., Hanxi Y. and Sajise, P. F. (1985). Structure and functional aspects of Indian and East Asia savanna ecosystem. Ecology and Management of Words Savanna (ed. By J. C. Tothill and J. J. Mott) pp. 34-55. Australian Academy of Science, Canberra.

Singh, J.S. and Jha, A.K. (1992). Restoration of degraded land: an overview In J.S.Singh (ed.) Restoration of Degraded Lands: Concepts and Strategies. Rostogi Pub., Meerut, 1-10 pp.

Soil Survey Division. (1986). Report on the reconnaissance soil survey carried out in Banni area in Kachchh district of Gujarat State. Soil Survey Division, Vadodara.

Suttie, J.M, Reynolds S.G. and Batello, C. (2005). Grasslands of the World. Food and Agriculture Organization of the United Nations, Plant Production and Protection Series (Food and Agriculture Organization, Rome), No. 34.

Thaker, J. I. (1926). Plants of Kutch and their utility (In Gujarati). Rajkot.

Weeda, W.C. (1967). The effect of cattle dung patches on pasture growth, botanical composition and pasture utilization. New Zealand Journal of Agricultural Research, 10: 150 159.

White, F. (1983). The vegetation of Africa, a descriptive memoir to accompany the UNESCO/AETFAT/UNSO Vegetation Map of Africa (3 Plates, Northwestern Africa, Northeastern Africa, and Southern Africa, 1:5,000,000). UNESCO, Paris.

White, R., Murray, S. and Rohweder, M. (2000). Pilot Analysis of Global Ecosystems: Grassland Ecosystems, World Resources Institute, Washington D.C. 69 pp.

WRD and CDO. (1989). Report of the sub-committee for studying the problems and suggesting the remedial measures for the salinity ingress in the Banni area of Kachchh district. Govt. of Gujarat, water Resources Department and Central Designs Organization, Gandhinagar.

Yanar, Y., Lipps, P. E. and Deep, I. W. (1997). Effect of soil saturation, duration and water content on root rot of maize caused by *Pythium arrhenomanes*. Plant Disease, 81: 475-480.

Zimmerman, H.G. (1991) Biological control of mesquite, *Prosopis* spp. (Fabaceae), in South Africa. Agriculture, Ecosystems and Environment, 37: 175-186.