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Natural and Human Dimensions of Semi-Arid Ecology; A Case of Little Rann of Kutch, India

Abstract

Intermittent drought and flood craft the ecosystem of the semi arid area more fragile. The Little Rann of Kutch (LRK) falls under the zone of northern semi-arid climate. The LRK is located at the junction of phytogeographic provinces and is composed of diverse floristic elements. The area experiences extreme climatic conditions. Flooding by both the tidal water ingression and freshwater inflows from rivers occurs during the monsoon season. During the summer season , water recedes and evaporates leaving behind a crust of halite and gypsum crystals which grow into clay and sand. The distribution patterns of biotic elements and human ecology are explained on the basis of bioclimatic conditions prevailing in the area. Anthropogenic activities, such as pastoral influences, salt mining, and dry farming, not only advocates climatic characteristics of the region, but also reduce vegetative cover. Subsequently, the soil is lost through erosion resulting in environmental degradation. A systematic account of regional ecological resources has been carried out in order to propose case sensitive strategies for protecting biodiversity and natural resources, and to improve quality of life in semiarid lands.

KEY WORDS: Semi-arid region; Ecology; Exploitation; Desertification; Restoration.

Introduction

"The situation (Desertification) has been likened to a skin disease in which existing eruptions worsen and coalesce with new outbreaks of the disease. And, as with any disease, treating the symptoms is secondary to tackling the causes Tolba (1984)".

Socio-ecological systems of the semi-arid regions of the world are threatened, for approximately 30% of the population depends on interactions with dry land systems for their continued survival. "With decreasing availability of surface and sub-surface water, reference to increase in population, semi-arid regions are expanding. Dregne (1981) states; (semi-)arid represent 30% of global terrestrial surface area. The said condition is reached either through low recharge rates or through excessive rate of Evapo-transpiration. Arid and semi-arid or sub-humid zones are characterized by low erratic rainfall of less than 70cm per annum, periodic droughts and different associations of vegetative cover and soils. Variability of rainfall varies from 50-100% in the arid zones of the world with averages of up to 35cm. In the semi-arid zones, variability of rainfall varies from 20-50% with averages of up to 70cm. Regarding livelihood systems, in general, light pastoral use is possible in arid areas and rain fed agriculture is usually not possible. In the semi-arid areas agricultural harvests are likely to be irregular, although grazing is satisfactory (Goodin and Northington, 1985).

United Nation Environment Program (UNEP) Desertification Control /Programme Activity Centre defined desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting mainly from adverse human impact", aggravated by the characteristics of dryland climates. Desertification has also been defined as "land degradation in arid, semi-arid and dry sub-humid areas resulting from climatic variations and human activities". In the former, human intervention is viewed as the central driving force in desertification; while the latter clearly identifies both human and climatic influences (Toulmin, 1993).

Basic problem of semi-arid area is overdependence of population over primary activities. The majority of the population of arid and semi-arid lands depends on agriculture and pastoralism for subsistence. These zones exhibit ecological constraints which set limits to nomadic pastoralism and settled agriculture (Salih and Ahmed, 1993).

Anthropogenic activity in the area has reduced the vegetation cover against marginal cropping, grazing land has been over used and subsequently, the soil is lost through erosion and thus the environmental degradation results. The programme for ecological management must be based on the survey of historical land use pattern and potential productivity of the region. This research work is yet another attempt to look upon the critically important challenges of semi-arid restoration, through systematic account of the ecological resource on a regional framework as devised by Gupta (2011), in order to understand the causal chain of actions that leads to desertification considering the environmental impacts of past actions and thereafter, and to propose valid strategies and methods of restoration through case sensitive strategies for protecting biodiversity, resource management and to improve quality of life in semi-arid lands, on the basis of petrography analysis.

MATERIAL and METHODS:

The study focuses on the ecological management of the semi-arid area through the better understanding of ecological parameters. The field study being the very foundation of this work was carried out in order to understand the ecological characteristics of the area. Petrographic analysis has been carried out to build the relationship between the soil type its geomorphic characteristics and the floral and faunal cover. The data base on climatic parameters was collected from various secondary sources. Basic information on the study area has been collected from published and unpublished reports, journals, books etc. In addition to it, uncounted interviews with various experts, officers and workers of salt industries and villagers were also carried out. Offices such as Gujarat Institute of Desert Ecology, Gujarat Ecology Commission, Gujarat Institute of Desert Ecology in Vadodara, Department of Forest in Vadodara etc. were visited during the initial stage of the study. Base Map for the Mapping has been generated through the digitization of topographical sheets of quarter inch to miles. The representation of various phenomena has been done through Arc GIS tool. The available Maps from secondary sources were geo-referenced with the base Map in order to show attributes on a self generated Map.

STUDY AREA:

The Little Rann salt marsh and island, with an extension of 23º 7′ to 23º 40′ N Latitude ; 70º38′ to 71º 44′ E Longitude and 23 islands encompassing 5180 sq.Km. area (Map-1), is the southward extension of the Great Rann and is similar in Physiography, edaphic conditions, ecoclimatic and vegetation but differs in inundation regime and geomorphological setup (Map-2). Biogeographically, Kutch is classified as desert as per the classification (WII, Dehradun, 1988). Little Rann of Kutch, a sub division of Biotic province of Kutch Desert has been modified by the fluvial, aeolian and marine processes under two major wet and dry phases. The eastern most portion of the Little Rann area is free from sea water intrusion. Geologically, this area was a part of oceanic floor and has immerged in the recent past. Geomorphology of the area plays a dominant role in the pattern and cause of saline water intrusion. The surface of Rann is at or slightly above sea level and possesses a monotonously plain character with some outcrop in the form of sandstone capped by basalts, resembling to island in the mid of the Rann. An important feature of the study area is the higher proportion of incoming water that is returned to the atmosphere through evaporation, mainly from the soil surface. Therefore evaporation is a major factor in reducing water storage in the study areas. The recurrent drought and flood make the ecosystem of the area more fragile. Spasmodic storm water drainage, its regulation and water resource management is an important phenomenon to deal with in the semi arid regions.

ECOLOGY OF LITTLE RANN OF KUTCH:

The Kutch district falls under the semi-arid climatic conditions, which belongs to the "Steppe-Bush type" as per the Koppen's classification. The climatic characteristics of area shows transitory phase between the arid and semi humid type in the west and east respectively. The intensity of heat goes on increasing from east to west in the district except in the coastal zones. The region experiences four main seasons namely winter, summer, South-west monsoon and post monsoon seasons. During winter season (December to February) winds are N-NE and rough sea conditions may prevail because of western disturbances characterized by chilly winds from the N-NE due to high pressure zone in the north of Himalayan ranges. Summer season (March to mid June) is characterized by high

temperature and high humidity with the maximum air temperatures often reaching 40-45°C. Southwest monsoon (mid June to mid September) has weak monsoon mainly due to monsoon low centered around more inland part making it a low rainfall area with strong winds with S -SW directions. Post monsoon season (mid September to November) is a transition period between monsoon and winter when the climate is pleasant with relatively calm periods.

Following are the climatic characteristics of the study area:

- The region is characterized by a high aridity index of over 40 percent.
- The mean annual temperature is 26°C.
- Average temperature of the coolest month (January) is 10°C.
- The mean maximum and minimum temperature is 30°C and 10°C respectively.
- Maximum temperature during summer month sometimes reaches upto 48°C.
- There are three rainy months i.e., June to August of which July is the wettest month, receives almost 80 percent of the total rainfall received in the area.
- There is definite dry period starting from October to May within which there is insignificant amount of rainfall.
- Average annual rainfall for the area is 320 mm with dependability less than 40 percent.
- Total rainy days are less than 15.
- Annual rainfall is variable, the coefficient of variability being 14.01 percent in Kutch, 9.46 percent in Surendranagar and 7.84l Percent in Rajkot.
- The average humidity of the year is less than 25 percent.
- Humidity during rainy and post rainy season that is from June to October even goes upto 80 percent.
- Strong summer winds, which blow from SW and W and often carry salts from dried salt encrustation of the Ranns towards the land, is also one of the factors contributing salinity to the area.

The area does not receive significant amounts of rainfall due to the lack of orographic elements with a moderate mean annual temperature while the mean annual potential Evapo-transpiration is maximum in the Little Rann of Kutch. High temperature in May leads to the development of very low pressure cells. During this period violent storms are very common. These violent storms or winds are of less duration and occurs in the afternoon regularly because by that time the low pressure develops to its fullest. A very harsh northerly and easterly wind prevails in winter season, followed by strong South-Western steady winds. The moving air masses remains always loaded with dust and salt and are carried to more inland part of the India and Pakistan. The area do not experiences a very cold climate but is associated with occasional cold waves. Here the unavailability of obstruction of required height reduces the amount of rainfall received in the area. The above facts largely conform to the criteria of alternating wet and extreme dry season. The above designation to the region can also be proved from the climate, vegetation and soil type.

The dry type (steppe-Bush) of environment is also reflected in the socio-cultural practices, such as pastoral, lumbering (of mangroves) and salt mining in the area. The complete absence of agriculture in most area and seasonal pastoral; related movement of the people is strongly related to the absence of rainfall and type of soil (saline soil) available in the region. Salt mining is also done only in the specific part of year that is dry period, which otherwise gets inundated and during wet season remains wet for longer period.

Looking to the condition of the vegetal cover in the Rann, Champion and Seth (1968) classified the vegetation of Little Rann of Kutch as Rann saline thorn Scrub and Tropical Euphorbia scrub at its degradation stage. Gupta and Saxena (1971) categorized this vegetation as Halophytic scrubland. The vegetation types present in semi arid zone of India are characterized according to their degree of aridity as envisaged by Meher-Homji (1972). Joshi (1959) points out the earlier records of mesquite Gando Bawal (Prosopis Juliflora) cultivation in Indian subcontinent back to 1877. In area adjacent to the Little Rann of Kutch, mesquite was introduced by the then ruler of Radhnapur during 1899-1900. These tree act as a home for the bees and the area is known for honey production. However, the plantation of P. Juliflora in the fringe grassland has displaced the natural shrub species. In 1954 the plantation of mesquite was taken up by the Department of Forest under the programme, "Immobilization of Kutch Desert" in the waste lands around the Little Rann. Work of Shah (1993) reveals that shrubs has not only secured a foothold but is rapidly spreading and is now by far the most economic species of the region, and is being increased through afforestation. The Little Rann of Kutch has diversity of vegetation types and all representing extremities of climatic conditions. The

Little Rann (main) is a saline mud flat with absolutely no vegetation. The islands (bets) in the Rann are the only vegetated island in the midst of the dry and barren Rann, having shrub and grass cover. Around the barren Rann is a vegetation belt mainly prosopis shrubs and grasses. Vegetation is more conspicuous in the eastern and southern fringe, whereas in the western fringe the vegetation is very sparse. Vegetation was only observed in the fringe and the bet area. Mangroves were seen along the coast on the south west boundary of Little Rann of Kutch.

The natural vegetation in the area is variable owing to the variation in the other morpho-ecological parameters. The natural vegetation types, upto a great extent is limited by the soil properties such as the high clay content in the study area. The role of climate is equally important in determining the vegetation types to grasses and the pace of growth, extent of root penetration, there morphology etc. Even the trees of same species show differential growth pattern in different micro-climatic zones as for example Acacia are found in varied climatic zones with different morphological characteristics. The main feature of the natural vegetations in the study area is its tolerance to drought, as well as development of deep roots to overcome root damage as a result of the annual cracking. In general vertisols have grassland or savanna vegetation as the native vegetation, and is true with the study area in correspondence with the moisture regime of the Little Rann of Kutch and its fringe zone. Major types of halophytic plants present in this area are Cress Cretica, Abeurapa Sp., and Chenopodium Sande. The xerophytes include low and stunted trees of Acacia Arabica (Babul), Prosopis Spicigera, Prosopis Julifera, salvadora Persica (piludi), Catotropic Gigantis (Akoda), Capparis Aphylla (Kerdo), etc. The islands (bets) are sparsely covered by Prosopis Julifora (Gando Bawal), Accacia Nilotica (Desi Bawal), Prosopis Cineraria (Khijdo/Kando), Buteq Frondosa (Khakhro).

With an understanding of soil's physical properties and its relation to soil moisture, one can take a better ecological management decision. Soil texture and structure influence permeability, infiltration and water holding capacity. Both soil texture and soil structure determine pore space for air and water circulation, erosion resistance, looseness, ease of tillage, and root penetration. While texture is related to the minerals in the soil and does not change with agricultural activities, structure can be improved or destroyed readily by choice and timing of farm practices. The soil in the study area is in the state of deterioration because of compaction. The soil is much denser and has reduced the biological activity, porosity and permeability. Compaction has reduced the water infiltration capacity and has increased the rate of erosion by accelerating run-off particularly in the eastern fringe zone. The water holding capacity of the Rann sediment is higher than the fringe area and the bet area because of the higher content of finer particles like clay and silt in the soil. However, the Rann could not support the vegetation because of other factors. Land use of the area with reference to the soil type is dominantly grazing by sheep, camel and cattle or dry land agriculture as in most countries with vertisols development.

The study area had some distinct variation in terms of its geomorphological characteristics and the land-cover at micro-level. And, on the basis of those variant the study area has been divided into various regions, "1) Fringe Area, two miles of frontier around the study area 2) Dry Rann, Eastern and Central part, 3) Wet Rann with numerous creeks, western part and 4) Islands" (Gupta, 2011). After a thorough analysis of these identified units, its relief, superficial expression, technically feasible and economically viable landscape management has been thought of to restore the fragile geo-ecological balance of the area (Table - 1). The study area in question has also been classified on the pretext of Geo-environmental region (Map-3) The detail study of the area unveils the challenges associated with it and also reveals its physical and ecological capabilities for restoration and landscape management.

Fringe area:

This unit, on ecological perspective is not as extreme as that of the Little Rann of Kutch in terms of climatic condition. There is variation in terms of soil type and therefore on the land cover of the area. The height of entire fringe area is more than 10 feet. The depth of standing water in this part of Rann goes upto 3 feet during monsoon season. In terms of its surfacial expression, it is gently sloping plain frontier joining the Little Rann of Kutch. This zone is rilled and gullied by local small streams (Map-4).

The soil in the fringe area has relatively less compact soil as compared to the Rann sediment and therefore offers better permeability capacity and that is why vegetation can be seen. Visual inspection and laboratory tests states that the presence of sand in the soil is more in the northern, northwestern and along the bank of river Banas and Rupen. Such soils are deficient in plant

nutrients; they leach out easily with rainfall. Sandy soils are less productive than silts and clay.

The marginal area being higher than the Rann depression did not get inundated and is covered by Prosopis scrubs. The numerous stream which that passes through these scrubland deposits pebbles, sands, silt and clay in this zone. Such deposits are found in close proximity to the fallow land and the croplands. The soils in such environment are sandier than any other areas of study. Bawar, Bordi, Aawad, Pilu, Sankhpushpi, Maidio, Bokano, Khijdo, Gegadi, Thor, Dharo, Jhinjwo and Kerdo is the common vegetation of this zone. Distributional pattern of the scrubs, grasses advocates the nutritional richness in the area. Increasing nutrient availability is generally considered as the norm for grasslands.

Soil moisture is recognized as one of the principal determinants of grassland (Dargie and E.L. Demardash1991), and this is true with the peripheral Rann grassland as well. Ground check, field tests and sample analysis reveals that the availability of moisture is higher and lesser salinity in the grassland than the other areas at both ends.

The perennial species that grows in the Rann grassland are Cressa Cretica and Aeluropus Lagopoides, whereas, Cyperus and Scirpus grew after the area gets inundated during monsoon. The saline grassland resembles to the depression of the Little Rann of Kutch with only difference of having grasses growing on them.

Management in the region needs to start with the afforestation, all along the margin of Little Rann to check further desertification. Developments of Pisciculture, fodder and animal husbandary and dry farming have a greater scope in the area. Harvesting of rain water through bunding is possible only in certain areas, with reference to local relief. Comparatively, this part of area has more of biodiversity and is at much better place on ecological account.

Dry Rann depression:

The soils present in the area are deep dark in colour with a very high proportion of clay in it (a characteristic of vertisols), increasing towards Rann depression from the surrounding fringe area. Such soil system supports grassland and deep rooting trees. However, the Rann do not support vegetation because of adverse climatic characteristics and soil salinity. The seasonal variation in the climatic characteristics, basically rainfall and temperature of the area has facilitated the development of vertisols. The entire study area is typical in terms of erratic soil moisture regime. The very basic attribute of such soil is shrinking and swelling during dry and wet seasons respectively (Fig-1 and 2). Generally, higher rainfall results in higher intensity of cracking and increased leaching of carbonates and salts (Map-5 and 6).

Vertisols develop out of broad variety of parent material as for example riverine and lacustrine alluvium, igneous, sedimentary and metamorphic rocks of basic nature, limestone, shales and calcareous rocks. Such soil may develop in situ or may develop out of alluviums. The development of vertisols in the Rann has result out of the alluvium deposited brought by the rivers from surrounding basaltic regions, mainly Saurashtra. This soil has developed on young landscape on a very old geomorphic surface of Indian peninsula.

Alternate shrinking and swelling of Rann soil (clayey soil) causes self-mulching. The consistent mixing of the soil through mulching leads to develop extremely deep horizon of vertisols. Rann sediment is formed of basalt and that is why it is black in colour. They are formed in climatic zone which is seasonally humid and subject to erratic droughts and floods. The very characteristics of vertisols do not support the vegetation. They are rather covered by grasses or thin stunted bushes, depending upon the availablity of moisture.

Comparatively this part of study area has less of soil moisture owing to the distance between both the source of water that is inland and marine. During the field check the soil showed a very poor mobility of water within the pores though the moisture was sufficient enough to show, especially in the furrows within the Rann.

Since the permeability of the Rann sediment is lesser and therefore it restricts the movement of air, water and nutrients availability for plant uptake. The continuous contraction and expansion of the soil causes roots of the vegetation to be stretched and thus broken. Very often the cattle and other fauna in the area also suffers foot injury caused due to due falling in the deep cracks.

Western wet ran:

Being closer to the Gulf of Kutch, the western most part of study area is more akin to the gulf. Generally, such areas are endowed with a diversity of natural ecosystems as for example intertidal zones, salt pans, mangroves, sand dunes, creeks etc. Salt pans and mangroves being approachable and more explicit in the study area, is given space for discussions.

There is a network of creeks and alluvial marshy tidal flats in the interior part of the Gulf. The creek system consists of three main creeks namely Nakti, Kandla and Hansthal. The Little Gulf of Kachchh is inter-connected through many other big and small creeks. The three desert rivers, Banas, Rupen and Saraswati, carry annually 140 m3 water to the Little Rann of Kachchh that gets flooded during the southwest monsoon period establishing short term connection with the creeks at the head of the Gulf. The creek receives negligible freshwater inflow during the dry season. Hence, the evaporation exceeds precipitation leading to salinities higher than that of typical seawater (35-36 ppt). The higher salinities may also result due to the drainage of brine from saltpans and higher evaporation rates in the adjoining creeks. Thus salinities upto 50 ppt. have been recorded in the Little Gulf of Kachchh. Thefreshwater runoff during monsoon considerably dilutes the seawater in creeks.

The intertidal zone lying between land and sea is consisting of particulate matters. The wave action and associated littoral sediments impart a unique environment to the ecosystem. The geomorphological, biological and physio-chemical features play an important role in determining the ecological setup of the area.

Saltpans are distinct enclosed system of tidal water. They are exposed to a variety of stress and disturbances which manifest it through variation in the salinity. The unique feature of the saline ecosystem is its stability and simplicity. The saline ecosystem is simplified because the number of species is less. Moreover, number of species is indirectly related to the amount of salinity. These saltpans serve as feeding grounds for a variety of resident as well as migrant birds.

Islands (bets):

The Jhilandar bet is rocky in its surfacial characteristics, with flakes of sandstone spreaded mainly all along the sides. The relatively flat top areas of the bet have a good thickness of soil. There is ample of vegetation on the bet ranging from the grasses to the Prosopis Juliflora of considerable height. This bet is named after the lakes (Jhils) which remains filled with water through out the year. A few families dwell on this island. Even the cattle are also brought from the near by fringe areas for grazing. The islands are the only area in the midst of the Rann depression having vegetation, resembling to oasis in the desert. However, not all islands have vegetal cover on them.

The drainage aspect of the island with respect to its various slope element (Fig-3) reflects variation in surface texture and moisture. There is lots of mud accumulation at the foot zone of bet and remains relatively wet for long. The landscaping of these geomorphic units can be done by taking conservation method like a development of contour, vegetative hedges, fodder, fuel wood, social forestry etc.

Discussions with the natives of Vanod village revealed that Andheri wen, Maharajawali, Khijadiya, Miyan, Pancham and Dhut Bets have Suaeda Fruticosa as the dominating shrub. These islands are covered with wind blown particles. The island such as Mardakh, Shedwa, Nanda and Jhilandhar are rockey in its surfacial characteristics. In 1991, Salvadora plantation was carried out by the Forest Department of Gujarat, but could not survived due to the extremity of climatic condition.

PRIORITIES IDENTIFIED

Soil Protection:

The study area being in a semi arid climatic condition suffers from the aridity and desertification. Also, the soil being Vertisols are underutilized because of difficult physical properties. The fringe area lying around the Little Rann of Kutch is used in the form of irrigated field with marginal production is very much susceptible to the desertification and in many areas the top soil is covered by windblown dusts and sands. The streams lying in the area have eroded the surface through gulling. The soil is also being destroyed in the process of salt mining and grassland fires. There is an also huge area, which are fallow and abandoned area. The soil surface in the bet areas are exposed to the erosion through runoff during monsoon. The fine particles are also blown through the winds, degrading the soil. The mining activity at large has changed the land cover. Apart from the deforestation, the mangroves also die out because of increasing salinity in the area.

The possible measures which could be taken in order to protect soil are:

- Classification of soil and creation of soil Maps at adequate level.
- Sustainable management and increase in the scrubland and mangroves, which will reduce the erosion.
- Fire prevention and fighting.
- Slope protection and flood control keeping in mind the environmental impact.
- Implementation of strict environmental laws.

Sustainable Management of Water Resources

Since the population exist only in the marginal area and therefore the priority is given to the fringe zone, to understand the nature of problem. However, few houses were also seen on the bet. To start with the sustainable management of water resource, adaptation of water protection plan is prerequisite. There is a need to monitor the distribution and utilization of groundwater and surface water in order to reduce the waste. Villagers are inadequately equipped with the irrigation techniques so to minimize the water requirement. Since the water is limited in the area and therefore the waste is also. Household sewage water is directly discharged in the kitchen garden. However, there is ample of scope to develop the harvesting of rainwater through making of bunds across the streams. There is a need to develop techniques for using as much as possible of the water received while also providing surface drainage to avoid water logging. Man-made microrelief patterns can also improve surface drainage include convex beds, ridges, narrow beds and furrows, and broad beds and furrows.

Land-cover restoration

Looking to the ecological problems related to the soil and water resources, the identified measures to be taken in the area are:

- To recover the soils which are damaged by erosion, desertification salinisation, mining, deforestation etc.
- Reclamation of saline waste areas and margins of Rann through checking the flow of saline water at small scale.
- Transformation of environment through plantation and nurturing of trees particularly in the furrows rather than on the beds and ridges, which will also act as water harvesting tool.

CONCLUSION:

Little Rann of Kutch, an example of the confluence of both arid and semi arid regions is characterized by the climatic condition with insufficient rainfall to sustain vegetation year around. The recurrent drought and flood make the ecosystem of the area more fragile. The entire study area (The Little Rann of Kutch) falls under the zone of northern semi-arid climate, which is contiguous with the Thar Desert. The Little Rann of Kutch is phytogeographically interesting, since it is located at the junction of several phytogeographic provinces and is composed of diverse floristic elements. The study area experiences a very high ambient temperature at one point of time while it gets flooded by both the tidal water ingression andfreshwater poured by the seasonal rivers during the monsoon season. During summer season the water recede and evaporate, they leave behind a crust of halite and gypsum crystals which grow in the clay and sands. The patterns of distribution of biotic elements and human ecology are at large explained on the basis of bioclimatic conditions prevailing in the area. Anthropogenic activities such as pastoral, salt mining and dry farming not only advocates for the climatic characteristics of the region but also reduces the vegetal cover, subsequently, the soil is lost through erosion and thus the environmental degradation results. Semi-arid ecosystems are by far most fragile ecosystem because of ever increasing pressure of man, being lying at the periphery of dense human settlement. Conditioning of such areas are related to proper understanding of biotic and abiotic elements such as soil type, its particle size, hygroscopic co-efficient, water holding capacity, plasticity of soil etc. An attempt has been made in this paper to understand the causal chain of actions that leads to desertification considering the environmental impacts of past actions and thereafter, developing valid strategies and methods of restoration on the basis of petrography analysis. A systematic account of the ecological resource has been carried on a regional framework as devised by Gupta (2011), in order to propose, a case sensitive strategies for protecting biodiversity, resource management and to improve quality of life in semi-arid lands.

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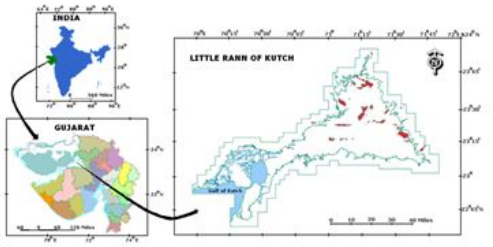
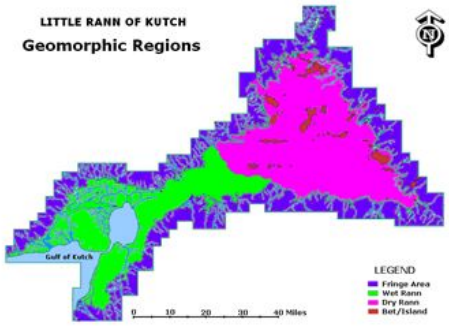
Table-1: Landscape Ecological Planning Measures , after Gupta and Ansari (2012) modified.

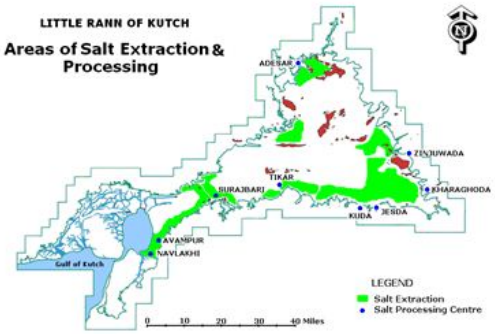
sl.no	GEOMORPHIC UNITS and ELEVATION	SURFACIAL EXPRESSION	LANDUSE	MANAGEMENT MEASURES
1	Fringe Area 10 feet (west of Maliya) to >100 feet (north-west of Dhrangdhara)	Gently sloping plain frontiers joining the Rann area. The zone is rilled and gullied by local small seasonal streams.	Covered with drought resistant vegetation, more dense in the eastern and southern side, while western fringe is sparser. Grasses grows in the marginal area of Rann for a few months in a year. Irrigated farming, Sandstone mining in Dhrangdhara	Afforestation all along the margin to check desertification, development of Pisciculture, fodder and animal husbandary, dry farming. Harvesting of rain water through bunding.
2	Dry Rann 7 feet (foot of Wasraj bet) to 25 feet (north of Jhilandhan)	Monotonous plain, covered with brine, clay and wind blown sand.	Completely barren, Extraction of salt is carried out during dry period	Reclamation of area and storage of water at small scale can be done by making bunds.
3	Western Wet Rann <7 feet above MSL	Monotonously plain with very high density of creek channels	covered with mangroves except in south eastern part	Check on deforestation and impetus on mangroves plantation, Pisciculture and Judicious use of resources
4	Islands 30 to 179 feet above MSL	Hard superficial character. Sandstone with flat topped basaltic rock	Thin grasses with short stunted Acacia Tree.	Contour vegetative hedge, fodder, fuel etc.



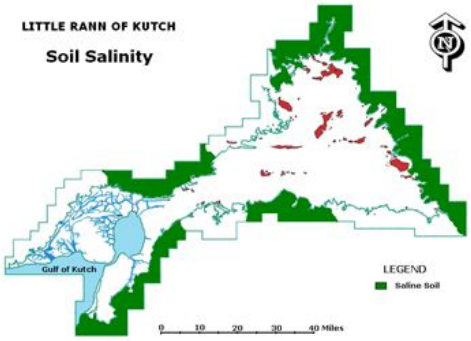
Map-1 Location Map (Study Area) *Source: Gupta (2011)*



Map-2 Geomorphic Regions



Map-5 Areas of Salt Extraction and Processing



Map-6 Soil Salinity

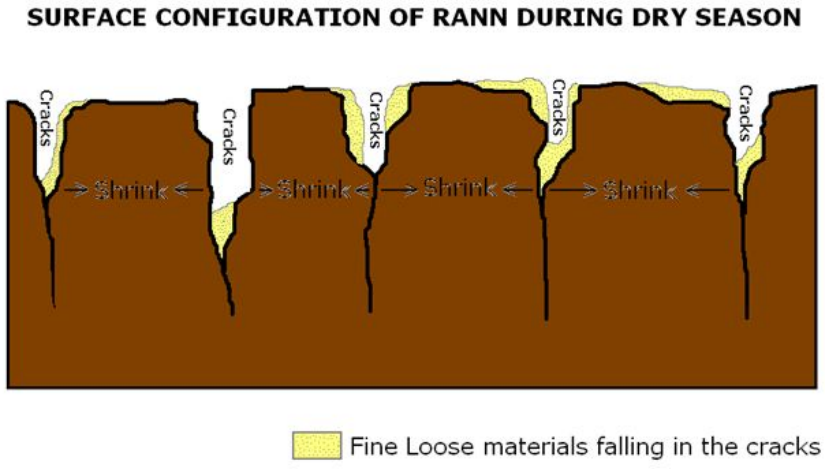


Fig-1 Surface Configuration of Rann During Dry Season

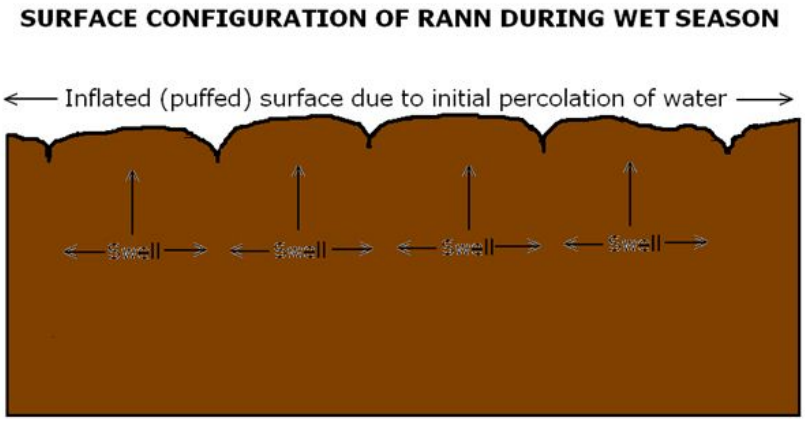


Fig-2 Surface Configuration of Rann During Wet Season

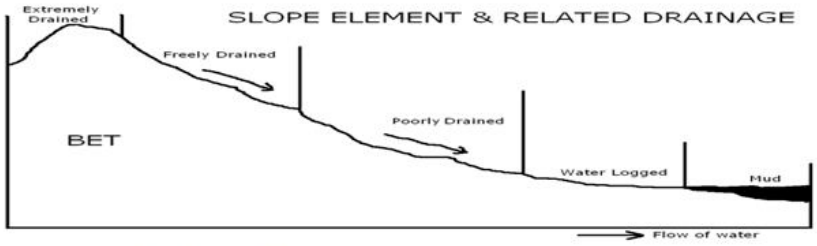


Fig-3 Slope Element and Related Drainage

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