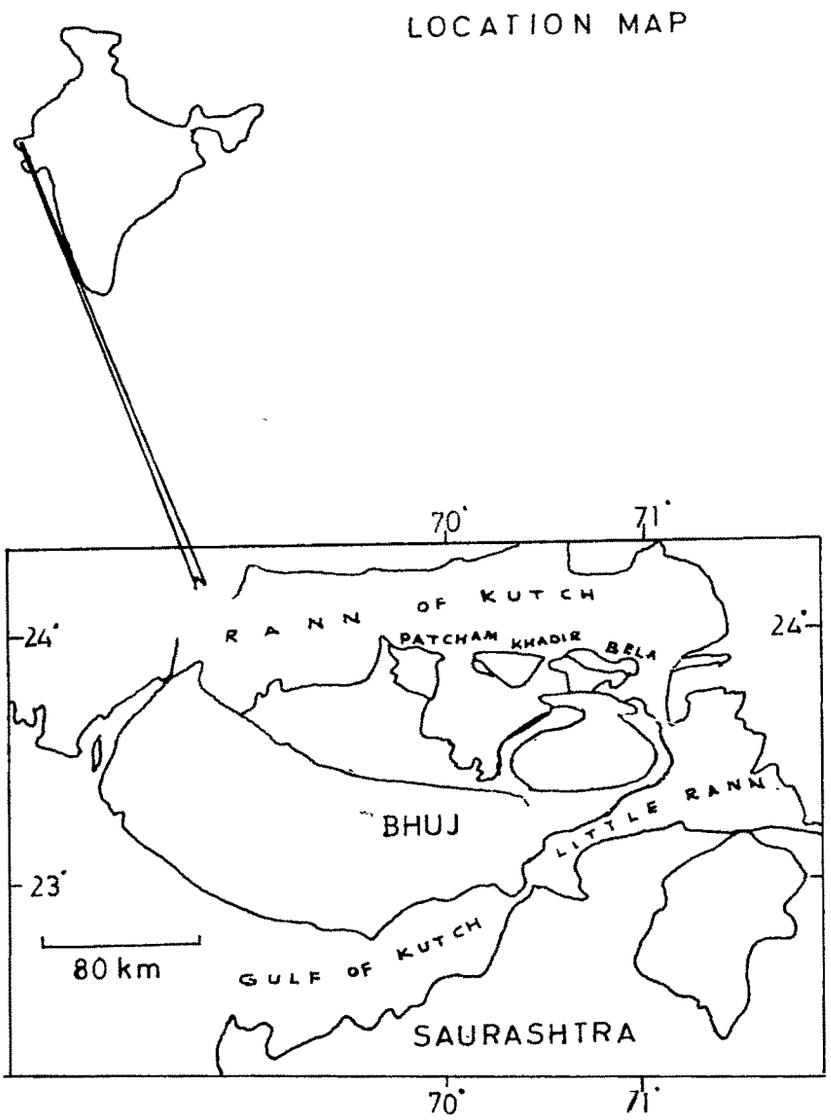
CHAPTER 1

I N T R O D U C T I O N

The Rann of Kutch (Fig. 1.1) comprises an unique and rather unusual geomorphic terrain of the Indian sub-continent. Its monotonous flatness, salinity and the annual inundation have rendered the Rann as a piece of mysterious ground. Year after year, the Rann of Kutch gets flooded by water and the pattern and causes of inundation have always baffled the scientist.

Any terrain, which has some uniqueness, draws the attention of investigators. But somehow, the Rann of Kutch, in spite of its unusual position and

Fig.1-1


LOCATION MAP
70°
71°
24°
RANN OF KUTCH
PATCHAM
KHADIR
BELA
BHUJ
LITTLE RANN
23°
80 km
GULF OF KUTCH
SAURASHTRA

character has hardly been studied at all. In fact, the geomorphic history, the deposition of sediments, the evolution of the Rann and the inundation aspect are but some of the manifold problems that confront any investigator. The area represents one which has shown striking geomorphic changes in the historical past, and even now is undergoing some changes. Though the mainland of Kutch has attracted several workers, it is unfortunate that the various aspects of the Rann still continue to be only half understood.

In the past, no serious attempt has been made to scientifically investigate this terrain, and only a few workers have prepared some reports which are academically rather inadequate. The present study is perhaps the first of its kind wherein all aspects of the Rann inundation have been systematically and critically investigated. The author took up the study, through a Grant-in-aid research project of the R & D Organisation (Ministry of Defence). The study has not only unravelled the mystery of inundation, but has also thrown light on many allied aspects viz. the geomorphic evolution, sedimentary history and the sediment characteristics of the Rann.

Looking to the vastness and inhospitality of the terrain and the complexities of the problems involved, the author feels that this study marks only a beginning, and if it inspires future workers to go into further details of the different aspects of the Rann, the author's present effort will be amply rewarded.

KUTCH IN GENERAL

Physiographic divisions

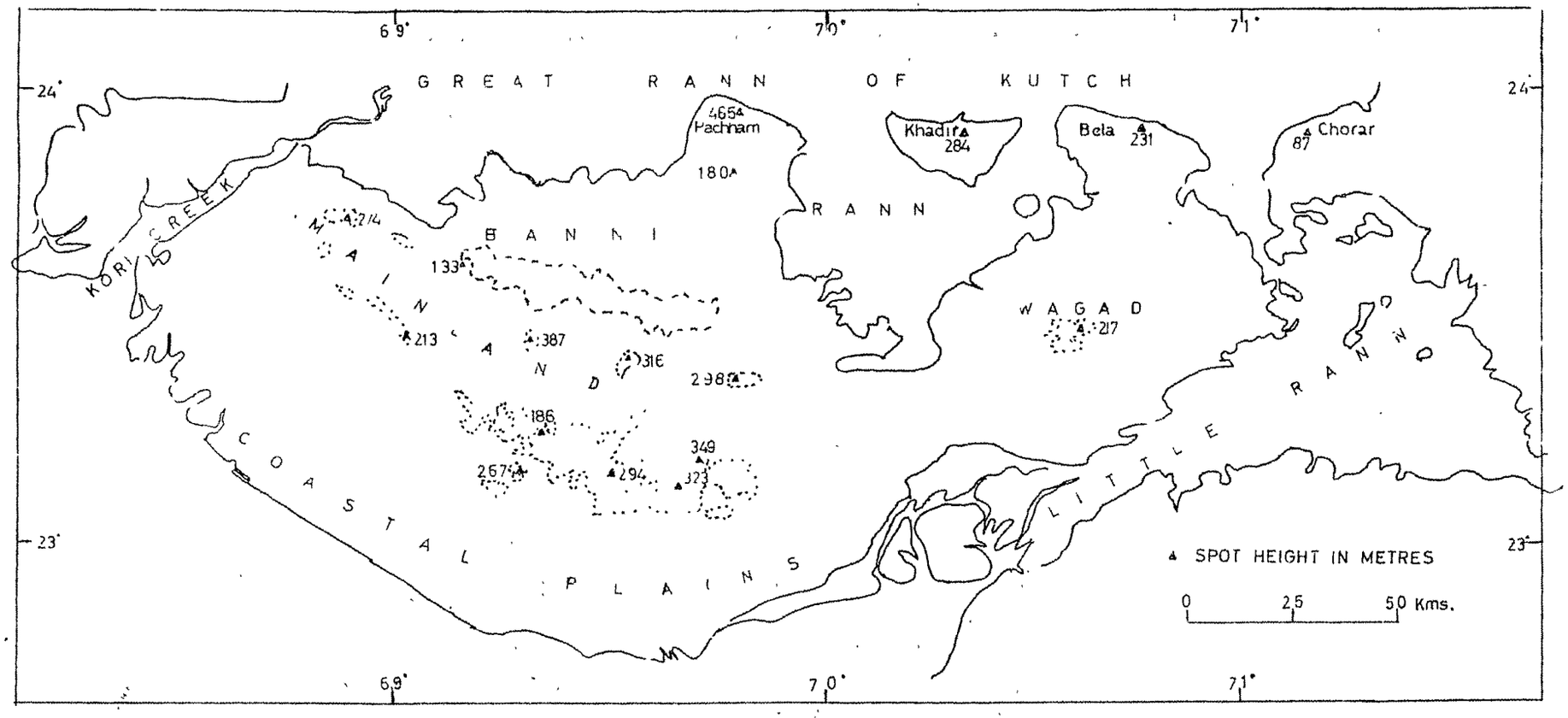
The Kutch district in the north-western part of Gujarat State forms an independent geographical and geological unit. Its terrain can be classified into four zones from north to south (Fig.1.2).

(i) The Rann
(ii) Banni
(iii) The Central Hilly region
(iv) The Southern Coastal Plains.

The Rann upon which the present work dwells, can be described as an unique salt-crusted wasteland to the north of the rocky mainland. It is divided into the Great Rann and the Little Rann. The former covers a vast area and can be regarded as a flat area being

Fig.1.2

PHYSIOGRAPHIC MAP OF KUTCH



almost on par with the sea-level. During rainy season, water stagnates on its surface and part of it comes under the influence of tidal water. During dry period, except for some perennially wet patches, the whole region gets practically covered with salt encrustations to varying degrees. Rising only a few meters above the Rann surface, are certain island-like features termed as 'bets'. The 'bets' are easily distinguished from the low-lying plain by means of the scanty vegetation that they support in contrast to the total lack of it in the latter.

Banni region lies between the Great Rann and the rocky mainland. It forms an E-W tract that rises a little higher than the surrounding Rann and is covered with grass and other shrubs. Obviously, the Banni owes its origin to the alluvium brought down by the north-flowing rivers of the mainland.

The Central hilly region comprises four parts as under:

(a) Island belt: This forms a belt of four rocky islands i.e. Pachham, Khadir, Bela and Chorar from west to east, cropping out of the Rann.

(b) Mainland : The area lying south of Banni and extending upto the Gulf of Kutch in south, is called the mainland.

(c) Wagad : This region lies to the north-east of the mainland and forms an isolated rocky mass.

Physiographically, a number of east-west hill ranges in Island belt, Mainland and Wagad are separated by large tracts of low ground. All hill ranges and low grounds in-between, run almost parallel, a characteristic feature in this part of the country giving some clue to the fact that topography has been controlled by geological features. The highest (465 m) peak in Kutch is that of Kala Dongar of Pachham Island i.e. Panchmai Pir. In the mainland, Dinodhar hill forms the highest peak with a height of 388 metres.

The Southern coastal plains border the mainland against the Gulf of Kutch in south and the Arabian Sea in west. The coastal plains are marshy. The sea coasts along the Kutch peninsula afford not only scenic beauty and different varieties of coast lines, but also have been found quite suitable to be used as natural ports.

Climate

Kutch has a semi-arid climate which belongs to the 'Steppe-Bush-Type' as per Koppen's classification. The steppe is a transitional belt bordering a real desert and separating it from the humid climate beyond. The Tropic of Cancer passes through the Kutch region and hence the area records a maximum variation of temperatures, typical of an arid climate (Table 1.1). Maximum temperature in May is about 38°C and which sometimes goes as high as 47°C. Minimum temperature in January is around 11°C. Temperatures as low as 1°C are also occasionally recorded. Hottest month is that of May, while the coldest is January. The winter season lasts usually from the middle of November to the end of February and is not severe, though short spells of cold waves are not uncommon. Easterly and northerly cold winds blow over the region during winter seasons. Winter is followed by summer from March to the end of July. It is during this period that violent storms are frequently registered, and their effects being particularly felt in the open terrain of the Rann. These storms are of short durations of a few hours only and are more common in the afternoons. Holland (1912) reports that harsh, easterly and northerly winds prevail in cold weather,

TABLE 1.1

Temperature values (in Centigrade)
(1970)

	JAN		FEB		MARCH		APRIL		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC	
	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
Dhara [illegible]	27	10	29	15	31	10	35	22	42	23	44	25	44	22	37	21	35	20	31	20	27	15	28	14
Dediya bet	27	10	28	15	31	18	36	23	43	24	44	26	44	23	38	21	34	19	31	20	27	15	27	13
Diar bet	22	9	28	15	33	19	38	24	45	25	45	27	45	26	39	22	36	21	33	20	25	13	25	11
Lakhpat	23	11	29	16	33	19	38	24	43	25	43	25	42	25	37	23	36	21	33	20	25	13	24	15
Karimshahi	20	8	26	17	34	19	39	24	47	29	47	28	47	29	39	24	36	22	33	21	24	12	24	9
Kuar bet	21	10	25	15	31	19	37	23	45	26	45	27	44	27	38	25	34	22	32	21	24	12	25	13
Kharda	23	11	26	15	31	19	37	24	45	25	45	25	45	24	38	25	34	22	31	20	24	13	25	14

followed by strong south-westerly gales and steady winds, the air being frequently loaded with dust. He suggests that great quantities of salt are carried inland from the Rann of Kutch, and according to his estimations as much as 130,000 tons of salt are annually carried by the wind into Rajasthan. The period from middle of May to end of August constitutes the south west monsoon season. July is the wettest month and during the rest of the monsoon period, there is scanty rain, usually less than 0.25 cm. There may be periods when there is no rainfall at all. October and November form the post-monsoon transition period from rainy to cold season when the days are very hot and sultry, while nights are breezy, cool and pleasant. The average annual rainfall is around 32 cm (Table 1.2). Insufficient rainfall causes famine and other scarcity conditions.

So far as humidity is concerned, it is rather high along the coastal areas. At Lakhpat for example, the relative humidity exceeds 60% on the average, and during the south-west monsoon, it may go as high as 80%. The air during other parts of the season is relatively dry. The Rann experiences relative humidity of as much

TABLE 1.2

Rainfall Values (in inches)

Years	Bhuj	Anjar	Rapar	Lakhpat (Narayan) Sarovar
1947	8.78	12.62	10.50	23.62
1948	4.33	3.90	7.27	1.30
1949	20.14	19.82	12.18	17.57
1950	27.95	24.90	7.12	2.43
1951	6.70	5.75	13.88	15.12
1952	13.22	12.12	17.75	20.22
1953	19.63	16.44	15.67	28.87
1954	19.51	18.53	23.84	7.86
1955	7.37	7.58	12.38	13.70
1956	20.92	16.11	10.53	19.08
1957	7.92	11.96	10.63	7.10
1958	10.45	14.28	17.10	30.13
1959	49.96	26.55	48.62	43.55
1960	6.51	5.50	5.98	0.80
1961	22.78	18.43	10.50	37.83
1962	10.00	8.09	6.74	7.48
1963	7.39	8.28	4.00	2.25
1964	35.51	7.75	18.44	21.20
1968	8.00	-	-	2.25
1969	7.40	-	-	2.50
1970	38.56	-	-	32.64
1971	11.00	-	-	7.50

as 85% during the monsoon, but otherwise it is of the order of 25% or less for the rest of the year.

Vegetation

From the point of view of vegetation, the Kutch region in general and the Rann is particular, presents a somewhat desolate landscape, and in a broad way represents a terrain with very scanty vegetation. In Rann, vegetation is confined mainly to the isolated bets, though stunted bushes and a variety of jungle grass is encountered at other places also. Along the fringes of the Rann and the Banni region, vegetation is comparatively better.

Apart from the few irrigated patches viz., near the towns and villages, the rest of the Kutch area offers a vegetation that could be classified into two main types:-

(a) Halophytic vegetation near the sea, and
(b) Typical low thorny shrubs of the 'Xerophytic' type all over.

Halophytic vegetation is predominantly represented by Chenopodium sanda, Abeurapa sp. and Cress cretica.

The thorny shrubs mainly consist of an association of low trees of Acacia arabica (Babul), Prosopis julifera (Vilayti Babul), Prosopis spicigera, Salvadora persica (Piludi) etc. interspersed with shrubs like Catotropic gigantis (Akdo), Capparis aphylla (Kerdo), Aerva etc. Besides these shrubs, few trees of wild date, mango, common nim, pipal, tamarind and banyan are found near villages and on road sides.

Fauna

As regards the fauna of Kutch region, wild animals are scarce and in the Rann, deer, fox, wildcats and rabbits are occasionally seen. Poisonous desert snakes and varieties of lizards are also encountered. Kutch is well known for flamingoes - a rare species of bird, which arrive in the area during winter months. Sindal bet, right in the centre of the Great Rann is called the 'flamingo city', where the flamingoes breed during winter.

Agriculture

Because of scanty rainfall, the position of agriculture and water supply is highly precarious.

In the Rann, there is no available source of sweet water, the ground-water being hyper-saline. Even in the Banni area and the Mainland, there is an acute shortage of ground-water. Some lakes are utilized for irrigation purposes. Ground-water survey by Pathak (1954), Taylor and Oza (1954) and Taylor and Pathak (1960) in the Kutch region and by Exploratory Tubewell Organization (Govt. of India) have yielded results, on account of which some land has been brought under cultivation. The main crops include Millet (Penicillaria spieata), Jowar (Sorghum vulgaree), wheat (Triticum oestivum), Bajra and other cereals. Cultivation terminates a few miles from the edge of the Rann. Due to scarcity of water, villages are scattered. Apart from agriculture, the main source of livelihood is the raising of cattle and sheep.

Population

The inhabitants of Kutch are mostly Hindus with a good number of Mohammadans. The spoken language is Kutchi (a dialect which is a mixture of Gujarati and Sindhi). Total population is around ९००,००० . The density thins out northwards, villages getting lesser and more scattered i.e. towards Rann where there is no permanent population.

In the Banni, the population is mostly nomadic, and keeps on shifting in search of new pastures for cattles, sheep or camels.

Communications

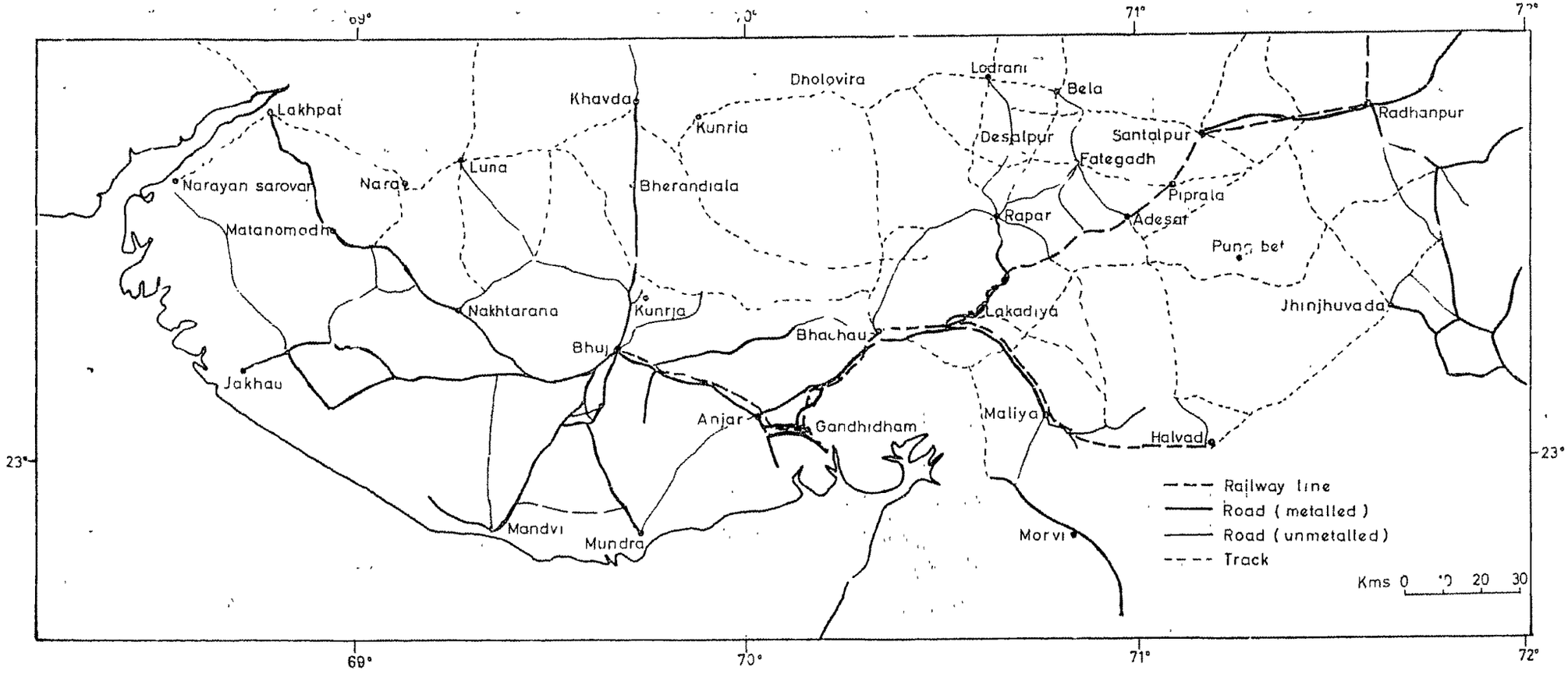
Bhuj, the district headquarters, is connected by a Meter-gauge railway line to Gandhidham, from where a Broad-gauge line goes to Ahmedabad and a Meter-gauge line to Palanpur. Also, daily I.A. flights connect Bhuj to Jamnagar and Rajkot. Northwards, Bhuj is connected to Khavda by a good, all-weather motorable road which goes right-up to the edge of Mori Bet in the Great Rann (Fig. 1.3). Banni and the Rann have no road system. Vehicles ply on the Rann surface except during rainy season when it is difficult to traverse over Rann by any vehicle. In times of inundation, the only means of transport is camel and boats.

Geology

Geologically, Kutch is very interesting, and the stratigraphy and structure of the entire terrain comprise an important unit in Indian Geology (Fig. 1.4).

The salient feature of the Geology of Kutch and the position of the Rann sediments have been given

COMMUNICATION MAP



by the author to provide a suitable background to the present study. The stratigraphy is as under:-

Rann Alluvium, Coastal sands, Miliolite limestone	Recent, Sub-Recent and Pleistocene
Marls, shales, sandstones, limestones etc.	Tertiary
Basalts	Deccan Traps
Sandstones	Cretaceous
Sandstones, shales & limestones etc. (Base not exposed)	Jurassic

The rocky islands in the Great Rann as well as the northern portions of the mainland comprise Jurassic and Cretaceous rocks, while the southern part is mostly covered by the lava flows of Deccan trap and the younger Tertiaries. To the north, the Jurassics go below the Rann - a recent deposit. A few outcrops of older Jurassics again crop out as inliers surrounded on all sides by the Great Rann. From the point of view of structure, the Mesozoic rocks are seen to form several domes. There are three parallel chains of domes, decreasing in size from north to south and each flanked by an E-W trending fault on its

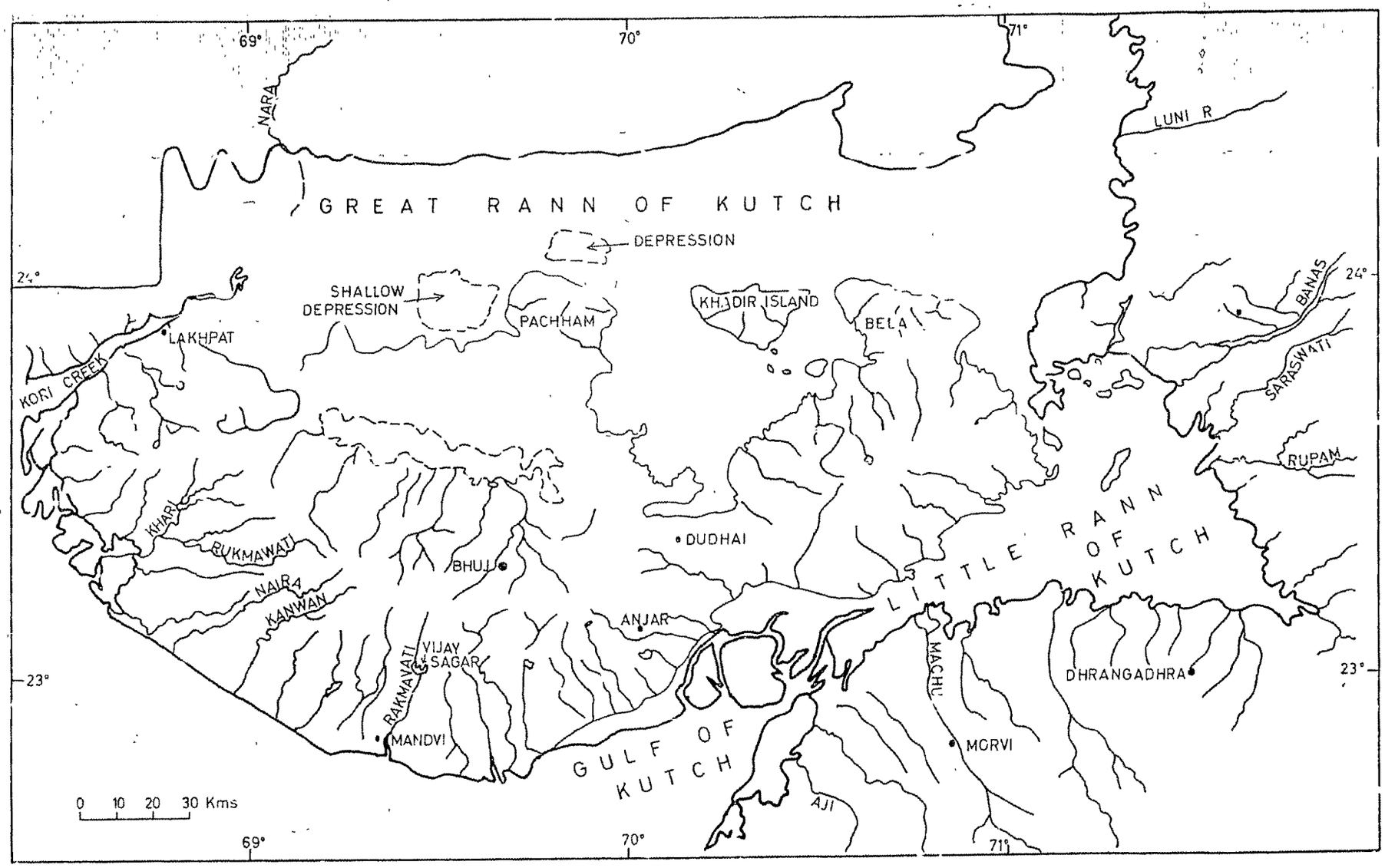
northern side. Within the Rann, these domes stand out as vertical isolated islands and rise almost vertically above the Rann surface.

THE GREAT RANN

Physiographically, the Great Rann can be divided into 3 parts. One part comprises the shallow, trench-like channel extending from Kori Creek to Kuar Bet, the other area north of it, is at a slightly higher elevation and consists of an intricate net-work of bets. The third division, the area north of hill ranges of Pachham, Khadir, Bela and Chorar, is a desolate salt encrusted plain, devoid of any mentionable vegetation. The hill massifs as mentioned above, stand out as individual islands and rise, at places almost vertically from the face of the Rann. The highest point in Kutch, Kala Dongar is about (465 m) high. A network of streams and rivulets debouch into the Rann from these hills and contribute to the inundation (Fig. 1.5). An appreciable quantity of dissolved salt is also brought down. The hills in the western section, north of Nakhatrana and around Lakhpat, are not as high as the peaks of Pachham and Khadir, though they rise as steeply as the former. Various rivulets debouch into the Rann from here also.

Fig.1 5.

OVERALL DRAINAGE MAP OF KUTCH DISTRICT



Most of these streams are seasonal, carrying water only during the monsoons. There are no flowing rivers or streams in the Rann. Old river courses and channels serve as conduits for rain water during the monsoon.

The Banni area sandwiched between Pachham Island and the hills north of Nakhatrana can be regarded as a transition zone between the Great Rann and the Mainland. Transition from Banni to Rann is rather abrupt, and is conspicuous by the thinning out of vegetation and a perceptible decrease in the gradient. These physiographic divisions are shown in Fig (1.2).

The overall drainage pattern is shown in Fig.(1.5). The absence of any major river flowing into the Great Rann is conspicuous. In the easternmost corner of the map, the only major river that enters the Rann is Luni. The part played by Luni, in inundation is very meagre as most of its water has been dammed upstream for irrigation by the Rajasthan Government.

SCOPE OF THE PRESENT INVESTIGATION

In this study, the author has confined himself to a detailed investigation of the causes and pattern of inundation of a large part of the Great Rann. The

study area is covered by the Survey of India 1 inch Topographical sheet Nos. 40H/3, 40H/4, 40H/8, 40H/12, 40H/16, 41A/13, 41E/2, 41E/5, 41E/9, 41E/13 and 41I/1.

It lies between North Latitudes 60°15' and 70°30' and East Longitudes 23°30' and 24°15' (Fig.1.1), covering an area of about 4500 sq km. The area under investigation is flanked by the Kutch mainland to the south, and in the north, it gradually merges into the sand ridges of Sindh (Pakistan).

A major portion of the Great Rann is annually inundated by water. This inundation phenomena has been observed and mentioned in the past by various geologists, travellers and personnels of the Indian and British army, but little was said about its causes and pattern. It was with a view to ascertain the exact causes and pattern of the inundation, that Terrain Evaluation Cell of the Ministry of Defence, entrusted the present study to the author. The project was started to know more about the Rann area, and to check how and why certain areas get flooded during certain seasons.

Previous workers envisaged a vast sheet of tidal water which swept along the entire Rann surface carried

many miles inland by strong winds along the flat gradient of the Rann. But in fact, the matter is not as simple as that. The author has found out that the causes of flooding and the movement pattern of water are much more complex.

The author has preferred to view the term 'inundation' in a wider sense, relating it not only to the mass movement of tidal water but also to (a) the movement of rain water along channels on the Rann surface, (b) rain-water carried down by the various rivers and streams that debouch into the Rann from the rocky mainland and (c) the water due to direct precipitation that stagnates into depressions and gives rise to the perennial wet patches. In short, the author has viewed the term 'inundation' in a sense where moisture transfer above and below the surface is included.

The causes of inundation are thus manifold. Apart from the meteorological causes such as rainfall, tidal movement etc., certain 'indirect' causes also control water movement or water stagnation to a very great extent. Such 'indirect' causes include

(a) geomorphology of the area and (b) the nature of sediments. Geomorphically, the Rann includes such landforms that control the flow and stagnation. To understand this, a detailed study of the geomorphology was carried out with the help of air-photos, field surveys and one-inch topographical sheets. The geomorphic map of the area, prepared by the author, shows the various geomorphic facets and landforms that control the phenomenon of inundation. The author's investigation included the study of the sediment properties and their variations location-wise. As movement of water in the Rann, below and above ground surface, is through sediments, it was pertinent that the detailed behaviour of the sediment conditions under different climatic and moisture conditions be properly understood. For this, several field and laboratory tests were conducted, their properties compared and the behaviour of the sediments under various moisture conditions ascertained.

The author devoted 3 years on this project and during this period, he made several field trips to the study area. He visited the Rann under different

climatic conditions, each trip ranging in duration from two weeks to three weeks. A large number of traverses by jeep were also taken to cover most of the accessible ground and fix suitable locations for detailed study. Such spots were individually visited and systematically investigated. Wherever the sediment behaviour showed change in their properties, sediment profiles were dug upto depths varying from 1.25 - 3.5 m. Samples were collected along suitable intervals and careful observations of the profiles in respect of laminations, wetness, colour, capillarity etc., made. A separate chapter on sediment profile and pit conditions has been included to give an insight into the top 3 m of the Rann sediments. It is observed that the type of sediments and the phenomenon of water movement and infiltration ratio, are always interconnected. Various other physical parameters of sediments such as permeability and hygroscopity etc. were calculated and their relation to the inundation problem investigated. The author's study has also revealed that the fineness of sediments and the presence of salt play an important role in the transfer of moisture through the profile, and this process has been found to be a major factor contributing to the water logging of the Rann at many places.

It was considered worthwhile to know the past depositional history of the Rann sediments. A study of the evolution of the Rann during the geologically Recent time, provides an useful key to the past, and also to the present changes on the face of the Rann.

The 'pattern' of inundation includes:

(i) the various types of inundation viz., the encroachment of tidal water, accumulation and stagnation of rain water and flow and accumulation of numerous stream water coming from the rocky mainland,

(ii) the overall direction of movement of the various water bodies, and

(iii) the extent of the areas inundated during different meteorological conditions.

The Rann in spite of its flatness has a lot of local depressions where the water tends to collect. As no micro-relief survey has been conducted by any agency, the exact pattern could not be ascertained in certain areas. However, and overall and fairly reliable pattern of inundation has been worked out by the author.

The various chapters of this thesis contain details of the author's investigations of the various factors briefly discussed above, and the reader will find in this work a coherent and systematic account of the causes and pattern of inundation phenomena.