INTRODUCTION
The state of Rajasthan is located in northwestern part of India and lies between 69°30' and 78°17'E longitudes and 23°3' and 30°12'N latitudes. It is the second largest state of the country with a surface area of 343 thousand sq. km. The Aravali Ranges divide the state into two halves. The southern and eastern parts of the Aravali receive comparatively much rainfall and therefore, the soils are more fertile as compared to the western and northwestern parts of the state. The western desertic track bears desolate look because of rolling sand dunes and stunted vegetational growth. The low and erratic rainfall coupled with deep brackish ground water have forced the human and livestock population since time immemorial to migrate to nearby areas in search of food, fodder and water more occasionally with the rainfailure. The state of Rajasthan is also divided in two distinct parts diagonally, northwest and southeast. About 91 per cent of the 'Thar Desert' covers an area of 2,34,985 sq. km. in northwestern parts of the Rajasthan. Thar desert is characterised as one of the most inhospitable and arid zone of the world. Uncertainty of monsoon is a special feature of this area.

However, the desert of Rajasthan is not like that of the other deserts of world. Infact this desert is generic. Elphistone on his way to Kabul during the year 1808 describes Thar-Desert, "the track is a waste as wildest part of Arabia but during and just after rains, it wears a very different appearance, becoming a green pasture land covered with richest and most succulent grasses."¹

1. INDIRA GANDHI CANAL PROJECT - A Historical Perspective

In the early part of the 19th century it was realised that if waters of the rivers of Punjab state could be brought to the desert of Rajasthan, this disolate land
would bloom with prosperity. On the successful execution of the Gang canal in northern part of Rajasthan, Late Kanwar Sain, the Chief Engineer, irrigation of the erstwhile Bikaner State, prepared an exhaustive paper on the water requirement of Bikaner state. The Chief Engineer, stated, "given moisture, the land is capable of growing good crops. The yields in years of good rainfall from what is known as desert, compare favourable with some of the waste land in the irrigated area in the Gang colony. I have gone over these areas by air and by Jeep all over the state. It can be made to yield very good crops provided the life giving water can be supplied.

There are untold millions of acres in the Rajasthan desert which it is quite feasible to irrigate from the Punjab rivers. My recommendations therefore are, that the waters of the Punjab rivers should be carried as far to the east and south as possible.

In order to utilise the Beas river water supplies, a new Headworks higher up on the river will be necessary. The simplest and relatively cheapest solution would appear to be building a new Headworks at Harike just below the junction of Sutlej and Beas rivers. As a first step towards the realisation of this dream, the Harike Headworks and canal (Rajasthan canal) may be constructed simultaneously with the Nangal Project.

As a result of the suggestions made in the above paper and due regard to some political considerations, the Harike Barrage was constructed just below the confluence of the rivers Beas and Sutlej during the period of 1951-53, alongwith the Beas works of the Rajasthan canal. 2
2. INDUS WATER DISPUTE

The independence of India achieved in 1947 was accompanied with the partition of the country into two sovereign states of India and Pakistan, brought in its wake the problem of the division of waters of the rivers of Indus basin. As India and Pakistan started to share and developing new uses of waters of the rivers of Indus - basin, tension mounted between the two countries.

The matters of dispute were discussed at various levels and it was in March 1952 that India and Pakistan finally agreed to accept the resolution of the World Bank on sharing the Indus waters. The World Bank while considering the distribution of water took into account various possibilities for the use by India and Pakistan. The Rajasthan Canal Project was considered in this context and was finally included in the Indian share of this water.³

3. INTER-STATE AGREEMENT

While the long and ardous negotiations between the two countries were going on under the auspices of the World Bank, India started a planning for the use of the waters of the three eastern rivers (Sutlej, Ravi and Beas rivers). It was clear, that the waters of the Sutlej were to be utilised entirely for the SirhindBhakra Nangal complex. As for the waters of the Ravi and Beas rivers, the supplies were to be distributed amongst the then state's of Punjab, Jammu and Kashmir, and Rajasthan. The net supplies available after meeting the pre-partition requirement from the two rivers were 19.56 billion metres³ (15.85 MAF). In January 1955 an agreement was amongst the states concerned with regard to the allocated of specific quantity of water to each state. Rajasthan in this way got 9.88 b m³ (8 MAF) waters based on the river flow studies made from 1921-22 to 1945-46.
According to a review of the flow series (1921-60) the total main supply of Ravi-Beas waters is 25.38 bm$^3$ (20.56 MAF). Deducting proportion uses of 3.86 bm$^3$ (3.13 MAF) and transit losses in Madhopur Beas ling of 0.32 bm$^3$ (0.26 MAF), the net surplus Ravi-Beas water works out to 21.20 bm$^3$ (17.17 MAF). Moreover, an agreement was also signed on 31 December 1981 by the three concerned states namely, Punjab, Haryana and Rajasthan for the revised availability of water. On the basis of that agreement, the share of Rajasthan was fixed as 10.61 bm$^3$ (8.60 MAF). IGCP envisages to utilise 9.36 bm$^3$ (7.59 MAF) and balance on Gang, Bhakra, Nohar and Sidmukh systems 0.41, 0.26, 0.16 and 0.42 bm$^3$ (0.33, 0.21, 0.13, and 0.34 MAF) respectively.

4. THE INDUS WATER TREATY

While the work on the project was in progress, with the efforts of the World Bank, an Indus water treaty was signed at Karanchi on 19 September 1960 between India and Pakistan after a prolonged negotiations of eight years. All through the negotiations, the Rajasthan canal was considered of prime importance for India to get more water from the Indus river. Emphasising the importance of Rajasthan canal in India's economy, the then Prime Minister Late J.L. Nehru wrote to the president of the World Bank in a letter (dated 11 July 1960) that Rajasthan canal was of vital importance to us and that our planning is based on it. There is a yearning all over the area served by the Rajasthan canal for water and any delay in providing adequate supplies of water to this canal would create very difficult political, social and economic problems for us. The signing of the Treaty was certainly an important landmark for the development of Rajasthan. Waters from Ravi, Beas and Sutlej rivers are now becoming available for use in the area.

According to the Indus Water Treaty of 1960 between India and Pakistan, the entire water of Ravi and Beas rivers
has been allocated to India. Rajasthan canal project was included to receive 9.36 \text{bm}^3 (759 \text{ MAF}) for irrigating the area of the Thar Desert.\textsuperscript{5}

5. **FINANCIAL ESTIMATES OF THE PROJECT**

A project estimate amounting to \text{Rs.} 66.67 crores including share cost of head works was sanctioned vide Rajasthan Government Irrigation Department for the construction of Rajasthan canal. The initial estimate was intended to provide irrigation to about 1358 thousand hectares of Canal Command Area (CCA). Out of which only 364 thousand hectares were expected to receive perennial irrigation and 994 thousand hectares non-perennial. With the settlement of water dispute on sharing waters of Indus basin between India and Pakistan in 1960, it became evident, that the full share of commitment of 9.36 \text{bm}^3 (7.59 \text{ MAF}) will be available to Rajasthan Canal Project. The revised project estimate was then framed in 1963 for a total sum of \text{Rs.} 184.09 crores. After the revision of project estimate in 1963, some of the major decisions were taken during the period 1964 to 1969:

(i) Increasing the intensity of irrigation from 78 to 110 per cent.

(ii) Lining of channels of distribution systems of stage-I & II of the canal in order to achieve the above intensity.

(iii) Revised rates fixed by the government for the sale of land coming under the canal command.

(iv) Revision in the cost of Pong Dam.

(v) Increase in the cost of construction due to higher wages to labour and cost of material.

The above points were discussed in the 54th meeting of Rajasthan Canal Board and it was then desired that these
items may also be included in the revised estimate of the year 1969.

The project estimate was again revised in the year 1970 and separate estimate were framed for stage - I & II of IGCP. Stage-I comprises of 204 km Feeder canal (out of which 169 km length lies in Haryana and Punjab) and main canal upto 189 km with all branches and distributaries taking-off from the main canal upto this reach.

The length of canal if considered from Harike is 393 km at the end of Stage-I. The main canal below 393 km and all its off-taking channels from stage-I.

The Planning Commission in 1970, cleared the construction of the canal under Stage-I only for ₹.110.20 crores.

Subsequently, the project report of Stage-II (Revised estimate) costing ₹.89.12 crores was approved by the Planning Commission in March 1972. According to this revised report irrigation was supposed in CCA of 607 thousand hectares in Stage-II.

In 1974, the National Commission on Agriculture in its report on Desert Development recommended the revision of Stage-II of the project by deleting from its scope the less suitable and sparsely populated area and instead bringing in its command in a series of lift channels, comparatively thickly populated areas of the districts of Bikaner, Jodhpur, Ganganagar and Jaisalmer.

The work of re-examination of the scope of the project was entrusted to Water and Power Consultancy Services (WAPCOS). The proposals of WAPCOS alongwith modifications suggested by the committees constituted by the
State Government were considered by the Council of Ministers and a decision was taken on 17th December 1976, which included:

(i) The flow areas under stage-II be kept as 500 thousand hectares.
(ii) The lift areas be kept 260 thousand hectares with lift upto 60 metres.

The revised project estimates of the expenditure on Stage-II were sent to the Central Water Commission (CWC) in 1977 with an estimated cost of Rs. 245 crores. The areas proposed to cover under the new lift schemes are presented in Table 1.

Table 1. Proposed New Lift Schemes - 1977

<table>
<thead>
<tr>
<th>Name of lift scheme</th>
<th>Canal Command Area (in ha.)</th>
<th>Estimated Cost (Rs. in Crores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nohar Sahwa</td>
<td>68,920</td>
<td>23.17</td>
</tr>
<tr>
<td>Gajner</td>
<td>46,440</td>
<td>17.60</td>
</tr>
<tr>
<td>Kolayat</td>
<td>79,580</td>
<td>21.95</td>
</tr>
<tr>
<td>Phalodi</td>
<td>47,290</td>
<td>15.60</td>
</tr>
<tr>
<td>Pokaran</td>
<td>18,900</td>
<td>7.72</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,61,130</strong></td>
<td><strong>86.04</strong></td>
</tr>
</tbody>
</table>

Source: IGCP Head Office, Jaipur

While the project proposals were under examination in CWC, the State Government revised it again in 1978 and kept in abeyance the lift schemes.
In August 1983, the Government of Rajasthan revised the scope of the Stage-II to include five lift irrigation schemes in the project and also to extend the Sagarmal Gopa Branch up to Gadra Road in Barmer District. The water allowance was reduced from 0.36 cumecs to 0.25 cumecs per 1000 hectares, and intensity of irrigation from 110 to 90 per cent.

A detailed report with same modified proposals for stage-II was submitted to CWC in September 1984. The report as submitted estimated to cost ₹846.26 crores and proposed to provide irrigation to command area of 1012 thousand hectares (700 by flow and 312 thousand hectares by lift canal) with an irrigation intensity of 90 per cent. The project particulars for stage-II as finalised by the CWC are presented in Table 2. Meanwhile, the State Government prepared a modified proposals to include 6 lift irrigation canals including Barmer lift canal to provide irrigation in strips with afforestation on both sides and a development of 366 thousand hectares of CCA for pasture land, afforestation and dairy development was also incorporated.

<table>
<thead>
<tr>
<th>Project Particulars</th>
<th>Measured in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canal command area</td>
<td>1012 thousand hectares (700 thousand ha by flow canal).</td>
</tr>
<tr>
<td>Annual irrigation</td>
<td>810 thousand ha.</td>
</tr>
<tr>
<td>Water reserved for drinking</td>
<td>34 cumecs</td>
</tr>
<tr>
<td>Intensity of irrigation</td>
<td>80 per cent</td>
</tr>
<tr>
<td>Estimated cost</td>
<td>₹. 931.24 crores</td>
</tr>
</tbody>
</table>

Source: IGCP Head Office, Jaipur
The acceptance of the Planning Commission to the revised project estimate of Stage-II at an estimated cost of Rs.931.24 crores was issued.

An extension, renovation and modernisation of the project amounted to Rs.86.39 crores was prepared for Stage-I in January 1993 and sent to CWC for the clearance. The major items of work to be included under the project are:

(i) The construction, remodelling and extension of channels and to bring additional area of 24 thousand hectares in canal command.

(ii) Utilisation of irrigation potential of stored water for more than 10 thousand hectares of Ghaggar depressions.

(iii) Augmenting pumping capacity of Kanwar Sain Lift Canal.

(iv) Restoration of bank of main canal.

6. RENAMING OF THE CANAL

The Rajasthan Canal Project, one of the largest man-made canal systems of India, was renamed as Indira Gandhi Canal Project in November 1984 as a mark of respect to the Late Prime Minister Smt. Indira Gandhi after her assassination.

7. PRESENT STATUS OF THE PROJECT

The Indira Gandhi Canal Project (IGCP) has been constructed in the northwestern part of the Thar Desert of Rajasthan. The construction of this canal in such an inhospitable and hazardous area has been a challenging task.

The IGCP formally commenced on 31st March 1958 and at present ranks first amongst the largest man-made projects in India with respect to its size, length, capacity,
command area, use of construction materials as well as human and animal power for the development of agriculture in a dry tract.

The IGCP is a Feeder up to a length of 204 km and traverses for a length of 150 km (in Punjab) and 19 km (in Haryana) where it does not have any outlet. The head of the main canal is located near Masitanwali in Ganganagar district. The tail of the 445 km long main canal is located near Mohangarh in Jaisalmer district. The command area of the canal is further extended to Gadra Road in Barmer district through with the construction of Sagarmal Gopa branch. Construction work of the project is still in progress and is being carried out into two different stages. The first water to the canal was released by Late Dr. Radha Krishnan the then Vice-President of India on 11th October 1961 at Naurangdesar. On 1st January 1987, Himalaya's water reached Mohangarh a far end village in Jaisalmer district. The main canal has a number of branches and distributions. All the right bank branches of the canal are designated as flow channels because of the land west of the main canal slopes down gently towards the Pakistan border. Whereas all the left bank channels except the Rawatsar branch, which takes-off from the head of the main canal. The main canal has a width of 40 metres, and its bottom reaches to 6.4 metres deep. The carrying capacity of canal amounts to 18,500 cusecs of water measured at its head. The command area lying east and southeast of the main canal and slopes towards the main canal, hence water has to be lifted against the slope of land. In 1981, Rajasthan was allocated 8.6 MAF of water. In view of the large size of the project, the construction work has been taken into two different stages for the convenience of management, utilisation of resources and achievement of early benefits (Fig.1).
Construction of IGCP Under Stage-I

The Stage-I of the project covers 204 km long feeder canal in Punjab, Haryana and Rajasthan, 189 km main canal, and 3,400 km of distribution system. It has five flow branches and one lift scheme, which are as follows:

Flow Branches

(i) Rawatsar branch
(ii) Naurangdesar branch
(iii) Suratgarh branch
(iv) Pugal branch and
(v) Anupagarh branch

Lift Canal System

(i) Kanwarsen lift scheme

Stage-I covers a culturable command area of 558 thousand hectares including the area under Kanwar Sain lift canal (Fig.?). The planned irrigation potential in 1996 amounted to 629 thousand hectares. The intensity of irrigation for Stage-I has been computed to 110 per cent. Some of the salient features of Stage-I of the project are presented in Appendix II.

Construction of IGCP Under Stage-II

The Stage-II of the project takes on start tail of Stage-I i.e., from 189 km of Indira Gandhi Main Canal (IGMC). The main canal for its entire length of 256 km was completed by December 1986 and the water was released on 1st January 1987. The total length of distribution system spreads over 5780 km. This stage would cover a canal command area of over 1315 thousand hectares at 80 per cent intensity of irrigation in flow and 60 per cent on lift area. There are six flow branches and six lift schemes (Table 3).
Table 3 Flow and Lift Branches Under Stage - II of IGCP

<table>
<thead>
<tr>
<th>Name of the Branch</th>
<th>Off-take Point on the IGCP (in km)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Under Flow Branch</strong></td>
<td></td>
</tr>
<tr>
<td>(i) Dattor branch</td>
<td>215</td>
</tr>
<tr>
<td>(ii) Birsalpur branch</td>
<td>232</td>
</tr>
<tr>
<td>(iii) Charanwali branch</td>
<td>445</td>
</tr>
<tr>
<td>(iv) Lilwa branch</td>
<td>445</td>
</tr>
<tr>
<td>(v) Shaheed Birbal branch</td>
<td>-</td>
</tr>
<tr>
<td>(vi) Sagarmal Gopa branch</td>
<td>-</td>
</tr>
<tr>
<td><strong>Under Lift Scheme</strong></td>
<td></td>
</tr>
<tr>
<td>(i) Gajner lift scheme</td>
<td>228.6</td>
</tr>
<tr>
<td>(ii) Kolayat lift scheme</td>
<td>229.0</td>
</tr>
<tr>
<td>(iii) Phalodi lift scheme</td>
<td>351.0</td>
</tr>
<tr>
<td>(iv) Pokran lift scheme</td>
<td>366.8</td>
</tr>
<tr>
<td>(v) Nohar Sahwa lift scheme</td>
<td>-</td>
</tr>
<tr>
<td>(vi) Bangarser lift scheme</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: IGCP Head Office, Jaipur, 1996

The Stage-II of the project provides an irrigation potential of 810 thousand hectares (1994). The work on the main canal has been completed upto tail and the remaining work on some distribution system is continuing. The Stage-II of the project is currently ready for implementation (Fig.3). The tasks of completion and the remaining work to be completed are presented in Appendix III.
INDIRA GANDHI CANAL PROJECT
COMMAND AREA STAGE-II

- DAT TAR BRANCH
- BIRSA LPUR BRANCH
- CHARANWALA BRANCH
- SAHID BIRBAL BRANCH
- SAGARMAL GOPA BRANCH
- ASUTAR
- Jaisalmer
- GADRA ROAD BRANCH
- BARMER
- NOHAR SAHWA LIFT CANAL
- KOLAYAT LIFT CANAL
- PHALODI LIFT CANAL
- FLOW CANAL
- LIFT CANAL

FIG. 3
The irrigation plan of the project was revised many times with a view for the extensive irrigation, which refers to reduce allowance of water per hectare and provide irrigation to maximum extent of the cultivated area. The irrigation intensity account for 86 per cent to the culturable command area. Water allowance of Stage-II stands for 3.50 cusecs which is relatively less than that of Stage-I. One of the basic objectives to design extensive irrigation for the region in order to provide irrigation to more and more areas in the desert and permit to grow light irrigated crops, prevent waterlogging and soil salinity.

The IGCPCA, however, covers approximately 4 per cent of the arid zone of India and nearly one-tenth of the Rajasthan state. The entire length of IGCP system with its main canal, branches, lift canals and distributeries will nearly by 9850 km long excluding the minor channels. The canal is oriented and seen approximately parallel to the India and Pakistan border at an average distance of 40 km.

8. OBJECTIVES OF INDIRA GANDHI CANAL PROJECT

Rajasthan is the second largest state of the Indian Union having 25600 thousand hectares of cultivable area. The entire Thar Desert occupies 19800 thousand hectares of area of Rajasthan state. Only 13 per cent of the cultivable area has irrigation facilities.

The major objectives of the construction of IGCP in Western Rajasthan were as follows:
(i) Drought proofing of the area and improving living conditions.
(ii) Providing irrigation facilities in the area to develop the waste land resources to meet the growing requirement for the area to be brought under cultivation.
(iii) Provision of water for drinking and industrial uses.
(iv) Creation of employment opportunities in rural sector.
(v) Settlement of population in the thinly populated areas to ease pressure scattered lands cultivated in the state.
(vi) To meet the needs of drinking water, fodder and forage for the animals in the region.
(vii) To check the spread of desert and improve ecosystem through large-scale afforestation in the area.
(viii) To provide opportunities for overall development of the area with the creation of infrastructure for exploitation of natural resources and development of industries etc.

9. DATA BASE AND METHODOLOGY

The present research work is an outcome of the data collected from secondary and primary sources. Many of the information were obtained from the secondary sources such as the Annual Progress Report of IGCP (Published by IGCP Head Office), Jaipur, Command Area Development Office, Jaipur, Ministry of Irrigation, New Delhi, Irrigation Department of Rajasthan, Jaipur, Rajasthan Forest Department, Jaipur, District Census Handbook Office, Jaipur, Indira Gandhi Canal Board Office, Bikaner and Jaisalmer, Land Revenue Department of Rajasthan, Jaipur, Operation Research Group Office, Jaipur and Baroda, NCAER Office, New Delhi, Water and Land Policy Research Institute, Jaipur, Soil Survey Unit of Command Area Development, Jaipur, Water and Power Consultancy Services, New Delhi, School of Planning and Architecture, New Delhi, B.M. Birla Science and Technology Centre, Jaipur, Department of Animal Husbandry, Jaipur, Marudhar Academy, Jaipur and State Department of Agriculture, Jaipur.

The network of IGCP spreads over five districts (Ganganagar, Bikaner, Jaisalmer, Jodhpur and Barmer) of Western Rajasthan. The study incorporates Stage-I and
Stage-II of the CCA, and the area of district covered in each stage of the canal command. In order to examine the impact of IGCP on socio-economic and subsequent ecological changes were studied at macro level for the period extending from 1961 to 1991 with a time interval of 10 years. In the last chapter of the study, the findings are based on field survey conducted in eight villages selected from different locations of Stage-I and Stage-II CCA during March-April, 1996. Among the selected villages, four belong to Stage-I and a equal number from Stage-II CCA. Out of four selected villages two of them represent the flow canal area of the Stage-I and the remaining two from lift canal area. The same considerations were followed in the selection of villages from Stage-II CCA.

For the sake of selection of households from the respective villages random sampling followed considering villages as a unit and households as the ultimate unit of study. The selection of villages was made purposively with due consideration of some (23) selected socio-economic and ecological variables. The details of methodology adopted is present in chapter 5.

CHAPTER SCHEME

The present work has been divided into three parts spreading over five chapters. Part one is devoted to the understanding of general geographical and social conditions of the study area. This part comprises two separate chapters. Chapter 1 deals with the physical setting of the region (structure and relief, climate and soils), and chapter 2 is devoted to deal with the social status of the canal command area. It incorporates the population characteristics like its distribution, density, growth, age-structure, sex-ratio and literacy. Part two is devoted to assess the economic and ecological conditions of the districts of the study area. This part consist of
chapters 3 and 4 to deals with the economic status including settlement patterns, occupational structure, agriculture (land use pattern, culturable wasteland, cropping pattern, use of modern agricultural inputs, crops and disease), animal husbandry, industry, and afforestation emphasised in chapter 3, whereas chapter 4 deals with a correlative assessment of ecological conditions and the changes that have taken place with the construction of IGCP in desert region. Part three is devoted for the assessment of socio-economic and ecological conditions at household and village level and consisting conclusion and suggestions. Chapter 5 deals with the ascertain the socio-economic and ecological aspects at micro level on the basis of informations collected through field surveys from eight selected villages which represent Stage-I and Stage-II canal command area of IGCP.
REFERENCES


